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DEPLETED UF_6

Final

Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride

Summary

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, Maryland 20874

DOE/EIS-0269

Department of Energy

Washington, DC 20585

April 15, 1999

Dear Interested Party:

Enclosed is a copy of the Department of Energy's (DOE) "Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride" (DOE/EIS-0269). This document has been prepared in accordance with the National Environmental Policy Act. It describes the potential environmental impacts of a range of reasonable alternatives to manage DOE's depleted uranium hexafluoride (UF_6) inventory.

The final programmatic environmental impact statement (PEIS) is available on the Office of Nuclear Energy, Science and Technology World Wide Web site (http://www.ne.doe.gov) or upon request through the web site or by calling 1-800-517-3191. The document is also available at DOE reading rooms in Paducah, Kentucky, Portsmouth, Ohio, Oak Ridge, Tennessee, and Washington, D.C. The final PEIS is comprised of three volumes: volume 1 -Main Text (about 500 pages), volume 2 -Appendices, and volume 3 -Responses to Public Comments.

The preferred alternative presented in the final PEIS has been revised based in part on public comments on the draft PEIS. The revised preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for future use of as much of this inventory as possible.

All comments submitted during the public comment period were considered by DOE in preparing the final PEIS. The comments are presented along with responses in volume 3 of the document. A record of decision will be issued 30 days or more following publication of the notice of availability of the final PEIS in the "Federal Register."

DOE appreciates your continued participation in this program.

Sincerely,

Beverly A Cook for

William D. Magwood, IV, Director
Office of Nuclear Energy,
Science and Technology

Enclosure

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DOE/EIS-0269

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

Summary

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology

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COVER SHEET

RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE)

TITLE: Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269)

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ABSTRACT: This PEIS assesses the potential impacts of alternative management strategies for depleted uranium hexafluoride (UF_6) currently stored at three DOE sites: Paducah site near Paducah, Kentucky; Portsmouth site near Portsmouth, Ohio; and K-25 site on the Oak Ridge Reservation, Oak Ridge, Tennessee. The alternatives analyzed in the PEIS include no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

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* Vertical lines in the right margin of this document indicate changes that have been added after the public comment period.

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SUMMARY[1]

S.1 INTRODUCTION

This programmatic environmental impact statement (PEIS) assesses the potential impacts of alternative strategies for managing the depleted uranium hexafluoride (UF_6) currently stored in cylinders at three U.S. Department of Energy (DOE) sites: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25[2] site on the Oak Ridge Reservation in Oak Ridge, Tennessee. A management strategy is a series of activities needed to achieve the safe long-term storage, use, or disposal of the depleted UF_6 inventory.

The proposed selection and implementation of a long-term management strategy constitute a major federal action with potentially significant environmental consequences. As such, it falls under the *National Environmental Policy Act* (NEPA). This PEIS has been prepared in compliance with the NEPA and all applicable NEPA implementing regulations set forth in the *Code of Federal Regulations* (40 CFR Parts 1500-1508 and 10 CFR Part 1021). Additional NEPA analyses, as appropriate, will be prepared once a long-term management strategy has been selected. The follow-on NEPA analyses will evaluate issues such as where to locate facilities (siting), which specific technologies or processes to use, and what site-specific impacts might result from construction and operations.

***National Environmental Policy Act* (NEPA) Regulations**

NEPA regulations require, among other things, federal agencies to include discussion of a proposed action and all reasonable alternatives in an environmental impact statement (EIS). Sufficient information must be included in the EIS for reviewers to evaluate the relative merits of each alternative. A programmatic EIS (PEIS) is an evaluation of a broad agency action setting the course of future activities.

The agency must briefly discuss any alternatives that were eliminated from further analysis. The agency should identify its preferred alternatives, if one or more exist, in the draft EIS and must identify its preferred alternative in the final EIS unless another law prohibits naming a preference. After completing the final EIS and in order to implement an alternative, the federal agency must issue a Record of Decision that announces the decision made and identifies the alternatives considered.

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[1] Vertical lines in the right margin of this summary indicate changes that have been added after the public comment period.

[2] The site of the K-25 plant is now called the East Tennessee Technology Park but is referred to by its original name, the K-25 site, throughout this PEIS.

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S.1.1 Background

Depleted UF_6 results from the process of making uranium suitable for use as fuel for nuclear reactors or military applications. The use of uranium in these applications requires increasing the proportion of the uranium-235 isotope found in natural uranium, which is approximately 0.7%, through an isotopic separation process called uranium enrichment. An enrichment process called gaseous diffusion is currently used in the United States.

The gaseous diffusion process requires uranium in the form of UF_6. UF_6 is a chemical compound consisting of one atom of uranium combined with six atoms of fluorine. It can be a solid, liquid, or gas, depending on its temperature and pressure. (See Appendix A of the PEIS for additional information on the properties of UF_6.) It is used for the gaseous diffusion process primarily because it can conveniently be used in the gas form for processing, in the liquid form for filling or emptying containers or equipment, and in the solid form for storage. At atmospheric pressure, UF_6 is a solid at temperatures below 134°F (57°C) and a gas at temperatures above 134°F. Solid UF_6 is a white, dense, crystalline material that resembles rock salt.

In the gaseous diffusion process, a stream of heated UF_6 gas is separated into two parts: one enriched in uranium-235 and the other depleted in uranium-235. The enriched UF_6 is used for manufacturing commercial reactor fuel, which typically contains 2 to 5% uranium-235, or for military applications (e.g., naval reactor fuel), which requires further enrichment of up to 95% or more uranium-235. The depleted UF_6, which typically contains 0.2 to 0.4% uranium-235, is stored as a solid in large metal cylinders at the gaseous diffusion facility.

Inventory of Depleted UF_6 Cylinders Considered in the PEIS

	No. of Cylinders (metric tons)		
Site	DOE-Generated	USEC-Generated[a]	Total
Paducah	28,351 (342,000)	12,000 (144,000)	40,351 (486,000)
Portsmouth	13,388 (161,000)	3,000 (36,000)	16,388 (197,000)
K-25	4,683 (56,000)	None	4,683 (56,000)
Total			61,422 (739,000)

[a] In May and June 1998, DOE assumed management responsibility for approximately 11,400 cylinders generated by United States Enrichment Corporation. For purposes of the PEIS, management of up to 15,000 USEC-generated cylinders was considered.

Large-scale uranium enrichment in the United States began as part of atomic bomb development by the Manhattan Project during World War II. Uranium enrichment activities were subsequently continued under the U.S. Atomic Energy Commission and its successor agencies, including DOE. The K-25 plant was the first of three gaseous diffusion plants constructed to produce enriched uranium. The K-25 plant ceased operations in 1985, but uranium enrichment continues at both the Paducah and Portsmouth sites. These two

plants are now operated by the United States Enrichment Corporation (USEC), created by law in 1993 to privatize the uranium enrichment program.

Since the 1950s, depleted UF_6 has been stored at all three storage sites in large steel cylinders. Several different cylinder types are in use, although the vast majority of cylinders have a 14-ton (12-metric-ton) capacity. A typical cylinder is shown in Figure S.1. The cylinders are typically 12 ft (3.7 m) long by 4 ft (1.2 m) in diameter, with most having a wall thickness of 5/16 in. (0.79 cm) of steel. Similar, but slightly smaller, cylinders with a capacity of 10 tons (9 metric tons) are also in use. During storage, a cylinder contains solid UF_6 in the bottom and UF_6 gas at less than atmospheric pressure in the top. The depleted UF_6 cylinders managed by DOE at the three sites are typically stacked two cylinders high in large areas called yards (Figure S.2).

The characteristics of UF_6 pose potential health risks, and the material is handled accordingly. Uranium is radioactive, and UF_6 in storage emits low levels of gamma and neutron radiation. The radiation levels measured on the outside surface of filled depleted UF_6 storage cylinders are typically about 2 to 3 millirem per hour (mrem/h), decreasing to about 1 mrem/h at a distance of 1 ft (0.3 m). In addition, if UF_6 is released to the atmosphere, it reacts with water vapor in the air, forming hydrogen fluoride (HF) and a uranium-fluoride compound called uranyl fluoride (UO_2F_2). These products are chemically toxic. Uranium is a heavy metal that, in addition to being radioactive, can have toxic chemical effects (primarily on the kidneys) if it enters the bloodstream by means of ingestion or inhalation. HF is an extremely corrosive gas that can damage the lungs and cause death if inhaled at high enough concentrations.

Cylinders are stored with minimum risks to workers, members of the general public, and the environment at the Paducah, Portsmouth, and K-25 sites. DOE maintains an active cylinder management program to improve storage conditions in the cylinder yards, to monitor cylinder integrity by conducting routine inspections for breaches, and to perform cylinder maintenance and repairs as needed.

Because storage began in the early 1950s, many of the cylinders now show evidence of external corrosion. Before 1998, seven cylinders (one at Paducah, two at Portsmouth, and four at K-25) had been identified that had developed holes (breaches), generally around spots previously damaged by handling activities. In 1998, one additional cylinder breach occurred during the course of cylinder maintenance operations. Because the depleted UF_6 is a solid at ambient temperatures and pressures, it is not readily released from a cylinder following a leak or breach. When a cylinder is breached, moist air reacts with the exposed UF_6 solid and iron, resulting in the formation of a dense plug of solid uranium and iron compounds and a small amount of HF gas. This plug limits the amount of material released from a breached cylinder. When a cylinder breach is identified, the cylinder is repaired or its contents are transferred to a new cylinder.

DOE has responsibility for continued management of the depleted UF_6 cylinders stored at the Paducah, Portsmouth, and K-25 sites. The management plan in place during much of the preparation of this PEIS was to continue safe storage of the cylinders and, if feasible alternative uses

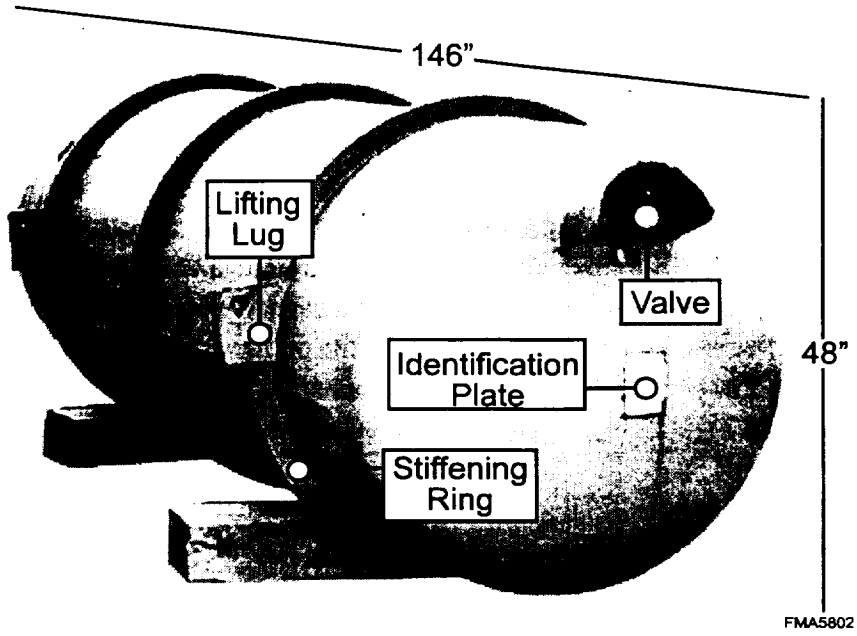

FIGURE S.1 Typical Depleted UF_6 Storage Cylinder (Cylinders are constructed of steel, with the majority of cylinders having a 14-ton capacity.)

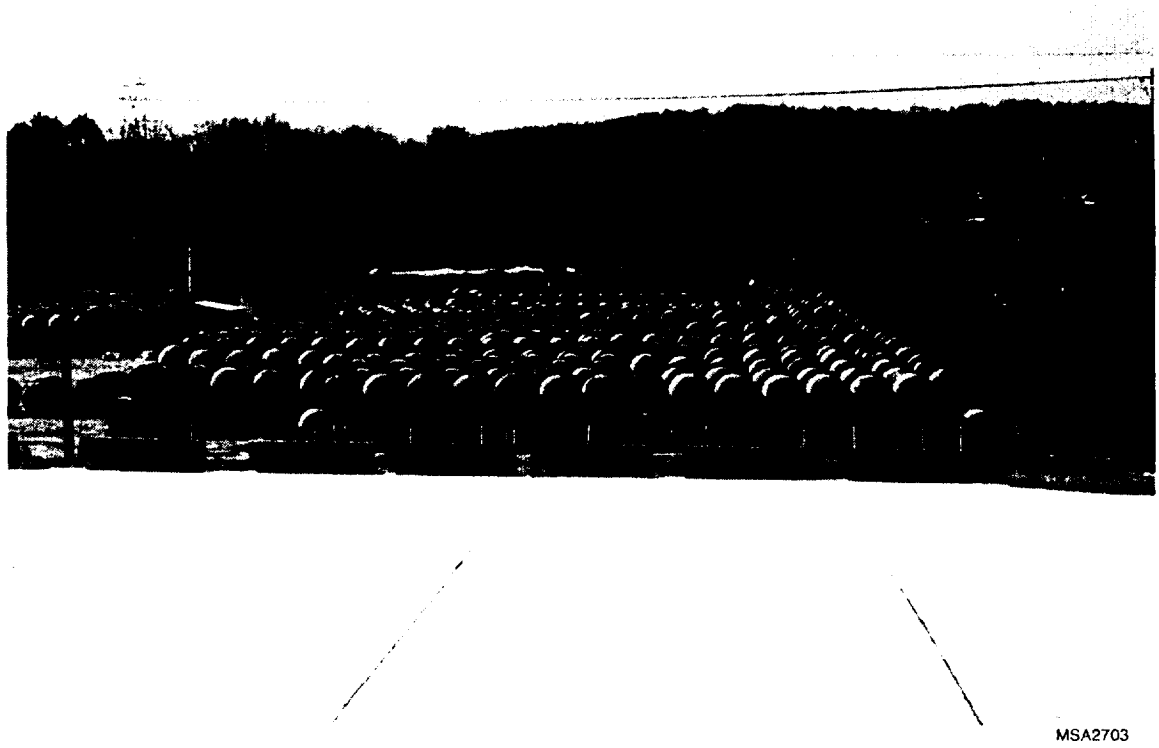

FIGURE S.2 Depleted UF_6 Cylinders in Storage Yards

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for the depleted uranium had not been found by about the year 2010, take steps to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020. The U_3O_8, which is more chemically stable than UF_6, would be stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste (LLW). The basis for the plan was to reserve depleted UF_6 for future defense needs and other potentially productive and economically viable purposes, including possible reenrichment in an atomic vapor laser isotope separation plant, conversion to depleted uranium metal for fabricating penetrators (anti-tank weapons) for military use, and use as fuel in advanced liquid metal nuclear reactors.

Since the former plan was put in place, several developments have occurred that suggest this plan should be revised. For example, the Energy Policy Act of 1992 assigned responsibility for uranium enrichment and development of atomic vapor laser isotope separation to the USEC, the demand for penetrators has diminished, and the advanced liquid metal nuclear reactor program has been canceled. In addition, stakeholders near the current cylinder storage sites have expressed concerns regarding potential environmental, safety, health, and regulatory issues associated with the continued storage of the depleted UF_6 inventory. The Ohio Environmental Protection Agency issued a Notice of Violation to DOE (which has since been resolved), and the Defense Nuclear Facilities Safety Board (DNFSB) provided a recommendation to the Secretary of Energy regarding improvements in the management of depleted UF_6.

DOE also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the depleted UF_6 stored at the K-25 site. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from K-25 or complete the conversion of their contents by December 31, 2009.

In July 1998, the President signed Public Law 105-204 which provides, in part, the following (see Appendix N for the complete text of Public Law 105-204):

> *(a) PLAN. – The Secretary of Energy shall prepare, and the President shall include in the budget request for fiscal year 2000, a Plan and proposed legislation to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to commence construction of, not later than January 31, 2004, and to operate, an onsite facility at each of the gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio, to treat and recycle depleted uranium hexafluoride consistent with the National Environmental Policy Act.*

DOE provided its initial plan for the conversion of depleted UF_6, responsive to Public Law 105-204, to Congress on March 12, 1999. In addition, it issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the

Commerce Business Daily published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

At this time, DOE has not recommended to the President that any additional legislation be proposed. Any proposal to proceed with the location, construction, and operation of a facility or facilities will involve additional review under NEPA.

S.1.2 Purpose and Need

The purpose of the PEIS is to reexamine DOE's management strategy for depleted UF_6 and alternatives to that strategy; DOE needs to take action in response to current economic, environmental, and legal developments. This PEIS examines the environmental consequences of alternative strategies of long-term storage, use, and disposal of the depleted UF_6 inventory. A long-term management strategy will be selected in the Record of Decision, which is scheduled to be issued no sooner than 30 days after the issuance of this PEIS.

S.1.3 Proposed Action

The proposed action assessed in this PEIS is DOE's selection of a long-term management strategy for depleted UF_6 that will be implemented following the Record of Decision. A strategy is a set of activities or steps for managing depleted UF_6, from its current storage at the three DOE storage sites to its ultimate use, long-term storage, or disposal. The alternative strategies considered in the PEIS evaluate options for continued storage of cylinders; conversion of the UF_6 to other chemical forms; use of the uranium as a metal or an oxide; long-term storage, disposal, and/or transportation. The time period for which activities were assessed for all strategies was approximately 40 years: generally 10 years for siting, design, and construction of any required new facilities; about 26 years for operations; and, when appropriate, about 4 years for monitoring.[3] In addition, for the continued storage component of all alternatives and for the disposal alternative, long-term impacts (primarily from potential groundwater contamination) were estimated. The actual implementation schedule would depend on the ultimate strategy selected in the Record of Decision and on other considerations, and activities could continue beyond the 40-year period. DOE would conduct additional NEPA reviews for such activities as appropriate.

The PEIS provides a broad environmental analysis of the various programmatic management strategies available to DOE. DOE has identified a preferred management strategy in the draft PEIS and modified the strategy in this final PEIS on the basis of public comments.

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[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

S.1.4 DOE's Depleted Uranium Hexafluoride Management Program

The DOE Depleted Uranium Hexafluoride Management Program was established to accomplish the long-term management of depleted UF_6. The program has two phases: (1) the selection of a strategy for long-term management of depleted UF_6; and (2) implementation of the strategy selected. The first phase is under way and is the subject of this PEIS. After this final PEIS is issued, DOE will select the strategy for long-term management of depleted UF_6 and describe the strategy selected in a Record of Decision that will be published in the *Federal Register* (FR). In the second phase of the program, DOE will identify specific sites and technologies necessary to carry out the strategy. These sites and technologies will be evaluated in subsequent NEPA reviews.

The program has and is conducting a variety of technical analyses in parallel with the PEIS. Technology assessment evaluations are based on suggestions for uses of depleted UF_6 and management technologies provided by respondents to a DOE Request for Recommendations issued on November 10, 1994 (59 FR 56324). This request resulted in a report entitled *Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride*, which was released on June 30, 1995. An engineering analysis, which is documented in the engineering report prepared in parallel with this PEIS — *Depleted Uranium Hexafluoride Management Program; Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* — provides an in-depth technical analysis of feasible options identified in the technology assessment report and includes all the options addressed in the PEIS. The life-cycle costs of alternative management strategies are also being assessed, and the results are documented in the *Cost Analysis Report for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride*.

The estimation of potential environmental impacts in the PEIS was based primarily on information provided in the engineering analysis report, which is incorporated by reference. The engineering analysis report contains preliminary facility design data for cylinder preparation, conversion, long-term storage (except for long-term storage of cylinders in yards), manufacture and use, and disposal options. For these options, the engineering analysis report includes descriptions of facility layouts, resource requirements, and construction requirements; estimates of effluents, wastes, and emissions during operations; and descriptions and estimated frequencies for a range of potential accident scenarios. These facility design data, as well as environmental setting information, were used as input to the calculational models or "tools" for estimating potential environmental impacts that could result under each alternative. The summary of the engineering analysis report is included in its entirety in Appendix O.

In addition to the management strategies considered in this PEIS, the use of some depleted UF_6 is being considered pursuant to other DOE programs, such as the disposition of surplus plutonium. Uses being considered by other DOE programs, which are subject to future decisions and other NEPA reviews, would generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy.

S.1.5 Scope of the Depleted UF_6 PEIS

On January 25, 1996, DOE published a Notice of Intent in the *Federal Register* (61 FR 2239), stating its plans to prepare the Depleted UF_6 PEIS and requesting comments on the scope of the PEIS. Three public scoping meetings were held between February 13 and February 20, 1996, at locations near each of the three depleted UF_6 storage sites. One important objective of scoping was to obtain public comments on DOE's proposed alternative management strategies. No new alternative management strategies were identified as a result of public comments.

This PEIS evaluates the environmental impacts of a range of alternative management strategies (these strategies are in addition to the potential use of some of the depleted UF_6 under other programs). Each alternative strategy consists of a series of activities needed to achieve the safe and effective long-term management of depleted UF_6. These activities could be accomplished in a number of different ways (called options). Options include technology or design variations for cylinder preparation, conversion of depleted UF_6 to another chemical form, use, storage, disposal, and transportation. The PEIS includes an assessment of the potential environmental impacts from a range of options for each activity. Representative options were evaluated in the PEIS; specific technologies and facilities will be evaluated in future NEPA reviews after an overall management strategy is selected in a Record of Decision. The PEIS evaluates the potential impacts to human health and safety, air, land, water, biota, cultural resources, waste management capabilities, socioeconomics, and environmental justice.

This final PEIS considers the depleted UF_6 inventory stored at the Paducah site, Portsmouth site, and K-25 site for which DOE has management responsibility. This inventory includes depleted UF_6 generated by DOE before the formation of USEC in July 1993 as well as depleted UF_6 generated by USEC that has been or will be transferred to DOE. Specifically, the PEIS considers the management of 46,422 cylinders (560,000 metric tons) generated by DOE and up to 15,000 cylinders (180,000 metric tons) generated by USEC.

S.1.6 Public Review of the Draft PEIS and Major Changes from the Draft to the Final PEIS

The draft PEIS was mailed to stakeholders in mid-December 1997, and a notice of availability was published by the U.S. Environmental Protection Agency (EPA) in the *Federal Register* on December 24, 1997. In addition, the entire PEIS was also made available on the World Wide Web at the same time. Stakeholders were encouraged to provide comments on the draft PEIS during a 120-day review period, from December 24, 1997, until April 23, 1998. Comments could be submitted via a toll-free number, fax, letter, e-mail, or the World Wide Web site. Comments could also be submitted at four public hearings held during a period from February 19, 1998, to March 10, 1998. Public hearings were held near each of the three current storage sites (Paducah, Kentucky; Oak Ridge, Tennessee; and Portsmouth, Ohio), and another was held in Washington, D.C.

A total of about 600 comments were received during the comment period. Comments received on the draft PEIS were considered in preparing the final PEIS. (As noted earlier, changes to the draft PEIS are denoted by a vertical line in the right margin of this final PEIS.) All comments received, along with DOE's responses to those comments, are presented in Volume 3 of this PEIS. A summary of the major issues raised by the reviewers of the draft PEIS, DOE's resolution of these issues, and resulting changes to the PEIS follows here.

- *The preferred alternative.* Many of the reviewers questioned DOE's preference for beginning to convert the depleted UF_6 inventory to uranium oxide or uranium metal only as uses for these materials became available. Several reviewers expressed a desire for DOE to start conversion as soon as possible. Conversion to U_3O_8 was the option most often cited as preferred, although several reviewers thought conversion to metal would be more advantageous. In addition, many reviewers expressed doubt about the prospects for any widespread uses for depleted uranium now or in the future.

  After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Sections S.5.1 and 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under this revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal products become available. The impacts of the preferred alternative are discussed in Sections S.5.2, 2.5.2, 5.7, and 6.3.7 of the PEIS.

- *Seismic hazards at the Paducah site.* Several reviewers commented that the draft PEIS did not adequately address the seismic hazards at the Paducah site. They requested that DOE review new information and reevaluate the risks associated with potential earthquakes at Paducah.

  In response, DOE reviewed those references that were available at the time this final PEIS was prepared. DOE determined that the analyses performed as part of the safety analysis reports recently completed at the three current storage sites (including Paducah) and for this PEIS were adequate. DOE will review any new data that become available and take appropriate action to maintain the safety basis of its cylinder management program.

- *Potential life-cycle impacts.* Several reviewers stated that depleted uranium and products made from using depleted uranium in various chemical forms would eventually need to be disposed of. They requested that the PEIS include a discussion of impacts for the disposal of these materials following long-term storage and use.

In response to their requests, a new section was added to this Summary (Section S.6) and to Chapter 5 of the PEIS (Section 5.9) to discuss issues related to the potential impacts of the long-term (beyond 2039) management of materials containing depleted uranium under all alternatives.

- *Cylinder inventory.* Several reviewers questioned the accuracy of the reported number of DOE-owned cylinders of depleted UF_6 (46,422) considered in the draft PEIS. Other reviewers requested that USEC-generated cylinders also be included within the scope of the PEIS.

  Although the number 46,422 used in the draft PEIS was accurate at the time the document was published, subsequent privatization of USEC and transfer of some cylinders from USEC to DOE changed the inventory of depleted UF_6 that falls within the scope of the PEIS (see Section 1.5.2). Chapter 6 has been added to the PEIS, and Chapter 2 and the Summary have been revised so the PEIS includes the impacts associated with the management of additional USEC-generated cylinders.

- *Current cylinder management.* Several reviewers raised questions and concerns about the current management of the cylinders at the three DOE locations.

  In response to these concerns, it has been emphasized that DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision-making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion, and regular inspection and surveillance of the cylinders and storage yard conditions.

The changes made in response to public comments, including the inclusion of up to 15,000 USEC cylinders, did not affect the types or overall significance of the environmental impacts presented in the draft PEIS. Although the estimated impacts did increase by up to 30% in some assessment areas, this increase was generally not significant because the impacts were typically small to begin with. Many impacts did not change at all with the inclusion of the USEC cylinders because these impacts were related to factors that were unaffected by the inventory increase. For example, the consequences of potential accidents did not increase because accidents generally involve only a limited amount of material that would be available, regardless of the overall inventory. In addition, other impacts did not change because they were related to the annual material processing rates, which were assumed to remain the same when the USEC cylinders were included. Consequently, it was not necessary to recirculate the draft PEIS for additional public review. The nature and magnitude of changes in environmental impacts resulting from the addition of USEC cylinders are discussed in Sections 2.4, 2.5, and Chapter 6 of the PEIS.

S.2 DESCRIPTION OF ALTERNATIVES

The alternative management strategies (also termed "alternatives") evaluated in this PEIS were developed by considering the two possible permanent dispositions for depleted uranium, use or disposal, and long-term storage of depleted uranium. Each of the alternatives involves some combination of seven activities: continued cylinder storage at the current sites, cylinder preparation for shipment, conversion to another chemical form, long-term storage, manufacture and use, disposal, and transportation. The activities required for each alternative are illustrated in Figure S.3 and summarized in Table S.1.

Alternative Management Strategies Considered in the PEIS*

No Action — Continued storage of depleted UF_6 cylinders indefinitely in yards at the Paducah, Portsmouth, and K-25 sites.

Long-Term Storage as UF_6 — Storage as UF_6 cylinders in yards, buildings, or a mine at a consolidated site.

Long-Term Storage as Uranium Oxide — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by storage in buildings, belowground vaults, or a mine at a consolidated site.

Use as Uranium Oxide — Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded spent nuclear fuel or high-level waste storage containers (casks).

Use as Uranium Metal — Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded spent nuclear fuel or high-level waste storage containers (casks).

Disposal — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

The alternatives for long-term management of depleted UF_6 evaluated for the period 1999 through 2039 are (1) no action, which involves continued storage of cylinders indefinitely at the three current storage sites; (2) long-term storage as UF_6 at a consolidated site; (3) long-term storage as an oxide at a consolidated site; (4) use as uranium oxide; (5) use as uranium metal; and (6) disposal as oxide. The first two alternatives involve the continued management of uranium in the form of UF_6. The other alternatives involve the conversion of UF_6 to another chemical form, either uranium oxide or uranium metal. During conversion, large amounts of HF would be produced that could potentially be sold for use or neutralized to calcium fluoride (CaF_2), which could be sold or disposed of.

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental,

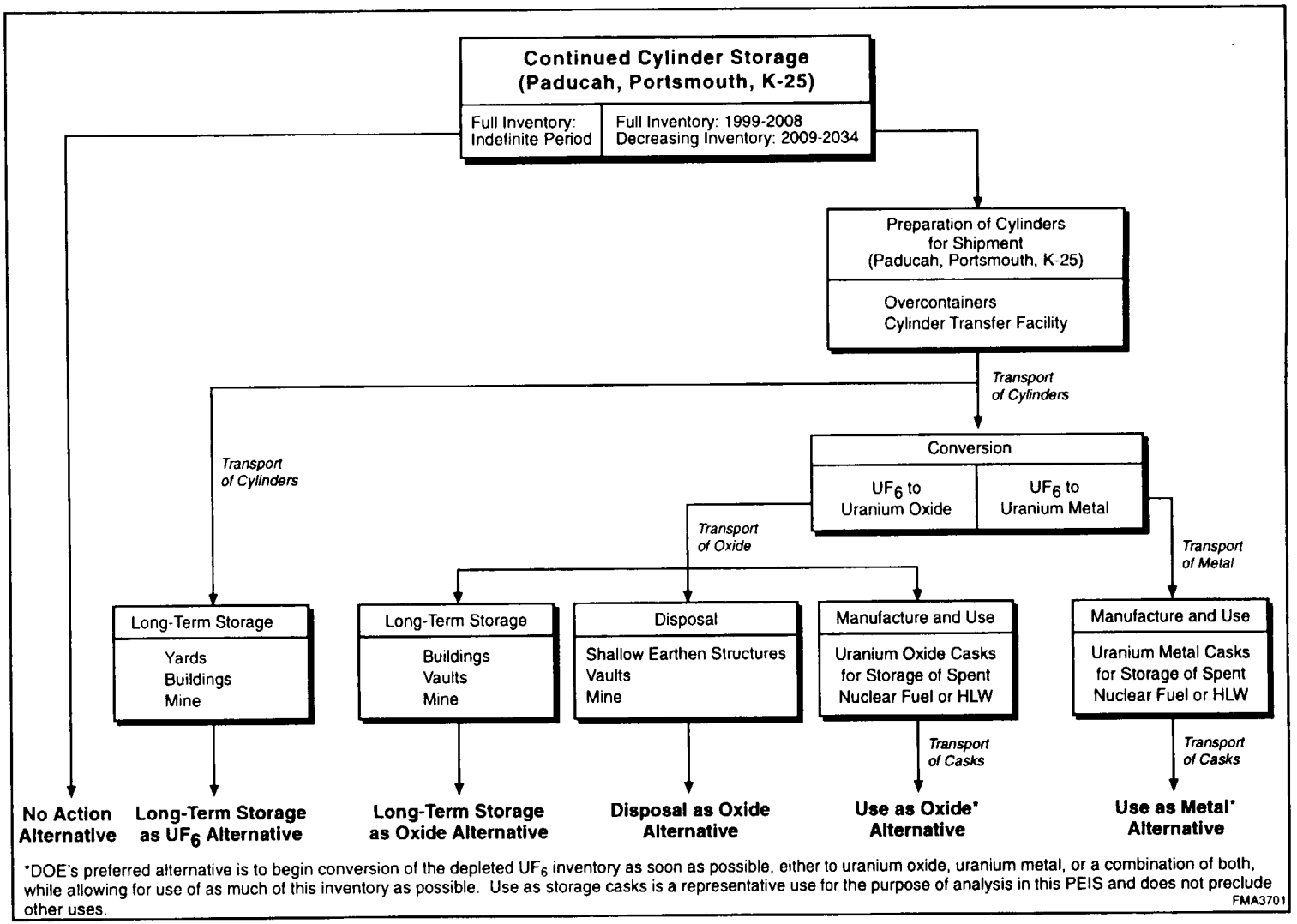

FIGURE S.3 Major Components of the Alternative Management Strategies

TABLE S.1 Comparison of Activities under the PEIS Alternatives (Note that DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Continued Cylinder Storage at Paducah, Portsmouth, and K-25			
The entire cylinder inventory would continue to be stored indefinitely at the Paducah, Portsmouth, and K-25 sites (impacts were evaluated from 1999 through 2039). Cylinders would be subject to a comprehensive monitoring and maintenance program, which would include routine inspections, cylinder painting, and cylinder yard upgrades.	The entire cylinder inventory would continue to be stored at the three current storage sites from 1999 through 2008. The inventory at each site was assumed to decrease to zero cylinders over the period 2009 through 2034 as cylinders were shipped to an off-site location.[a] During storage at current locations, cylinders would be subject to similar management activities as under no action.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Cylinder Preparation for Transportation			
Not applicable. The cylinders would remain at the three current storage sites.	The cylinders would be prepared at each current storage site for off-site shipment. Cylinders not suitable for shipment would either be provided with over-containers or the contents would be transferred to new cylinders.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Conversion			
Not applicable.	Not applicable.	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to the oxide UO_2 at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium metal at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Consolidated Long-Term Storage			
Not applicable. Cylinders would remain at the three current storage sites.	UF_6 cylinders would be stored for the long term in yards, buildings, or a mine at a site to be determined in the future. Cylinders would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Oxide (either U_3O_8 or UO_2) would be stored for the long term in drums in buildings, belowground vaults, or a mine at a site to be determined in the future. Material would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Not applicable.	Not applicable.	Not applicable.
		Manufacture and Use			
Not applicable.	Not applicable.	Not applicable.	Depleted uranium oxide (UO_2) would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Depleted uranium metal would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Not applicable.
		Disposal of Uranium			
Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Uranium oxide (either U_3O_8 or UO_2) would be disposed of as LLW at a site to be determined in the future. Disposal was considered for grouted (immobilized) and ungrouted oxide (in drums) in shallow earthen structures, belowground vaults, and a mine.

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Transportation[b]			
Small amounts of LLW and LLMW would be shipped from the current storage sites to treatment/disposal site(s).	UF_6 cylinders would be shipped from the current storage sites to a long-term storage site. LLW/LLMW would be shipped from storage sites to a disposal/treatment site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a long-term storage site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (UO_2) would be shipped from a conversion site to a manufacturing site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site. Casks would be shipped from a manufacturing site to a user site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium metal would be shipped from a conversion site to a manufacturing site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site. Casks would be shipped from a manufacturing site to a user site. Magnesium fluoride (MgF_2) would be shipped from a conversion site to a disposal site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site. Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a disposal site. HF (if produced) would be shipped from a conversion site to a user site. CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site. NH_3 would be shipped from a supplier to a conversion site. LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.

[a] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

[b] Because the locations of conversion, manufacture, long-term storage, and disposal sites will be decided in future studies, it was assumed that these sites were at separate locations, requiring transportation between them. This approach was intended to provide a conservative estimate of potential transportation impacts. Colocation of facilities would reduce transportation impacts.

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

economic, technical, and other factors. This identification does not represent a decision by DOE; rather, it reflects the DOE's preference on the basis of existing information. A discussion of the preferred alternative is presented in Section S.5. The Record of Decision, when issued, will present DOE's decision for the long-term management of depleted UF_6.

S.3 AFFECTED ENVIRONMENT

The affected environment is defined as the location or locations that may be impacted by the proposed action. For this PEIS, the affected environment consists of the three current depleted UF_6 storage locations: the Paducah site, the Portsmouth site, and the K-25 site.

S.3.1 Paducah Site

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River. The site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area. The city of Paducah is the largest urban area in the six counties surrounding the site. The area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) within the Paducah site occupies a 750-acre (303-ha) complex that is surrounded by a security fence. The PGDP, now operated by the USEC and previously operated by DOE, has been in operation since 1955. The Paducah site has 13 yards that are used for storage of DOE-generated depleted UF_6 cylinders; an additional 4 yards are used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Paducah site is in attainment for all six criteria pollutants; that is, the ambient air concentrations of the criteria pollutants — carbon monoxide, sulfur dioxide, particulate matter, ozone, nitrogen oxides, and lead — are within the corresponding standards. The Paducah site is also in compliance with 40 CFR 61 (National Emission Standards for Hazardous Air Pollutants, or NESHAPS), which places a maximum dose limit of 10 mrem/yr for the maximally exposed individual (MEI) of the general public from emissions of radioactive materials.

Several zones of faulting occur in the vicinity of the Paducah site. The largest earthquake in the region, with a magnitude of 7.3, occurred in 1812. The epicenter was 60 miles southwest of the site.

Big Bayou Creek and Little Bayou Creek, tributaries of the Ohio River, receive drainage from the Paducah site. All effluent discharges are regulated under the Kentucky Pollutant Discharge Elimination System. Groundwater at the Paducah site is monitored for pollutants, and

trichloroethylene has been detected at levels above the drinking water standard at several off-site locations. The radioactive isotope technetium-99 has also been detected in groundwater at the site. A municipal water supply has been provided to all residents whose wells are within the area of groundwater contamination from the site.

About 5 acres (2 ha) of jurisdictional wetland have been identified in drainage ditches scattered throughout the PGDP, and a large number of wetlands occur in the natural areas surrounding the developed center of the site where the yards are located. No federal-listed threatened or endangered species are known to occur on the Paducah site; however, several state-listed threatened and special concern terrestrial and aquatic species have been found outside the security fence of the PGDP.

The Paducah site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and low-level mixed waste (LLMW). Wastewater is discharged through permitted outfalls; nonhazardous solid waste is disposed of at an on-site landfill; and nonradioactive hazardous waste is stored on-site and sent to permitted commercial disposal facilities. The LLW is sent to a commercial facility for volume reduction; LLMW is currently stored on-site or, if appropriate, sent to the K-25 site for incineration.

Both workers and members of the general public receive small radiation doses from Paducah site operations. The estimated maximum radiation dose to a member of the general public near the site is about 2 mrem/yr, which is 2% of the DOE maximum dose limit. The 2-mrem/yr dose also represents less than a 1% increase over the 360-mrem/yr average dose from background radiation in the United States. Cylinder yard workers receive average radiation doses of about 16 to 56 mrem/yr, which is considerably below DOE's maximum dose limit of 5,000 mrem/yr for workers. Under normal operating conditions, cylinder yard workers at the Paducah site are not exposed to chemicals in amounts that exceed guideline values.

S.3.2 Portsmouth Site

The Portsmouth site is located in Pike County, Ohio, approximately 22 miles (35 km) north of the Ohio River and 3 miles (5 km) southeast of the town of Piketon. The two largest cities in the vicinity are Chillicothe, located 26 miles (42 km) north of the site, and Portsmouth, 22 miles (35 km) south. Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly over 1 mile (1.6 km) from the site boundaries.

The Portsmouth site includes the Portsmouth Uranium Enrichment Complex, a gaseous diffusion plant operated by the USEC and previously operated by DOE. The Portsmouth site occupies 3,708 acres (1,500 ha) of land, with an 800-acre (320-ha) fenced area containing the core facilities. The 2,908 acres (1,180 ha) outside the fenced area consist of restricted buffer zones, waste management areas, plant management and administrative facilities, and vacant lands. The

Portsmouth site contains two storage yards for DOE-generated depleted UF_6 cylinders; one additional yard is used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Portsmouth site is in attainment for all six criteria pollutants. The Portsmouth site is also in compliance with NESHAPS for radionuclide emissions (40 CFR 61). The Portsmouth site is drained by Big Beaver Creek and Little Beaver Creek. All site effluents are discharged either through permitted outfalls to Little Beaver Creek or downstream to the Scioto River. Groundwater is monitored at and around the Portsmouth site; several chlorinated hydrocarbons, uranium, and other metals have been detected in on-site monitoring wells.

Approximately 34 acres (13.8 ha) of wetlands occur on the Portsmouth site, excluding retention ponds. Two wetland areas near the site have been listed by the Ohio State Division of Natural Areas and Preserves as significant wetland communities. No federal-listed threatened or endangered plant or animal species are known to occur on the Portsmouth site, although the endangered Indiana bat may be present in the summer. One state-listed endangered species occurs on the site, and one threatened species occurs near the site.

The Portsmouth site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls; and nonhazardous solid waste is disposed of at an on-site landfill. Nonradioactive hazardous waste is stored on-site until treatment or disposal; solid nonradioactive hazardous waste is sent to permitted commercial disposal facilities, whereas liquid nonradioactive hazardous waste streams are sent to the approved incinerator at the K-25 site in Tennessee. The LLW is sent to off-site treatment/disposal facilities. Some LLW has been sent to the DOE Hanford site (Washington) for disposal. The LLMW is currently stored on-site or, if appropriate, sent to K-25 for incineration.

Both workers and members of the general public receive small radiation doses from Portsmouth site operations. The estimated maximum radiation dose to a member of the general public is about 0.07 mrem/yr, approximately 0.07% of the DOE maximum dose limit. Cylinder yard workers receive average radiation doses of about 55 to 196 mrem/yr, which is considerably below the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers at Portsmouth are not exposed to chemicals in amounts that exceed guideline values.

S.3.3 K-25 Site on the Oak Ridge Reservation

The K-25 site is part of the Oak Ridge Reservation, which consists of three major facilities (the K-25 site, Oak Ridge National Laboratory, and the Y-12 plant) and surrounding property in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville. The K-25 site, in the northwest part of the Oak Ridge Reservation, consists of 1,700 acres (688 ha) and contains the former Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities. The K-25 site contains three storage yards for depleted UF_6 cylinders.

The air quality region that includes the K-25 site is in attainment for all six criteria pollutants. The K-25 site is also in compliance with NESHAPS for radionuclide emissions (40 CFR Part 61). The K-25 site is drained by Poplar Creek and the Clinch River, and permitted outfalls are located on both streams. Contaminants detected in groundwater from on-site wells include trichloroethylene and radioactivity.

Numerous wetlands are found in the vicinity of the K-25 site along the creeks and rivers. No federally listed threatened or endangered species are known to occur on the K-25 site; however, several state-listed threatened or endangered plant and animal species are known to be in the vicinity of the K-25 site.

The K-25 site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls. Nonhazardous solid waste is disposed of at a landfill at the Y-12 Plant on the Oak Ridge Reservation. Solid nonradioactive hazardous waste is stored on-site in permitted facilities until it is sent to off-site permitted disposal facilities, and liquid nonradioactive hazardous waste is treated in a permitted on-site incinerator. The LLW is either treated and sent to disposal facilities on the Oak Ridge Reservation or stored for off-site disposal. The LLMW is sent to the K-25 site incinerator.

The estimated maximum radiation dose to a member of the general public from site operations is approximately 5 mrem/yr, about 5% of the DOE maximum dose limit. The average annual dose to cylinder yard workers ranges from 32 to 92 mrem/yr, much less than the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers are not exposed to chemicals in amounts that exceed guideline values.

S.3.4 Representative Environmental Settings for Future Depleted UF_6 Management Activities

Because this PEIS is an analysis of programmatic strategies, rather than specific siting alternatives, certain impacts have been assessed using representative or generic environmental settings. In particular, impacts associated with potential conversion, long-term storage, manufacturing, and disposal activities were assessed assuming representative or generic site environmental conditions. The purpose of this approach was to provide as substantive an assessment as possible and to allow for a comprehensive comparison of alternative management strategies. Therefore, the following settings were developed to provide a reasonable range of environmental conditions for impact assessment:

- For conversion and long-term storage, the range of environmental conditions present at the current storage sites was used as the representative range for purposes of analysis. Because of the large quantity of material to be shipped and the consequent costs, conversion and long-term storage facilities might be located at relatively short distances from the current storage sites. The current

storage sites have a well documented and comparable set of environmental data on both the natural environment and on operations of facilities handling depleted UF_6. Use of these data allows for a comprehensive assessment of impacts associated with potential conversion and long-term storage facilities. However, use of the current storage site settings does not imply that a conversion facility or a long-term storage facility would be located there.

- For long-term storage in a mine, a "dry" environmental setting (climatic conditions typical of the western United States) was assumed.

- For disposal, both a "wet" setting (climatic conditions typical of the eastern United States) and a dry setting were assessed. The settings were assumed to be in a rural environment (low population density).

- For manufacturing, both a rural setting (low population density) and an urban setting (high population density) were evaluated for both wet and dry conditions.

- For transportation, representative truck and rail route characteristics were defined on the basis of national statistics; however, transportation accidents were evaluated for both rural and urban locations.

S.4 SUMMARY AND COMPARISON OF IMPACTS FOR ALTERNATIVE MANAGEMENT STRATEGIES

For each of the alternative management strategies considered in the PEIS, the potential environmental consequences were estimated for a period of about 40 years, from 1999 through 2039. In addition, long-term impacts (primarily from potential groundwater contamination) were estimated for the continued storage component of all alternatives and for the disposal alternative. Consequences were evaluated in the areas of human health and safety (normal operations and accidents), air quality, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice. The assessment considered impacts that could result from construction of necessary facilities, normal operations of facilities, accidents, and transportation of materials.

The potential environmental consequences of the alternative management strategies would depend on the type and number of activities necessary to accomplish each strategy. The no action alternative (continued cylinder storage) would involve the fewest activities. It would require only limited construction of new or improved storage yards and routine monitoring and maintenance of cylinders to ensure continued safe storage. All other alternatives would involve activities in addition to continued cylinder storage. For example, the long-term storage as UF_6 alternative would require the construction and operation of a long-term cylinder storage facility. Each of the other four

alternatives would require construction and operation of a conversion facility to convert UF_6 to another chemical form. The converted material would then be stored, disposed of, or manufactured and used.

The original scope of the PEIS considered the management and processing of only DOE-generated cylinders (i.e., 46,422 cylinders). It was assumed that facilities for cylinder preparation, conversion, long-term storage, manufacture, and disposal would process this inventory over a 20-year period. The final PEIS considers the additional management of up to 15,000 USEC-generated cylinders. In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years.

A comparison of the estimated environmental impacts associated with management of the total cylinder inventory (DOE-generated plus USEC-generated cylinders) for each alternative is provided in Table S.2. To supplement the information in Table S.2, each area of impact evaluated in the PEIS is discussed separately in Sections S.4.1 through S.4.12. Major similarities and differences among the alternatives are highlighted. The preferred alternative, which combines aspects of several of the alternatives evaluated in the PEIS, is discussed separately in Section S.5.

S.4.1 Human Health and Safety — Normal Facility Operations

For all alternatives, exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations. Levels of radiation and/or chemical exposures for the general public and noninvolved workers for all alternatives during normal facility operations were estimated to be very low, with zero latent cancer fatalities (LCFs) expected among these groups over the duration of the program. Involved workers (persons directly involved in the handling of radioactive or hazardous materials) could be exposed to low-level radiation emitted by uranium during the normal course of their work activities, and this exposure could result in a slight increase in the risk for radiation-induced cancer fatality among the involved worker population. The annual number of workers so exposed could range from about 70 (under the no action alternative) to about 700 (under the use as metal alternative.) For management of DOE- and USEC-generated cylinders, the increased exposure to radiation resulted in total estimates of from 1 LCF among workers (under the no action alternative) up to 3 LCFs among workers (under the long-term storage as oxide and disposal alternatives) over the assessment period.

Possible radiological exposures from using groundwater potentially contaminated from releases from breached cylinders or facility releases were also evaluated. For all alternatives except the disposal as oxide alternative, these exposures were estimated to be within applicable public health standards and regulations. During the operational phase of the disposal as oxide alternative, exposures were also estimated to remain within standards and regulations.

TABLE S.2 Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies[a]

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b]			
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within regulatory limit of 5 rem/yr or lower	Same as NAA[c]	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among involved workers (1999–2039)	1 additional LCF	1 to 2 additional LCFs	1 to 3 additional LCFs	1 to 2 additional LCFs	1 to 2 additional LCFs	1 to 3 additional LCFs
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among noninvolved workers (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA for a disposal facility located in a dry environmental setting. In a wet environmental setting, the maximum dose from the use of groundwater was estimated to be about 100 mrem/yr within 1,000 years of facility failure.
Total health effects among members of the public (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[d]	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b] (Cont.)			
General public MEI	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA in a dry environmental setting. In a wet environmental setting, a hazard index of about 10 was estimated within 1,000 years of facility failure.
			Human Health and Safety — Facility Accidents[b]			
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999–2039)	0 fatalities; 180 injuries	1–2 fatalities; 310–1,200 injuries	1–3 fatalities; 900–2,100 injuries	2–3 fatalities; 1,600–2,600 injuries	2–3 fatalities; 1,700–2,700 injuries	1–3 fatalities; 900–2,400 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[c]						
Accident[f]	Corroded cylinder spill, dry conditions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 10 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	4 potential accidents	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	70	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Likely Cylinder Accidents (Cont.)						
Radiation exposure – public						
Dose to MEI	3 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	1 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	0.4 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	77 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	3 in 100,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	2.2 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Low Frequency-High Consequence Cylinder Accidents[h]						
Accidents[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 100,000 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	1	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	300	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	7 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	1 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	8 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	16 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Noninvolved workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h]						
Chemical accident[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	HF or NH_3 tank rupture	Same as LTSO[c]	Same as LTSO	Same as LTSO
Release	Uranium, HF	Same as NAA	HF, NH_3	Same as LTSO	Same as LTSO	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Same as LTSO	Same as LTSO	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	< 1 in 1 million years	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 50,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	41,000	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	1	Same as NAA	1,700	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	0	Same as NAA	30	Same as LTSO	Same as LTSO	Same as LTSO
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	1,100	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	300	Same as NAA	440	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	3	Same as NAA	4	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h] (Cont.)						
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Noninvolved workers[g]	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Radiological accident[f]	Vehicle-induced fire, 3 full cylinders	Same as NAA	Earthquake damage to storage building at conversion site	Earthquake damage to storage building at conversion site	Vehicle-induced fire, 3 full cylinders	Same as LTSO
Release	Uranium	Same as NAA	Uranium (U_3O_8)	Uranium (UO_2)	Uranium	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Conversion site	Conversion site	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	1 in 100,000 years	1 in 100,000 years	1 in 100,000 years	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 5,000	1 chance in 5,000	1 chance in 5,000	Same as LTSO
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	270 mrem	68 mrem	15 mrem	Same as LTSO
Risk of LCF	7 in 1 million	Same as NAA	1 in 10,000	3 in 100,000	7 in 1 million	Same as LTSO
Total dose to population	28 person-rem	Same as NAA	20 person-rem	5.1 person-rem	56 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	9,000 mrem	2,300 mrem	20 mrem	Same as LTSO
Risk of LCF	8 in 1 million	Same as NAA	1 in 250	9 in 10,000	8 in 1 million	Same as LTSO
Total dose to workers	16 person-rem	Same as NAA	840 person-rem	210 person-rem	8 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Accident risk (consequence times probability)						
General public	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO
Noninvolved workers[g]	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b]			
Major Materials Assumed to Be Transported between Sites	LLW/LLMW	UF_6 cylinders LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0	0	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Negligible	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	Negligible	2 fatalities	4 fatalities	4 fatalities	4 fatalities	4 fatalities
Maximum use of rail	Negligible	1 fatality	2 fatalities	3 fatalities	2 fatalities	2 fatalities
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Not applicable	Urban rail accident involving 4 cylinders	Same as $LTSUF_6$[c]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Release	Not applicable	Uranium, HF	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident probability (1999–2039)	Not applicable	1 chance in 10,000	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b] (Cont.)			
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	4	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Fatalities	Not applicable	0	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Radiation exposure – All workers and members of general public						
Total LCFs	Not applicable	60	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident risk (consequence times probability) – Workers and general public	Not applicable	0 fatalities	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Not applicable	Not applicable	Urban rail accident involving anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Release	Not applicable	Not applicable	Anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	Not applicable	Not applicable	1 chance in 30,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	Not applicable	30,000	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	300	Same as LTSO	Same as LTSO	Same as LTSO
Accident risk (consequence times probability)						
Irreversible adverse effects	Not applicable	Not applicable	1	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	0	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]						
Pollutant emissions during construction and operations	Not applicable	Pollutant emissions well within standards (all less than 20% of standards)	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Water and Soil[j]			
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other parameters[k]	No change	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Surface water, groundwater, and soil quality	Not applicable	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Uranium concentration in groundwater would remain within guideline for more than 1,000 years after failure in a dry environmental setting; could exceed guideline before 1,000 years after failure in a wet setting
Other parameters[k]	No change	Site-dependent; none to moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Site-dependent; negligible to moderate impacts
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Change in topography from 210,000 to 2.1 million yd^3 of excavated material	Change in topography from 100,000 to 2.6 million yd^3 of excavated material	Not applicable	Not applicable	Change in topography from 400,000 to 3.6 million yd^3 of excavated material

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics [1]			
Current Storage Sites						
Continued storage	**Jobs:** 38 peak year, construction; 140 per year over 40 years, operations **Income:** $1.8 million peak year, construction; $6.0 million per year over 40 years, operations	**Jobs:** 38 peak year, construction; 150 per year over 26 years, operations **Income:** $1.8 million peak year, construction; $7 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Cylinder preparation	Not applicable	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years, operations **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities						
Conversion (Site undetermined)	Not applicable	Not applicable	**Jobs:** 340–730 peak year, construction; 330–490 per year over 26 years, operations **Income:** $16–33 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO	**Jobs:** 480–540 peak year, construction; 340–500 per year over 26 years, operations **Income:** $17–21 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics[1] *(Cont.)*			
Other Facilities (Cont.)						
Long-term storage (Site undetermined)	Not applicable	**Jobs:** 100–500 peak year, construction; 60-70 per year over 30 years, operations **Income:** $5–29 million peak year, construction; $4 million per year over 30 years, operations	**Jobs:** 120–410 peak year, construction; 70–80 per year over 30 years, operations **Income:** $5–20 million peak year, construction; $4–5 million per year over 30 years, operations	Not applicable	Not applicable	Not applicable
Manufacturing (Site undetermined)	Not applicable	Not applicable	Not applicable	**Jobs:** 160 peak year, construction; 470 per year over 26 years, operations **Income:** $7 million peak year, construction; $33 million per year over 26 years, operations	**Jobs:** 190 peak year, construction; 470 per year over 26 years, operations **Income:** $9 million peak year, construction; $33 million per year over 26 years, operations	Not applicable
Disposal (Site undetermined)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**Jobs:** 65–770 peak year, construction; 60–180 per year over 26 years, operations **Income:** $3.5–42 million peak year, construction; $6–18 million per year over 26 years, operations

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Ecology			
Current Storage Sites						
Habitat loss	Up to 7 acres; negligible impacts	Up to 28 acres; negligible to potential moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Wetlands and threatened or endangered species	None to negligible impacts	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Habitat loss[m]	Not applicable	**Long-term storage:** 110–170 acres; potential large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** 80--260 acres; potential moderate to large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–35 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Disposal:** 40–590 acres; potential moderate to large impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Below harmful levels for more than 1,000 years in a dry environmental setting; potential chemical effects on aquatic biota before 1,000 years after failure in a wet setting; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Not applicable	Site-dependent; avoid or mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[1]	Not applicable	**Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste **Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required); potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Disposal:** Negligible to low impacts with respect to both current and projected nationwide waste generation

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Resource Requirements[n]			
All Sites	No effects on local, regional, or national availability of materials are expected	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation dependent on site location	Same as $LTSUF_6$	Same as NAA	Same as NAA	Same as $LTSUF_6$
			Land Use[m]			
Current Storage Sites	Up to 7 acres; less than 1% of available land; negligible impacts	Up to 28 acres; less than 1% of available land; negligible impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]	Not applicable	**Long-term storage:** 110–170 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts	**Conversion:** 30–40 acres; negligible impacts	**Conversion:** 30–35 acres; negligible impacts	**Conversion:** 30–40 acres; negligible impacts
			Long-term storage: 80–260 acres; potential moderate to large impacts	**Manufacturing:** 90 acres; potential moderate impacts	**Manufacturing:** 90 acres; potential moderate impacts	**Disposal:** 40–590 acres; potential moderate to large impacts
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	Impacts dependent on location; avoid and mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] LTSO = long-term storage as oxide alternative; $LTSUF_6$ = long-term storage as UF_6 alternative; NAA = no action alternative.

[d] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[e] Accidents with probabilities of occurrence greater than 0.01 per year.

[f] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[g] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[h] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[i] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[j] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g (EPA 1995a).

Footnotes continue on next page

TABLE S.2 (Cont.)

Footnotes (Cont.)

[k] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[l] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operation.

[m] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[n] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

Although design criteria are such that disposal facilities would not be expected to fail (i.e., release material to the environment) until several hundred years after closure, for purposes of analysis, it was assumed that these facilities would fail 100 years after closure. For the disposal as oxide alternative, if the disposal facility was located in a "wet" environment (typical of the eastern United States), the estimated dose from the use of groundwater at 1,000 years after the assumed failure of the facility would be about 100 mrem/yr, which would exceed the regulatory dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A for the disposal of LLW. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices would range up to 10, indicating the potential for chemically induced adverse effects from the possible use of contaminated groundwater. The groundwater analysis indicated that if disposal was in a dry environmental setting (typical of the western United States), no measurable groundwater contamination would occur at 1,000 years after failure of the disposal facility, because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.

S.4.2 Human Health and Safety — Facility Accidents

S.4.2.1 Physical Hazards

Under all alternatives, workers (including both involved and noninvolved) could be injured or killed from on-the-job accidents unrelated to radiation or chemical exposure. On the basis of accident statistics for similar industries, under the no action alternative, it was estimated that zero fatalities and about 180 injuries might occur over the period 1999 through 2039. Under all other alternatives, it was estimated that from one to three fatalities and from 310 to 2,700 injuries might occur over the same period. Accidental injuries and deaths are not unusual in industries that use heavy equipment to manipulate heavy objects and bulk materials. The differences among the alternatives reflect differences in the total number of work hours that would be required.

S.4.2.2 Facility Accidents Involving Releases of Radiation or Chemicals

Under all alternatives, accidents are possible that could release radiation or chemicals to the environment, potentially causing adverse health effects among workers and members of the public. Of all the accidents considered, those involving depleted UF_6 cylinders and those involving chemicals at a conversion facility were estimated to have the largest potential adverse effects.

Under all alternatives, accidents involving UF_6 cylinders could occur at the current storage sites because continued storage of cylinders is a component of all of the alternatives. In addition, cylinder accidents could occur at a consolidated long-term storage facility and at a conversion facility. Cylinder accidents could release UF_6 to the environment. If a release occurred, the UF_6 would combine with moisture in the air, forming gaseous HF and UO_2F_2, a soluble solid in the form

of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public to radiation and chemical effects. The amount released would depend on the severity of the accident and the number of cylinders involved. The potential consequences of cylinder accidents are presented in Table S.2 for (1) accidents that might happen at least once in 100 years (considered "likely" accidents; assumed frequency of once in 10 years for probability calculations) and (2) accidents that might happen much less frequently, from once in 10,000 to less than once in 1 million years (assumed frequency of once in 100,000 years for probability calculations).

For releases involving UF_6 and other uranium compounds, both chemical and radiological adverse effects could occur if the material was ingested or inhaled. The chemical effect of most concern associated with internal uranium exposure is kidney damage, and the radiological effect of concern is an increase in the probability of developing cancer. For uranium, chemical effects (kidney damage) occur at lower exposure levels than radiological effects. Exposure to HF from accidental releases could result in a range of health effects, from eye and respiratory irritation to death, depending on the exposure level.

Chemical and radiological exposures for involved workers (those within 100 m of the release) under accident conditions would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

For accidents involving cylinders that might happen at least once in 100 years ("likely" accidents), the off-site concentrations of HF and uranium were estimated to be considerably below levels that would cause adverse chemical effects among members of the general public from exposure to these chemicals. However, up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that three noninvolved workers might experience potential irreversible adverse effects that are permanent in nature (such as lung damage or kidney damage), with no fatalities among these workers expected. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or members of the general public for these types of accidents.

Cylinder accidents that are less likely to occur could be more severe, having greater consequences that could potentially affect off-site members of the general public. These types of accidents are considered extremely unlikely, expected to occur with a frequency of between once in 10,000 and once in 1 million per year of operations. Over the period 1999 through 2039, the probability of this type of accident would be about 1 chance in 2,500. Among all the accidents

analyzed, the accident resulting in the largest number of people with adverse effects (including mild and temporary, as well as permanent effects) was a vehicle-induced fire involving three cylinders. If this type of accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse chemical effects from HF and uranium exposure (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). More adverse effects are estimated among the general public than among noninvolved workers because of buoyancy effects of the fire on contaminant plume spread (that is, concentrations that occur are higher at points distant from the release than at closer locations).

The modeled accident resulting in the largest number of persons with irreversible adverse health effects was a corroded cylinder spill under wet conditions. If this accident occurred, it was estimated that 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage). No fatalities would be expected among the public; there would be a potential for three fatalities among noninvolved workers from chemical effects. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or the general public.

The number of persons actually experiencing adverse or irreversible adverse effects from cylinder accidents would likely be considerably fewer than those estimated for this analysis and would depend on the actual circumstances of the accident and the individual chemical sensitivities of the affected persons. For example, although exposures to releases from cylinder accidents could be life-threatening (especially with respect to immediate effects from HF inhalation), the guideline exposure level of 20 parts per million (ppm) of HF used to estimate the potential for irreversible adverse effects from HF exposure is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm, and generally, if death does not occur quickly after HF exposure, recovery is complete.

Similarly, the guideline intake level of 30 mg used to estimate the potential for irreversible adverse effects from the intake of uranium in this PEIS is that suggested in guidance given by the U.S. Nuclear Regulatory Commission (NRC). This level is somewhat conservative; that is, it is intended to overestimate rather than underestimate the potential number of irreversible adverse effects in the exposed population following uranium exposure. In over 40 years of cylinder handling activities, no accidents involving releases from cylinders containing *solid* UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers. In previous accidental exposure incidents involving *liquid* UF_6 in gaseous diffusion plants, some worker fatalities occurred immediately following the accident as a result of inhalation of HF generated from the UF_6. However, no fatalities occurred as a result of the toxicity of the uranium exposure. A few workers were exposed to estimated amounts of uranium approximately three times the guideline level (30 mg) used for assessing irreversible adverse effects, but none of these workers actually experienced such effects.

For all of the management strategies considered in the PEIS, low-probability accidents involving chemicals at a conversion facility were estimated to have the largest potential

consequences to noninvolved workers and members of the public. Conversion would be required for long-term storage as oxide, use as oxide, use as metal, and disposal. At a conversion site, accidents involving releases of chemicals, such as ammonia and HF, are possible. Ammonia is used for some conversion options, and HF can be produced as a by-product of converting UF_6 to either uranium oxide or uranium metal. The primary impacts from conversion accidents are related to potential chemical exposures to the released material.

The conversion accidents estimated to have the largest potential consequences were accidents involving the rupture of tanks containing either anhydrous HF or ammonia. Such accidents could be caused by a large earthquake and are expected to occur with a frequency of less than once in 1 million per year of operations. The probability of these types of accidents occurring during the operation of a conversion facility would be about 1 chance in 50,000. If such accidents occurred, it was estimated that up to 41,000 members of the general public around the conversion facility and 1,100 noninvolved workers might experience adverse effects from chemical exposures (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). Of these, up to 1,700 members of the general public and 440 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage), with the potential for about 30 fatalities among the public and 4 fatalities among noninvolved workers. In addition, irreversible or fatal effects among involved workers very near the accident scene are possible.

These high consequence accidents are expected to be extremely rare. The risk (defined as consequence multiplied by probability) for these accidents would be zero fatalities and zero irreversible adverse health effects expected for noninvolved workers and the members of the public combined, and one adverse health effect expected for the general public. Ammonia and anhydrous HF are commonly used chemicals for industrial applications in the United States. Industrial accident prevention and mitigative measures are well established for HF and ammonia storage tanks. These include storage tank siting principles, design recommendations, spill detection, and containment measures. These measures would be implemented, as appropriate, if conversion were required by the selected alternative.

S.4.3 Human Health and Safety — Transportation

A conservative estimate of transportation impacts was provided by assuming that continued cylinder storage, conversion, consolidated long-term storage, manufacture and use, and disposal facilities would be located at separate sites, requiring transportation of materials between these sites. The actual transportation requirements would depend on the management strategy selected in the Record of Decision and the ultimate locations of any required facilities.

Under the no action alternative, only small amounts of LLW and LLMW generated during cylinder maintenance activities would require transportation, with only negligible impacts expected. The major materials assumed to require transportation for the other alternatives are summarized in Table S.2. Most materials could be shipped by either truck or rail. For purposes of comparison

among the alternatives, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. (Transportation impacts are evaluated for a range of shipment distances in Appendix J of the PEIS). Most shipments were assumed to occur over a 26-year period, from 2009 through 2034. Impacts from transportation activities could be reduced if several facilities were located at the same site.

During normal transportation operations, radioactive material and chemicals would be contained within their transport packages. Potential health impacts to crew members (i.e., workers) and members of the general public along the route could occur if there were exposure to low-level external radiation in the vicinity of shipments of uranium materials. In addition, exposure to vehicle engine exhaust emissions could potentially cause adverse health effects from inhalation. Under all alternatives other than the no action and long-term storage as UF_6 alternatives, it was conservatively estimated that no more than one fatality would occur from these causes. Under all alternatives, members of the general public living along truck and rail transportation routes would receive extremely small doses of radiation from shipments, less than 0.1 mrem over 40 years. This would be true even if a single person were to be exposed to every shipment of radioactive material during the program.

Under all alternatives, traffic accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public either from the actual accident or from accidental releases of radioactive materials or chemicals.

Under each alternative, the total number of traffic fatalities (unrelated to the type of cargo) was estimated on the basis of national traffic statistics for shipments by both truck and rail modes. If it was assumed that shipments were predominantly by truck, it was estimated that from two to four traffic accident fatalities could occur over the duration of the program. If shipments were predominantly by rail, it was estimated that one to three traffic accident fatalities could possibly occur. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

Severe transportation accidents could also result in a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material dispersed and diluted to lower concentrations as it moved downwind.

All alternatives other than the no action alternative could involve the transportation of UF_6 cylinders between sites. For cylinder shipments, among all the accidents analyzed, a severe rail accident involving four cylinders was estimated to have the highest potential consequences. The

consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 for shipping all cylinders by rail (the actual probability would depend on the route selected). In the unlikely event that such an accident were to occur, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung damage or kidney damage) from chemical exposure to HF and uranyl fluoride generated from released UF_6, with zero fatalities expected. Over the long term, radiation effects would also be possible from exposure to the uranium released. It was estimated that approximately 60 cancer fatalities could occur in the urban population from such an accident in addition to the approximately 700,000 that would occur from all other causes (approximately 3 million persons were assumed to be exposed to low levels of uranium from the accident as the uranium dispersed in the air). The radiological risk (consequence multiplied by probability) for this accident would be zero expected LCFs.

For all other materials assumed to be transported in this PEIS, the highest potential accident consequences would be caused by a rail accident involving anhydrous HF that might be produced during conversion. Conversion would be required for the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives. Although anhydrous HF is a highly corrosive and hazardous gas, it has many industrial applications and is commonly safely transported by industry as a liquid in trucks and rail tank cars. Anhydrous HF could be produced during conversion and could potentially be transported to a user. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site could potentially experience irreversible adverse effects from chemical exposure to HF. However, the probability of such an accident occurring if all the anhydrous HF produced was transported 620 miles (1,000 km) was estimated to be only about 1 chance in 30,000. Anhydrous HF is routinely shipped commercially in the United States for industrial applications. To provide perspective, since 1971, the period covered by U.S. Department of Transportation records, there have been no fatal or serious injuries to the public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars have been reported that had no associated evacuations or injuries. The only major release (estimated at 6,400 lb of anhydrous HF) occurred in 1985 and resulted in approximately 100 minor injuries. Another minor HF release during transportation occurred in 1990. The improved safety record of transporting anhydrous HF in the past 10 years can be attributed to several practices. Such practices include installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Nonetheless, if the unlikely rail accident described above (i.e., release of HF from a railcar in a densely populated urban area under stable weather conditions) were to occur, it was estimated

that up to 30,000 persons might experience irreversible adverse effects (such as lung damage), with the potential for about 300 fatalities. If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, including one expected fatality. The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF accident would be much less under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and lower downwind concentrations. Under unstable conditions, an area of about 1 mi^2 (2 km^2) could be affected by an accident. If such an accident occurred in an urban area, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, with the potential for about 30 fatalities. If the accident occurred in a rural area under unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with zero fatalities expected. When considering the probability of an HF accident occurring, one person would be expected to experience irreversible adverse effects, and no fatalities would be expected over the shipment period.

S.4.4 Air Quality

For management of both DOE- and USEC-generated cylinders, air quality from construction and facility operations for all alternatives would be within existing regulatory standards and guidelines. All construction activities planned to support continued cylinder storage (e.g., constructing new storage yards) would be required within the first 10 years of continued storage, when all cylinders would still be in storage under each alternative. Therefore, air quality impacts from construction activities at the current storage sites would be the same across the alternatives. Estimated concentrations of particulate matter (dust) that could be generated during construction activities are close to the regulatory standard levels; these temporary emissions could be controlled by good construction practices.

If it is assumed that cylinder maintenance and painting activities would not reduce cylinder corrosion rates, it is possible that cylinder breaches could result in HF air concentrations greater than the regulatory standard level at the K-25 storage site around the year 2020; HF concentrations at the Paducah and Portsmouth sites were estimated to remain within applicable standards or guidelines. However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, air concentrations of HF would be kept within regulatory standards at all storage sites.

S.4.5 Water and Soil

For operations under all alternatives, uranium concentrations in surface water, groundwater, and soil at the three current storage sites would remain below guidelines throughout the project duration (when the EPA proposed maximum contaminant level [MCL] of 20 µg/L for drinking water

is used as a guideline for water and the EPA health-based residential soil guideline of 230 µg/g is used as a guideline for soil). Under the no action alternative, if cylinder maintenance and painting would not reduce cylinder corrosion rates, it is possible that the uranium groundwater concentration could be greater than the 20 µg/L guideline at all three sites at some time in the future (earliest about the year 2100 at the Paducah site). However, if continued cylinder maintenance and painting are effective in controlling corrosion, as expected, groundwater uranium concentrations would remain less than 20 µg/L. For all other alternatives, groundwater concentrations would remain less than 20 µg/L, even without continued cylinder maintenance and painting, because the cylinders would begin to be removed around the year 2009.

Under the disposal alternative, if a disposal facility in a dry environmental setting were to fail, groundwater impacts would be unlikely for at least 1,000 years. (No measurable groundwater contamination would have occurred because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.) For a disposal facility in a wet environmental setting, the uranium concentration in groundwater beneath the facility might be greater than 20 µg/L within 1,000 years after failure of the facility. It should be noted, however, that the disposal calculations are subject to a great deal of uncertainty, and results would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were part of the management strategy selected. If disposal was implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW.

Under all alternatives, construction activities have the potential to result in surface water, groundwater, or soil contamination through spills of construction chemicals. By following good engineering practices, concentrations in soil and wastewater (and therefore surface water and groundwater) could be kept well within applicable standards or guidelines.

Under the long-term storage as UF_6, long-term storage as oxide, and disposal as oxide alternatives, from 100,000 yd^3 to 3.6 million yd^3 (76,000 to 2.8 million m^3) of soil and rock could require excavation and surface disposal, depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was selected. The excavated material could result in changes to topography at the facilities; these changes could be mitigated, if necessary, through trucking the excavated material off-site and/or by contouring and reseeding the site. Mine storage and disposal would generally result in the largest excavation volumes. If mine storage or disposal were selected as a UF_6 management strategy, excavation volumes could also be reduced through use of a previously existing mine.

S.4.6 Socioeconomics

Socioeconomic impacts are evaluated in terms of jobs and income generated, which are considered positive impacts. The no action alternative would result in the smallest positive socioeconomic impacts of the alternatives considered, creating about 140 direct jobs and generating about $6 million in direct income per operational year. The long-term storage as UF_6 alternative would have the second smallest socioeconomic impacts because conversion would not be required; this alternative would create about 610 to 1,200 direct jobs and generate about $35 to $65 million in direct income per year. The other alternatives (long-term storage as oxide, use as oxide, use as metal, and disposal as oxide) would have similar socioeconomic impacts, creating about 970 to 1,600, 1,250 to 1,600, 1,260 to 1,600, and 900 to 2,100 direct jobs per year, respectively, and generating about $55 to $85 million, $79 to $93 million, $79 to $93 million, and $55 to $120 million in direct income per year, respectively. Under the storage and disposal alternatives, the upper ends of the ranges of jobs created and income generated correspond to options requiring mine excavation. The process of manufacturing under the use as oxide and use as metal alternatives is labor-intensive and makes the socioeconomic impacts under these two alternatives similar to those under the long-term storage and disposal alternatives.

Continued cylinder storage under all alternatives would result in negligible impacts on regional growth and housing near the three current storage sites. Such impacts would be site dependent, but would be minor for conversion and long-term storage on the basis of the analysis for representative sites.

S.4.7 Ecology

Habitat loss at the current storage sites for all alternatives would range from 0 to 7 acres (2.8 ha) for the no action alternative to 0 to 28 acres (11 ha) or less for all other alternatives, depending on whether cylinder transfer facilities at the three sites were selected as the cylinder preparation option. These habitat losses would constitute less than 1% of available land at the current sites and would have negligible impacts on biota.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. The large ranges in estimated land requirements result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. The consequences of habitat loss would be site dependent in terms of adverse impacts to threatened and endangered species and wetlands, and they would be evaluated in subsequent site-specific NEPA reviews. As a general guideline, potential moderate adverse impacts to vegetation and wildlife from habitat loss were assumed if the required land area was greater than 10 acres, and potentially large adverse impacts were assumed if the required land area was greater than 100 acres.

If a disposal facility in a wet environmental setting were to fail, the uranium concentration in groundwater beneath the facility might exceed the guideline value of 20 μg/L within 1,000 years after failure. If the groundwater discharged to nearby surface waters, aquatic biota might be exposed to elevated concentrations of uranium, possibly resulting in adverse chemical effects; however, no adverse radiological effects would occur at the concentrations estimated.

S.4.8 Waste Management

During continued storage at the current sites under all alternatives, LLMW would be generated from cylinder scraping and painting activities. The amount of LLMW generated from these activities could result in moderate impacts to waste management at the Paducah site (annual volumes could be about 30% of the current site annual LLMW generation volume of 100 m^3/yr); however, the amount is less than 1% of the current estimated annual LLMW treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr) and would have a negligible to low impact on DOE's waste management system as a whole.

The alternatives requiring conversion to oxide are long-term storage as oxide, use as oxide, and disposal as oxide. Depending on the conversion option selected, anhydrous HF or CaF_2 could be produced. Industrial experience indicates that anhydrous HF, if produced, would contain only trace amounts of depleted uranium (less than 1 part per million [ppm]). Because of the considerable market for HF (it is commonly used for many industrial applications, including the production of UF_6 from natural uranium ore), it was assumed that if anhydrous HF was produced, it would be sold for use. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use.

If an option involving CaF_2 production was selected, it is currently unknown whether CaF_2 generated in the conversion to oxide processes could be sold, whether the low uranium content would allow disposal as nonhazardous solid waste, or whether disposal as LLW would be required. The low level of uranium contamination expected (i.e., less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste would be most likely. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use. Waste management for disposal as nonhazardous waste could be handled through appropriate planning and design of the facilities. If the CaF_2 was considered to be LLW, the largest CaF_2 generation volumes (about 550,000 m^3 over the 26-year period for the conversion to oxide with neutralization of HF option) would represent about 13% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e., 4.25 million m^3) and could result in moderate impacts on waste management (if the LLW was considered to be DOE waste).

Under alternatives requiring conversion to either oxide or metal, the empty cylinders would be treated to remove the heels material and crushed. It is assumed that the treated, crushed cylinders would become part of the DOE scrap metal inventory. If a decision to dispose of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 4% addition

to the projected DOE complexwide LLW disposal volume. This would constitute a low impact on DOE's waste management system as a whole.

Under the use as metal alternative, magnesium fluoride (MgF_2) would also be produced during conversion. It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonhazardous solid waste. (It is estimated that the MgF_2 would contain uranium at a concentration of about 90 ppm.) If the MgF_2 was considered to be DOE LLW, the volume generated would represent about 8% of the projected DOE complexwide LLW disposal volume, a low to moderate impact on DOE's waste management system as a whole. Under the metal conversion option, if the HF was neutralized and the CaF_2 generated was considered to be DOE LLW, the CaF_2 would represent approximately an additional 4% of the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact on DOE's waste management system.

The LLW volumes requiring disposal under the disposal as oxide alternative represent an addition of about 3 to 10% to the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact for DOE's waste management system. The waste management impacts for all alternatives requiring conversion of UF_6 would be similar, having the potential for a moderate impact on DOE's LLW management system.

S.4.9 Resource Requirements

Resource requirements include construction materials, fuel, electricity, process chemicals, and containers. In general, all of the alternatives would have a negligible effect on the local or national availability of these resources (when both DOE- and USEC-generated cylinders are considered). However, under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during mine construction (up to 1,400 MW-yr). The availability of this electricity would depend on site location, and use of a previously existing mine would substantially decrease the electrical requirements. Also, the disposal alternative would result in permanent disposition of the depleted uranium, a material that DOE considers to be a valuable national resource. Disposal would constitute an irreversible and irretrievable commitment of this resource to a nonproductive purpose.

S.4.10 Land Use

For current sites, continued storage and cylinder preparation could require up to 28 acres (11 ha) of land for new or reconstructed cylinder yards and transfer facilities, if built. This acreage constitutes less than 1% of available land at the three sites. Furthermore, it is likely that previously developed land could be used for these needs.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres around the conversion facilities. The large ranges in the estimated land required result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. Potential land-use impacts would depend on where the facilities were sited. As a general guideline, potentially moderate land use impacts were assumed if the required land area was greater than 50 acres, and potentially large land use impacts were assumed if the required land area was greater than 200 acres.

S.4.11 Cultural Resources

Impacts to cultural resources at the current storage sites would be unlikely. Potential for impacts at new sites would depend entirely on their locations. Such impacts would be minimized through surveys conducted prior to construction activities and through consultation with state historic preservation officers.

S.4.12 Environmental Justice

No disproportionately high or adverse human health or environmental impacts would be expected to minority or low-income populations during normal facility operations for any of the alternatives (when both DOE and USEC-generated cylinders are considered). Although the consequences of facility accidents could be high if severe accidents occurred, the risk of irreversible adverse effects (including fatalities) among members of the general public from these accidents (taking into account the consequences and probability of the accidents) would be less than one. Furthermore, transportation accidents with high and adverse impacts are unlikely, their locations have not been projected, and the types of persons who would be involved cannot be reliably predicted; therefore, there is no reason to expect that minority and low-income populations would be affected disproportionately by high and adverse impacts.

S.4.13 Cumulative Impacts

The continued cylinder storage and cylinder preparation components of the depleted UF_6 management alternatives would result in environmental impacts that, even when combined with other activities that could occur at the three current storage sites, would be expected to be relatively minor. The estimated cumulative doses to members of the general public at all three sites would be below levels expected to result in a single cancer fatality over the life of the project, and the annual dose to the off-site maximally exposed individual would be considerably below the EPA maximum

standard of 10 mrem/yr from the air pathway. The cumulative collective dose to workers at the three sites would result in one to three additional cancer fatalities over the duration of the program. Cumulative demands for water, wastewater treatment, and power would be well within existing capacities at all three sites. Relatively small amounts of additional land would be needed for depleted UF_6 management at the three current storage sites. If continued cylinder maintenance and painting were effective in reducing corrosion rates, as expected, groundwater concentrations would remain below the 20-μg/L guideline level at all three sites. If continued maintenance and painting of the cylinders were not able to reduce corrosion rates, the uranium concentration in groundwater could exceed 20 μg/L at some time in the future at all three sites. In addition, if continued cylinder maintenance and painting were to be ineffective, the concentration of HF in air could exceed the regulatory standard at the K-25 site around the year 2020; HF air concentrations at the Paducah and Portsmouth sites would be expected to remain within applicable standards and guidelines.

The cumulative impacts of conversion, long-term storage, and disposal activities could not be determined because specific sites and technologies have not been designated for these options. Further analyses of cumulative impacts would be performed as required by NEPA and DOE regulations for any technology or siting proposals that would involve these facilities.

S.5 DOE'S PREFERRED ALTERNATIVE

S.5.1 Description

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors.

DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and metal products for use. Conversion to oxide or metal would generate fluorine or fluorine compounds such as HF, which would also have beneficial uses. This preferred alternative provides the flexibility to respond to changing market conditions and to the continued development of new uses for the conversion products. During the time that the depleted UF_6 inventory is being converted for long-term storage and product applications, some depleted UF_6 would also be available for other uses that might develop.

Potential uses for fluorine products exist now in the aluminum, chemical, steel, and glass industries. Large-scale uses for the depleted uranium products are under development. These uses include radiation-shielding applications, in which uranium oxide is used as a substitute for the aggregate in concrete. Concrete made with depleted uranium would be a more effective shielding material than conventional concrete and would provide the same level of radiation shielding with less thickness than conventional concrete. Among other uses, this concrete could be fabricated into casks for storage of spent nuclear fuel or HLW.

In addition to the above potential large-scale uses of the depleted UF_6, small-scale use of some depleted UF_6 is being considered in industrial applications and by other DOE program decisions and NEPA analyses, such as that for the disposition of surplus plutonium. At this time, uses being considered by other DOE programs generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy in the Record of Decision to be issued following the publication of this PEIS.

DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the *Commerce Business Daily* published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

The locations for conversion and fabrication facilities, the start-up date for conversion, the rate of conversion, and the chemical form of depleted uranium and fluorine products would be subject to follow-on (tiered) NEPA analyses and availability of any necessary federal funding. Conversion of the depleted UF_6 to uranium oxide under the preferred alternative would begin as early as practicable. DOE expects that in the future, uses will be available for some portion of the converted material. The value of depleted uranium and HF or CaF_2 for use is based on their unique qualities, the size of the inventory, and the history of uses already implemented (e.g., industrial applications for fluorine compounds). DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted uranium inventory.

Current practices for managing the depleted UF_6 cylinder inventory include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, and surveillance and maintenance of the cylinders and cylinder yards. Under the preferred alternative, these practices would continue or be modified, as necessary, to meet any changing requirements for protection of worker and public health and safety and of the environment. Safe management of the cylinder inventory would continue through conversion of 100% of the inventory for use or storage. Aggressive cylinder management will ensure that continued storage of the depleted UF_6 cylinders prior to conversion will be consistent with DOE's policy of safe, effective material management.

S.5.2 Impacts of the Preferred Alternative

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. Most of the inventory would likely require interim storage as depleted uranium oxide pending use. The impacts of the 100% use as oxide alternative, 100% use as metal alternative, and 100% long-term storage as oxide alternative are described in detail in Sections 5.3, 5.4, and 5.5 of the PEIS for the DOE-generated cylinders. The impacts of adding the USEC cylinders under these alternatives are described in Sections 6.3.3, 6.3.4, and 6.3.5 of the PEIS. The impacts of these three alternatives may be considered representative for the preferred alternative. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was also analyzed. The potential impacts of this combination strategy are discussed in detail in Section 5.7 and Section 6.3.7 of the PEIS. A tabular summary of the potential impacts of this combination strategy that is representative of the preferred alternative is shown in Table S.3.

For the four alternative management strategies considered representative of the preferred alternative (100% use as oxide; 100% use as metal; 100% long-term storage as oxide; and combination 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide), potential environmental impacts for many technical areas are very similar (Tables S.2 and S.3). With respect to human health and safety impacts of normal facility operations, the strategies have similar impacts; that is, radiological and chemical exposures for the general public and workers would remain well within regulatory limits and public health standards under all four strategies. Also, the maximum-consequence accidents would be similar under all four strategies. Impacts to air quality, water and soil quality, and waste management would also be similar for the four management strategies representative of the preferred alternative.

Potential differences in impacts arise under the 25% use as oxide, 25% use as metal, 50% long-term storage as oxide combination strategy because of increased requirements for workforce, acreage, and construction and operational materials associated with the potential need for two conversion facilities, two manufacturing facilities, two cylinder treatment facilities, and a long-term storage facility. The resources required for these facilities are nonlinear with throughput; that is, the resources required to build and operate a 25%-capacity or a 50%-capacity facility are more than one-quarter or one-half the resources required to build and operate one 100%-capacity facility. This situation results in some increased impacts for the combination strategy. For example, the estimated number of worker fatalities and injuries for construction and operation under the combination strategy (4 to 5 fatalities; 2,900 to 4,100 injuries) is about 1.5 times that estimated for the 100% use as oxide and 100% use as metal strategies, separately. Similarly, required jobs and income produced under the combination strategy are greater than they are under the 100% use strategies. If the combination strategy resulted in construction of separate conversion, manufacturing, cylinder

TABLE S.3 Summary of Potential Environmental Consequences of a Combination Management Strategy Representative of the Preferred Alternative[a]

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Normal Facility Operations[b]	
Radiation Exposure	
Involved Workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	2 to 3 additional LCFs
Noninvolved Workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General Public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[c]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[b]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	4–5 fatalities; 2,900–4,100 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[d]	
Accident[e]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	4 potential accidents

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[f]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[g]	
Accident[e]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – Noninvolved workers[f]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g]	
Chemical accident[e]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[f]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident[e]	Earthquake damage to storage building at conversion site
Release	Uranium (U_3O_8)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	270 mrem
Risk of LCF	1 in 10,000
Total dose to population	20 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[f]	
Dose to MEI	9,000 mrem
Risk of LCF	1 in 250
Total dose to workers	840 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[b]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo) Maximum use of trucks	5 fatalities
Maximum use of rail	2 fatalities

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Transportation[b] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequency-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[h]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Water and Soil[i]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[j]	No change
Other Facilities[h]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[j]	Site-dependent; none to moderate impacts
Excavation of soil for long-term storage	Change in topography from 51,000 yd^3 to 1.3 million yd^3 of excavated material
Socioeconomics[k]	
Current Storage Sites	
Continued storage	**Jobs:** 38 peak year, construction; 150 per year over 26 years of operation **Income:** $1.8 million peak year, construction; $7 million per year over 26 years of operation
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years of operation **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 26 years of operation
Other Facilities[h]	
Conversion	**Jobs:** 670–960 peak year, construction; 510–720 per year over 26 years of operation **Income:** $28–41 million peak year, construction; $30–41 million per year over 26 years of operation

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Socioeconomics*[k] *(Cont.)	
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 26 years of operation **Income:** $13 million peak year, construction; $30 million per year over 26 years of operation
Long-term storage	**Jobs:** 60-210 peak year, construction; 39–46 per year over 30 years of operation **Income:** $3–10 million peak year, construction; $3–4 million per year over 30 years of operation
Ecology	
Current Storage Sites	
Habitat loss[l]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[h]	
Habitat loss[l]	**Conversion:** Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 79 acres at a single site; total of 160 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** About 61 acres; potential moderate impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Waste Management	
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation
Other Facilities[h] Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
Long-term storage	Negligible impacts with respect to current regional or nationwide waste generation
Resource Requirements[m]	
All Sites	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation depend on site location
Land Use	
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[h] Conversion	Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts
Manufacturing	Up to 79 acres at a single site; total of 160 acres; potential moderate impacts
Long-term storage	About 61 acres; potential moderate impacts
Cultural Resources	
Current Storage Sites	Impacts unlikely
Other Facilities[h]	Impacts depend on location; avoid and mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Environmental Justice	
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[d] Accidents with probabilities of occurrence greater than 0.01 per year.

[e] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[f] In addition to noninvolved worker impacts, involved worker injuries and fatalities are possible from chemical, radiological, and/or physical forces of accidents. Chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[g] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[h] Other facilities are facilities for conversion, manufacturing, and storage.

[i] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 μg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 μg/g.

[j] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[k] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operations.

[l] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[m] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 μm or less; UF_6 = uranium hexafluoride.

treatment, and long-term storage facilities, total land use requirements could almost double, also resulting in an increased potential for adverse ecological impacts.

For the purposes of analysis of the combination strategy, it was assumed that independent conversion, manufacturing, and storage facilities would be constructed. However, in practice, such facilities may be located together, which would reduce the resource needs of the combination strategy.

S.6 SUMMARY OF ISSUES RELATED TO LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the PEIS. The potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready to be decided upon at this time. Issues related to the potential life-cycle impacts associated with depleted uranium management are summarized here.

The management of depleted uranium beyond the year 2039 would depend on the management strategy in place at that time. If depleted uranium was in long-term storage in 2039, the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and then used or disposed of. Continued storage may require refurbishment or replacement of facilities and containers as their design lifetimes are exceeded.

Depleted uranium might also require management after use, depending on the type of product and nature of the use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or treated and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time. Disposal after use may also require further treatment or processing, such as conversion to a suitable chemical form. Some uses might also result indirectly in the permanent disposal of the material. For example, it is possible that casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or high-level radioactive waste in a geologic repository.

DEPLETED UF_6

Final

Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride

Volume 1 Main Text

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, Maryland 20874

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FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

Volume 1: Main Text

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology

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COVER SHEET

RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE)

TITLE: Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269)

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ABSTRACT: This PEIS assesses the potential impacts of alternative management strategies for depleted uranium hexafluoride (UF_6) currently stored at three DOE sites: Paducah site near Paducah, Kentucky; Portsmouth site near Portsmouth, Ohio; and K-25 site on the Oak Ridge Reservation, Oak Ridge, Tennessee. The alternatives analyzed in the PEIS include no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

* Vertical lines in the right margin of this cover sheet and the notation list, summary, and Chapters 1 through 11 indicate changes that have been added after the public comment period.

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NOTATION

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

AIHA	American Industrial Hygiene Association
AQCR	Air Quality Control Region
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
BEA	U.S. Bureau of Economic Analysis
CAAA	*Clean Air Act Amendments*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act* of 1980
CFR	*Code of Federal Regulations*
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	environmental assessment
EBE	evaluation basis earthquake
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guide
FFA	Federal Facilities Agreement
FFCA	*Federal Facilities Compliance Act* of 1992
FR	*Federal Register*
HAP	hazardous air pollutant
HLW	high-level radioactive waste
ICRP	International Commission on Radiological Protection
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department of Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
LMES	Lockheed Martin Energy Systems, Inc.
MCL	maximum contaminant level
MEI	maximally exposed individual
MMES	Martin Marietta Energy Systems, Inc.

MOA	memorandum of agreement
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act* of 1969
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
PEL	permissible exposure limit
PGDP	Paducah Gaseous Diffusion Plant
PM_{10}	particulate matter with a mean diameter of 10 µm or less
PUEC	Portsmouth Uranium Enrichment Complex
ROI	region of influence
RCRA	*Resource Conservation and Recovery Act*
SAR	safety analysis report
TDEC	Tennessee Department of Environment and Conservation
TSCA	*Toxic Substances Control Act*
USC	*United States Code*
USEC	United States Enrichment Corporation
USGS	U.S. Geological Survey
WM PEIS	*Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*

Chemicals

CaF_2	calcium fluoride
CO	carbon monoxide
HC	hydrocarbons
HF	hydrogen fluoride
MgF_2	magnesium fluoride
NH_3	ammonia
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O_3	ozone
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyl
SO_2	sulfur dioxide
SO_x	sulfur oxides
SVOC	semivolatile organic compound

TCE	trichloroethylene
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
U_3O_8	triuranium octaoxide (uranyl uranate)
VOC	volatile organic compound

UNITS OF MEASURE

°C	degrees Celsius
°F	degrees Fahrenheit
Ci	curie(s)
cm	centimeter(s)
cm^3	cubic centimeter(s)
d	day(s)
ft	foot (feet)
ft^2	square foot (feet)
g	gram(s)
gal	gallon(s)
GWh	gigawatt hour(s)
h	hour(s)
ha	hectare(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
lb	pound(s)
µCi	microcurie(s)
µg	microgram(s)
µm	micrometer(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter(s)
mrem	millirem(s)
MVa	megavolt-ampere(s)
MW	megawatt(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
rem	roentgen equivalent man
s	second(s)
ton(s)	short ton(s)
yd^3	cubic yard(s)
yr	year(s)

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS

In this document, units of measure are presented with the English unit first, followed in most cases by the metric equivalent in parentheses; if the measurement was originally made in metric units, the values were not converted back to English units. In tables, the data are expressed in one unit only. The following table lists the appropriate equivalents for English and metric units.

Multiply	By	To Obtain
English/Metric Equivalents		
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) -32	0.5555	degrees Celsius (°C)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) +17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

SUMMARY[1]

S.1 INTRODUCTION

This programmatic environmental impact statement (PEIS) assesses the potential impacts of alternative strategies for managing the depleted uranium hexafluoride (UF_6) currently stored in cylinders at three U.S. Department of Energy (DOE) sites: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25[2] site on the Oak Ridge Reservation in Oak Ridge, Tennessee. A management strategy is a series of activities needed to achieve the safe long-term storage, use, or disposal of the depleted UF_6 inventory.

The proposed selection and implementation of a long-term management strategy constitute a major federal action with potentially significant environmental consequences. As such, it falls under the *National Environmental Policy Act* (NEPA). This PEIS has been prepared in compliance with the NEPA and all applicable NEPA implementing regulations set forth in the *Code of Federal Regulations* (40 CFR Parts 1500-1508 and 10 CFR Part 1021). Additional NEPA analyses, as appropriate, will be prepared once a long-term management strategy has been selected. The follow-on NEPA analyses will evaluate issues such as where to locate facilities (siting), which specific technologies or processes to use, and what site-specific impacts might result from construction and operations.

***National Environmental Policy Act* (NEPA) Regulations**

NEPA regulations require, among other things, federal agencies to include discussion of a proposed action and all reasonable alternatives in an environmental impact statement (EIS). Sufficient information must be included in the EIS for reviewers to evaluate the relative merits of each alternative. A programmatic EIS (PEIS) is an evaluation of a broad agency action setting the course of future activities.

The agency must briefly discuss any alternatives that were eliminated from further analysis. The agency should identify its preferred alternatives, if one or more exist, in the draft EIS and must identify its preferred alternative in the final EIS unless another law prohibits naming a preference. After completing the final EIS and in order to implement an alternative, the federal agency must issue a Record of Decision that announces the decision made and identifies the alternatives considered.

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[1] Vertical lines in the right margin of this summary indicate changes that have been added after the public comment period.

[2] The site of the K-25 plant is now called the East Tennessee Technology Park but is referred to by its original name, the K-25 site, throughout this PEIS.

S.1.1 Background

Depleted UF_6 results from the process of making uranium suitable for use as fuel for nuclear reactors or military applications. The use of uranium in these applications requires increasing the proportion of the uranium-235 isotope found in natural uranium, which is approximately 0.7%, through an isotopic separation process called uranium enrichment. An enrichment process called gaseous diffusion is currently used in the United States.

The gaseous diffusion process requires uranium in the form of UF_6. UF_6 is a chemical compound consisting of one atom of uranium combined with six atoms of fluorine. It can be a solid, liquid, or gas, depending on its temperature and pressure. (See Appendix A of the PEIS for additional information on the properties of UF_6.) It is used for the gaseous diffusion process primarily because it can conveniently be used in the gas form for processing, in the liquid form for filling or emptying containers or equipment, and in the solid form for storage. At atmospheric pressure, UF_6 is a solid at temperatures below 134°F (57°C) and a gas at temperatures above 134°F. Solid UF_6 is a white, dense, crystalline material that resembles rock salt.

In the gaseous diffusion process, a stream of heated UF_6 gas is separated into two parts: one enriched in uranium-235 and the other depleted in uranium-235. The enriched UF_6 is used for manufacturing commercial reactor fuel, which typically contains 2 to 5% uranium-235, or for military applications (e.g., naval reactor fuel), which requires further enrichment of up to 95% or more uranium-235. The depleted UF_6, which typically contains 0.2 to 0.4% uranium-235, is stored as a solid in large metal cylinders at the gaseous diffusion facility.

Inventory of Depleted UF_6 Cylinders Considered in the PEIS

	No. of Cylinders (metric tons)		
Site	DOE-Generated	USEC-Generated[a]	Total
Paducah	28,351 (342,000)	12,000 (144,000)	40,351 (486,000)
Portsmouth	13,388 (161,000)	3,000 (36,000)	16,388 (197,000)
K-25	4,683 (56,000)	None	4,683 (56,000)
Total			61,422 (739,000)

[a] In May and June 1998, DOE assumed management responsibility for approximately 11,400 cylinders generated by United States Enrichment Corporation. For purposes of the PEIS, management of up to 15,000 USEC-generated cylinders was considered.

Large-scale uranium enrichment in the United States began as part of atomic bomb development by the Manhattan Project during World War II. Uranium enrichment activities were subsequently continued under the U.S. Atomic Energy Commission and its successor agencies, including DOE. The K-25 plant was the first of three gaseous diffusion plants constructed to produce enriched uranium. The K-25 plant ceased operations in 1985, but uranium enrichment continues at both the Paducah and Portsmouth sites. These two

plants are now operated by the United States Enrichment Corporation (USEC), created by law in 1993 to privatize the uranium enrichment program.

Since the 1950s, depleted UF_6 has been stored at all three storage sites in large steel cylinders. Several different cylinder types are in use, although the vast majority of cylinders have a 14-ton (12-metric-ton) capacity. A typical cylinder is shown in Figure S.1. The cylinders are typically 12 ft (3.7 m) long by 4 ft (1.2 m) in diameter, with most having a wall thickness of 5/16 in. (0.79 cm) of steel. Similar, but slightly smaller, cylinders with a capacity of 10 tons (9 metric tons) are also in use. During storage, a cylinder contains solid UF_6 in the bottom and UF_6 gas at less than atmospheric pressure in the top. The depleted UF_6 cylinders managed by DOE at the three sites are typically stacked two cylinders high in large areas called yards (Figure S.2).

The characteristics of UF_6 pose potential health risks, and the material is handled accordingly. Uranium is radioactive, and UF_6 in storage emits low levels of gamma and neutron radiation. The radiation levels measured on the outside surface of filled depleted UF_6 storage cylinders are typically about 2 to 3 millirem per hour (mrem/h), decreasing to about 1 mrem/h at a distance of 1 ft (0.3 m). In addition, if UF_6 is released to the atmosphere, it reacts with water vapor in the air, forming hydrogen fluoride (HF) and a uranium-fluoride compound called uranyl fluoride (UO_2F_2). These products are chemically toxic. Uranium is a heavy metal that, in addition to being radioactive, can have toxic chemical effects (primarily on the kidneys) if it enters the bloodstream by means of ingestion or inhalation. HF is an extremely corrosive gas that can damage the lungs and cause death if inhaled at high enough concentrations.

Cylinders are stored with minimum risks to workers, members of the general public, and the environment at the Paducah, Portsmouth, and K-25 sites. DOE maintains an active cylinder management program to improve storage conditions in the cylinder yards, to monitor cylinder integrity by conducting routine inspections for breaches, and to perform cylinder maintenance and repairs as needed.

Because storage began in the early 1950s, many of the cylinders now show evidence of external corrosion. Before 1998, seven cylinders (one at Paducah, two at Portsmouth, and four at K-25) had been identified that had developed holes (breaches), generally around spots previously damaged by handling activities. In 1998, one additional cylinder breach occurred during the course of cylinder maintenance operations. Because the depleted UF_6 is a solid at ambient temperatures and pressures, it is not readily released from a cylinder following a leak or breach. When a cylinder is breached, moist air reacts with the exposed UF_6 solid and iron, resulting in the formation of a dense plug of solid uranium and iron compounds and a small amount of HF gas. This plug limits the amount of material released from a breached cylinder. When a cylinder breach is identified, the cylinder is repaired or its contents are transferred to a new cylinder.

DOE has responsibility for continued management of the depleted UF_6 cylinders stored at the Paducah, Portsmouth, and K-25 sites. The management plan in place during much of the preparation of this PEIS was to continue safe storage of the cylinders and, if feasible alternative uses

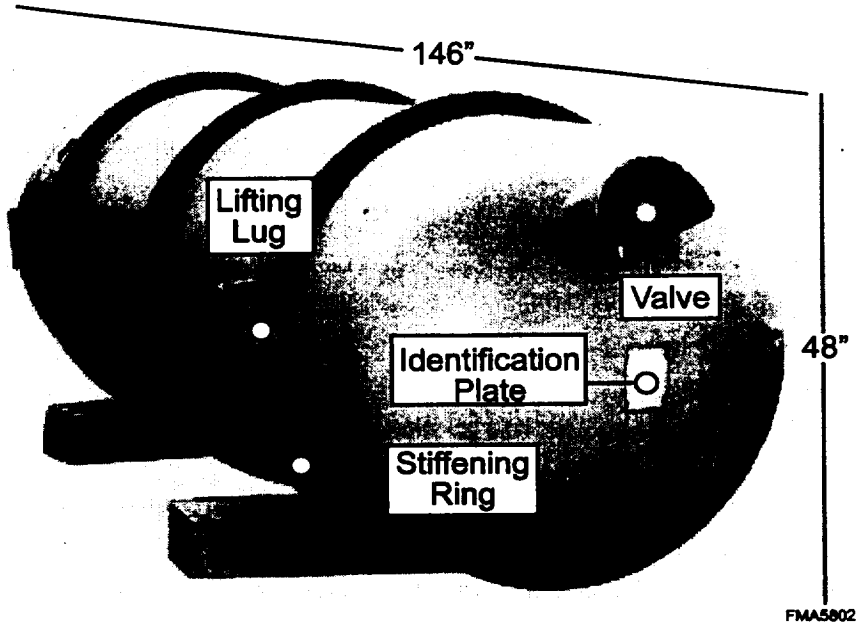

FIGURE S.1 Typical Depleted UF_6 Storage Cylinder (Cylinders are constructed of steel, with the majority of cylinders having a 14-ton capacity.)

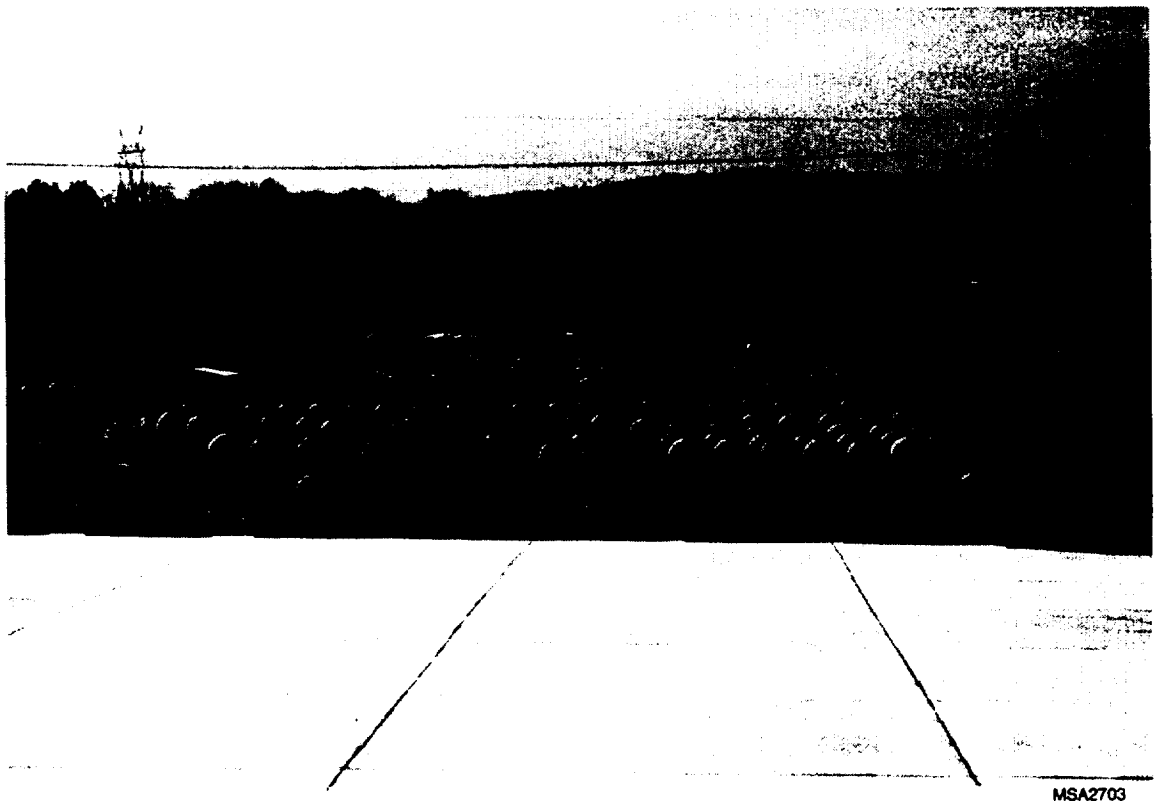

FIGURE S.2 Depleted UF_6 Cylinders in Storage Yards

for the depleted uranium had not been found by about the year 2010, take steps to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020. The U_3O_8, which is more chemically stable than UF_6, would be stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste (LLW). The basis for the plan was to reserve depleted UF_6 for future defense needs and other potentially productive and economically viable purposes, including possible reenrichment in an atomic vapor laser isotope separation plant, conversion to depleted uranium metal for fabricating penetrators (anti-tank weapons) for military use, and use as fuel in advanced liquid metal nuclear reactors.

Since the former plan was put in place, several developments have occurred that suggest this plan should be revised. For example, the Energy Policy Act of 1992 assigned responsibility for uranium enrichment and development of atomic vapor laser isotope separation to the USEC, the demand for penetrators has diminished, and the advanced liquid metal nuclear reactor program has been canceled. In addition, stakeholders near the current cylinder storage sites have expressed concerns regarding potential environmental, safety, health, and regulatory issues associated with the continued storage of the depleted UF_6 inventory. The Ohio Environmental Protection Agency issued a Notice of Violation to DOE (which has since been resolved), and the Defense Nuclear Facilities Safety Board (DNFSB) provided a recommendation to the Secretary of Energy regarding improvements in the management of depleted UF_6.

DOE also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the depleted UF_6 stored at the K-25 site. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from K-25 or complete the conversion of their contents by December 31, 2009.

In July 1998, the President signed Public Law 105-204 which provides, in part, the following (see Appendix N for the complete text of Public Law 105-204):

> *(a) PLAN. – The Secretary of Energy shall prepare, and the President shall include in the budget request for fiscal year 2000, a Plan and proposed legislation to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to commence construction of, not later than January 31, 2004, and to operate, an onsite facility at each of the gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio, to treat and recycle depleted uranium hexafluoride consistent with the National Environmental Policy Act.*

DOE provided its initial plan for the conversion of depleted UF_6, responsive to Public Law 105-204, to Congress on March 12, 1999. In addition, it issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the

Commerce Business Daily published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

At this time, DOE has not recommended to the President that any additional legislation be proposed. Any proposal to proceed with the location, construction, and operation of a facility or facilities will involve additional review under NEPA.

S.1.2 Purpose and Need

The purpose of the PEIS is to reexamine DOE's management strategy for depleted UF_6 and alternatives to that strategy; DOE needs to take action in response to current economic, environmental, and legal developments. This PEIS examines the environmental consequences of alternative strategies of long-term storage, use, and disposal of the depleted UF_6 inventory. A long-term management strategy will be selected in the Record of Decision, which is scheduled to be issued no sooner than 30 days after the issuance of this PEIS.

S.1.3 Proposed Action

The proposed action assessed in this PEIS is DOE's selection of a long-term management strategy for depleted UF_6 that will be implemented following the Record of Decision. A strategy is a set of activities or steps for managing depleted UF_6, from its current storage at the three DOE storage sites to its ultimate use, long-term storage, or disposal. The alternative strategies considered in the PEIS evaluate options for continued storage of cylinders; conversion of the UF_6 to other chemical forms; use of the uranium as a metal or an oxide; long-term storage, disposal, and/or transportation. The time period for which activities were assessed for all strategies was approximately 40 years: generally 10 years for siting, design, and construction of any required new facilities; about 26 years for operations; and, when appropriate, about 4 years for monitoring.[3] In addition, for the continued storage component of all alternatives and for the disposal alternative, long-term impacts (primarily from potential groundwater contamination) were estimated. The actual implementation schedule would depend on the ultimate strategy selected in the Record of Decision and on other considerations, and activities could continue beyond the 40-year period. DOE would conduct additional NEPA reviews for such activities as appropriate.

The PEIS provides a broad environmental analysis of the various programmatic management strategies available to DOE. DOE has identified a preferred management strategy in the draft PEIS and modified the strategy in this final PEIS on the basis of public comments.

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[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

S.1.4 DOE's Depleted Uranium Hexafluoride Management Program

The DOE Depleted Uranium Hexafluoride Management Program was established to accomplish the long-term management of depleted UF_6. The program has two phases: (1) the selection of a strategy for long-term management of depleted UF_6; and (2) implementation of the strategy selected. The first phase is under way and is the subject of this PEIS. After this final PEIS is issued, DOE will select the strategy for long-term management of depleted UF_6 and describe the strategy selected in a Record of Decision that will be published in the *Federal Register* (FR). In the second phase of the program, DOE will identify specific sites and technologies necessary to carry out the strategy. These sites and technologies will be evaluated in subsequent NEPA reviews.

The program has and is conducting a variety of technical analyses in parallel with the PEIS. Technology assessment evaluations are based on suggestions for uses of depleted UF_6 and management technologies provided by respondents to a DOE Request for Recommendations issued on November 10, 1994 (59 FR 56324). This request resulted in a report entitled *Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride*, which was released on June 30, 1995. An engineering analysis, which is documented in the engineering report prepared in parallel with this PEIS — *Depleted Uranium Hexafluoride Management Program; Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* — provides an in-depth technical analysis of feasible options identified in the technology assessment report and includes all the options addressed in the PEIS. The life-cycle costs of alternative management strategies are also being assessed, and the results are documented in the *Cost Analysis Report for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride*.

The estimation of potential environmental impacts in the PEIS was based primarily on information provided in the engineering analysis report, which is incorporated by reference. The engineering analysis report contains preliminary facility design data for cylinder preparation, conversion, long-term storage (except for long-term storage of cylinders in yards), manufacture and use, and disposal options. For these options, the engineering analysis report includes descriptions of facility layouts, resource requirements, and construction requirements; estimates of effluents, wastes, and emissions during operations; and descriptions and estimated frequencies for a range of potential accident scenarios. These facility design data, as well as environmental setting information, were used as input to the calculational models or "tools" for estimating potential environmental impacts that could result under each alternative. The summary of the engineering analysis report is included in its entirety in Appendix O.

In addition to the management strategies considered in this PEIS, the use of some depleted UF_6 is being considered pursuant to other DOE programs, such as the disposition of surplus plutonium. Uses being considered by other DOE programs, which are subject to future decisions and other NEPA reviews, would generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy.

S.1.5 Scope of the Depleted UF_6 PEIS

On January 25, 1996, DOE published a Notice of Intent in the *Federal Register* (61 FR 2239), stating its plans to prepare the Depleted UF_6 PEIS and requesting comments on the scope of the PEIS. Three public scoping meetings were held between February 13 and February 20, 1996, at locations near each of the three depleted UF_6 storage sites. One important objective of scoping was to obtain public comments on DOE's proposed alternative management strategies. No new alternative management strategies were identified as a result of public comments.

This PEIS evaluates the environmental impacts of a range of alternative management strategies (these strategies are in addition to the potential use of some of the depleted UF_6 under other programs). Each alternative strategy consists of a series of activities needed to achieve the safe and effective long-term management of depleted UF_6. These activities could be accomplished in a number of different ways (called options). Options include technology or design variations for cylinder preparation, conversion of depleted UF_6 to another chemical form, use, storage, disposal, and transportation. The PEIS includes an assessment of the potential environmental impacts from a range of options for each activity. Representative options were evaluated in the PEIS; specific technologies and facilities will be evaluated in future NEPA reviews after an overall management strategy is selected in a Record of Decision. The PEIS evaluates the potential impacts to human health and safety, air, land, water, biota, cultural resources, waste management capabilities, socioeconomics, and environmental justice.

This final PEIS considers the depleted UF_6 inventory stored at the Paducah site, Portsmouth site, and K-25 site for which DOE has management responsibility. This inventory includes depleted UF_6 generated by DOE before the formation of USEC in July 1993 as well as depleted UF_6 generated by USEC that has been or will be transferred to DOE. Specifically, the PEIS considers the management of 46,422 cylinders (560,000 metric tons) generated by DOE and up to 15,000 cylinders (180,000 metric tons) generated by USEC.

S.1.6 Public Review of the Draft PEIS and Major Changes from the Draft to the Final PEIS

The draft PEIS was mailed to stakeholders in mid-December 1997, and a notice of availability was published by the U.S. Environmental Protection Agency (EPA) in the *Federal Register* on December 24, 1997. In addition, the entire PEIS was also made available on the World Wide Web at the same time. Stakeholders were encouraged to provide comments on the draft PEIS during a 120-day review period, from December 24, 1997, until April 23, 1998. Comments could be submitted via a toll-free number, fax, letter, e-mail, or the World Wide Web site. Comments could also be submitted at four public hearings held during a period from February 19, 1998, to March 10, 1998. Public hearings were held near each of the three current storage sites (Paducah, Kentucky; Oak Ridge, Tennessee; and Portsmouth, Ohio), and another was held in Washington, D.C.

A total of about 600 comments were received during the comment period. Comments received on the draft PEIS were considered in preparing the final PEIS. (As noted earlier, changes to the draft PEIS are denoted by a vertical line in the right margin of this final PEIS.) All comments received, along with DOE's responses to those comments, are presented in Volume 3 of this PEIS. A summary of the major issues raised by the reviewers of the draft PEIS, DOE's resolution of these issues, and resulting changes to the PEIS follows here.

- *The preferred alternative.* Many of the reviewers questioned DOE's preference for beginning to convert the depleted UF_6 inventory to uranium oxide or uranium metal only as uses for these materials became available. Several reviewers expressed a desire for DOE to start conversion as soon as possible. Conversion to U_3O_8 was the option most often cited as preferred, although several reviewers thought conversion to metal would be more advantageous. In addition, many reviewers expressed doubt about the prospects for any widespread uses for depleted uranium now or in the future.

  After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Sections S.5.1 and 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under this revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal products become available. The impacts of the preferred alternative are discussed in Sections S.5.2, 2.5.2, 5.7, and 6.3.7 of the PEIS.

- *Seismic hazards at the Paducah site.* Several reviewers commented that the draft PEIS did not adequately address the seismic hazards at the Paducah site. They requested that DOE review new information and reevaluate the risks associated with potential earthquakes at Paducah.

  In response, DOE reviewed those references that were available at the time this final PEIS was prepared. DOE determined that the analyses performed as part of the safety analysis reports recently completed at the three current storage sites (including Paducah) and for this PEIS were adequate. DOE will review any new data that become available and take appropriate action to maintain the safety basis of its cylinder management program.

- *Potential life-cycle impacts.* Several reviewers stated that depleted uranium and products made from using depleted uranium in various chemical forms would eventually need to be disposed of. They requested that the PEIS include a discussion of impacts for the disposal of these materials following long-term storage and use.

In response to their requests, a new section was added to this Summary (Section S.6) and to Chapter 5 of the PEIS (Section 5.9) to discuss issues related to the potential impacts of the long-term (beyond 2039) management of materials containing depleted uranium under all alternatives.

- *Cylinder inventory.* Several reviewers questioned the accuracy of the reported number of DOE-owned cylinders of depleted UF_6 (46,422) considered in the draft PEIS. Other reviewers requested that USEC-generated cylinders also be included within the scope of the PEIS.

  Although the number 46,422 used in the draft PEIS was accurate at the time the document was published, subsequent privatization of USEC and transfer of some cylinders from USEC to DOE changed the inventory of depleted UF_6 that falls within the scope of the PEIS (see Section 1.5.2). Chapter 6 has been added to the PEIS, and Chapter 2 and the Summary have been revised so the PEIS includes the impacts associated with the management of additional USEC-generated cylinders.

- *Current cylinder management.* Several reviewers raised questions and concerns about the current management of the cylinders at the three DOE locations.

  In response to these concerns, it has been emphasized that DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision-making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion, and regular inspection and surveillance of the cylinders and storage yard conditions.

The changes made in response to public comments, including the inclusion of up to 15,000 USEC cylinders, did not affect the types or overall significance of the environmental impacts presented in the draft PEIS. Although the estimated impacts did increase by up to 30% in some assessment areas, this increase was generally not significant because the impacts were typically small to begin with. Many impacts did not change at all with the inclusion of the USEC cylinders because these impacts were related to factors that were unaffected by the inventory increase. For example, the consequences of potential accidents did not increase because accidents generally involve only a limited amount of material that would be available, regardless of the overall inventory. In addition, other impacts did not change because they were related to the annual material processing rates, which were assumed to remain the same when the USEC cylinders were included. Consequently, it was not necessary to recirculate the draft PEIS for additional public review. The nature and magnitude of changes in environmental impacts resulting from the addition of USEC cylinders are discussed in Sections 2.4, 2.5, and Chapter 6 of the PEIS.

S.2 DESCRIPTION OF ALTERNATIVES

The alternative management strategies (also termed "alternatives") evaluated in this PEIS were developed by considering the two possible permanent dispositions for depleted uranium, use or disposal, and long-term storage of depleted uranium. Each of the alternatives involves some combination of seven activities: continued cylinder storage at the current sites, cylinder preparation for shipment, conversion to another chemical form, long-term storage, manufacture and use, disposal, and transportation. The activities required for each alternative are illustrated in Figure S.3 and summarized in Table S.1.

Alternative Management Strategies Considered in the PEIS*

No Action — Continued storage of depleted UF_6 cylinders indefinitely in yards at the Paducah, Portsmouth, and K-25 sites.

Long-Term Storage as UF_6 — Storage as UF_6 cylinders in yards, buildings, or a mine at a consolidated site.

Long-Term Storage as Uranium Oxide — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by storage in buildings, belowground vaults, or a mine at a consolidated site.

Use as Uranium Oxide — Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded spent nuclear fuel or high-level waste storage containers (casks).

Use as Uranium Metal — Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded spent nuclear fuel or high-level waste storage containers (casks).

Disposal — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

The alternatives for long-term management of depleted UF_6 evaluated for the period 1999 through 2039 are (1) no action, which involves continued storage of cylinders indefinitely at the three current storage sites; (2) long-term storage as UF_6 at a consolidated site; (3) long-term storage as an oxide at a consolidated site; (4) use as uranium oxide; (5) use as uranium metal; and (6) disposal as oxide. The first two alternatives involve the continued management of uranium in the form of UF_6. The other alternatives involve the conversion of UF_6 to another chemical form, either uranium oxide or uranium metal. During conversion, large amounts of HF would be produced that could potentially be sold for use or neutralized to calcium fluoride (CaF_2), which could be sold or disposed of.

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental,

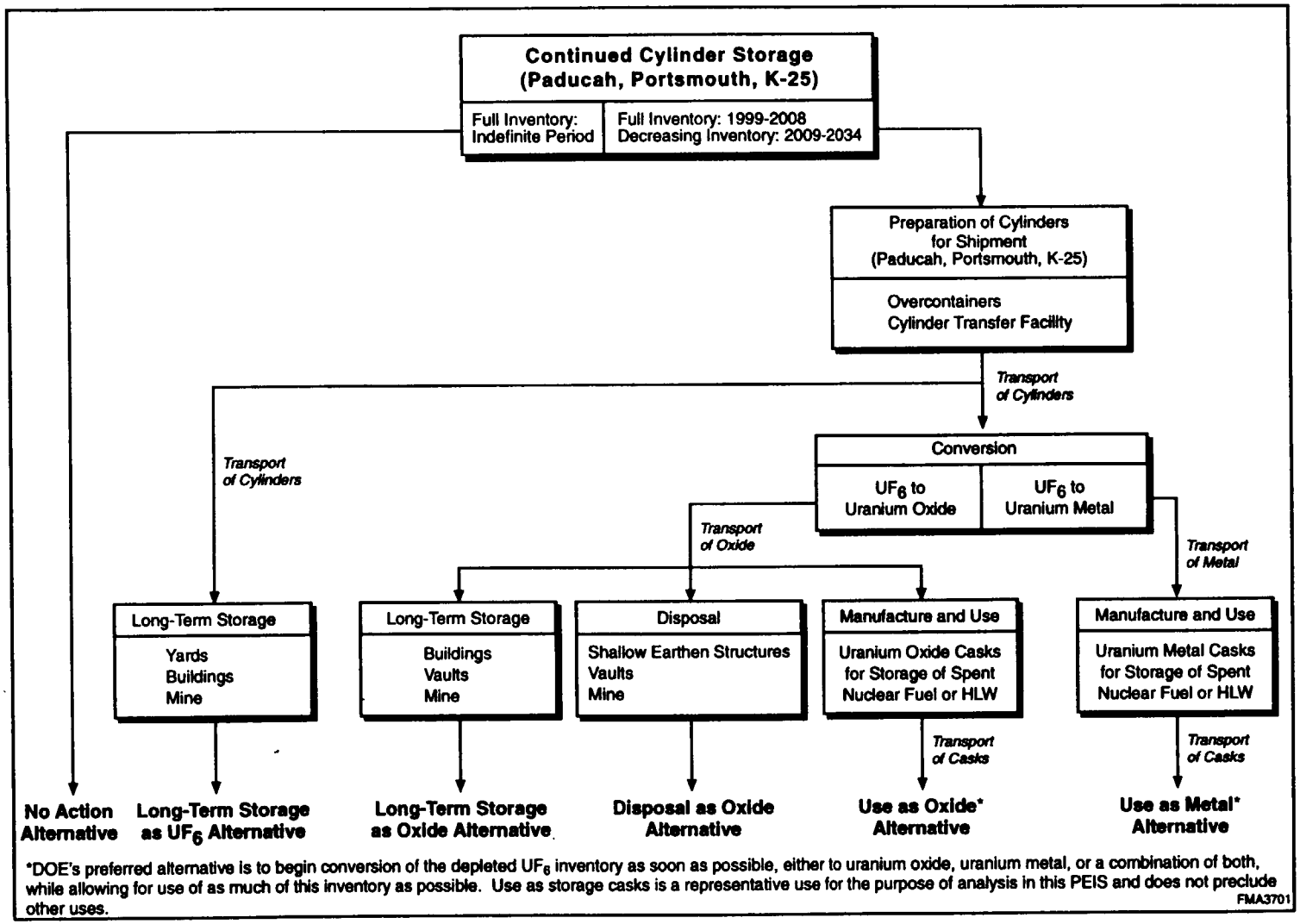

FIGURE S.3 Major Components of the Alternative Management Strategies

TABLE S.1 Comparison of Activities under the PEIS Alternatives (Note that DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Continued Cylinder Storage at Paducah, Portsmouth, and K-25			
The entire cylinder inventory would continue to be stored indefinitely at the Paducah, Portsmouth, and K-25 sites (impacts were evaluated from 1999 through 2039). Cylinders would be subject to a comprehensive monitoring and maintenance program, which would include routine inspections, cylinder painting, and cylinder yard upgrades.	The entire cylinder inventory would continue to be stored at the three current storage sites from 1999 through 2008. The inventory at each site was assumed to decrease to zero cylinders over the period 2009 through 2034 as cylinders were shipped to an off-site location.[a] During storage at current locations, cylinders would be subject to similar management activities as under no action.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Cylinder Preparation for Transportation			
Not applicable. The cylinders would remain at the three current storage sites.	The cylinders would be prepared at each current storage site for off-site shipment. Cylinders not suitable for shipment would either be provided with over-containers or the contents would be transferred to new cylinders.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Conversion			
Not applicable.	Not applicable.	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to the oxide UO_2 at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium metal at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Consolidated Long-Term Storage			
Not applicable. Cylinders would remain at the three current storage sites.	UF_6 cylinders would be stored for the long term in yards, buildings, or a mine at a site to be determined in the future. Cylinders would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Oxide (either U_3O_8 or UO_2) would be stored for the long term in drums in buildings, belowground vaults, or a mine at a site to be determined in the future. Material would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Not applicable.	Not applicable.	Not applicable.
		Manufacture and Use			
Not applicable.	Not applicable.	Not applicable.	Depleted uranium oxide (UO_2) would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Depleted uranium metal would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Not applicable.
		Disposal of Uranium			
Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Uranium oxide (either U_3O_8 or UO_2) would be disposed of as LLW at a site to be determined in the future. Disposal was considered for grouted (immobilized) and ungrouted oxide (in drums) in shallow earthen structures, belowground vaults, and a mine.

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
			Transportation[b]		
Small amounts of LLW and LLMW would be shipped from the current storage sites to treatment/disposal site(s).	UF_6 cylinders would be shipped from the current storage sites to a long-term storage site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.
	LLW/LLMW would be shipped from storage sites to a disposal/treatment site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a long-term storage site.	Uranium oxide (UO_2) would be shipped from a conversion site to a manufacturing site.	Uranium metal would be shipped from a conversion site to a manufacturing site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a disposal site.
		HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.
		CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.
		NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.
		LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.
			Casks would be shipped from a manufacturing site to a user site.	Casks would be shipped from a manufacturing site to a user site.	
				Magnesium fluoride (MgF_2) would be shipped from a conversion site to a disposal site.	

[a] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

[b] Because the locations of conversion, manufacture, long-term storage, and disposal sites will be decided in future studies, it was assumed that these sites were at separate locations, requiring transportation between them. This approach was intended to provide a conservative estimate of potential transportation impacts. Colocation of facilities would reduce transportation impacts.

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

economic, technical, and other factors. This identification does not represent a decision by DOE; rather, it reflects the DOE's preference on the basis of existing information. A discussion of the preferred alternative is presented in Section S.5. The Record of Decision, when issued, will present DOE's decision for the long-term management of depleted UF_6.

S.3 AFFECTED ENVIRONMENT

The affected environment is defined as the location or locations that may be impacted by the proposed action. For this PEIS, the affected environment consists of the three current depleted UF_6 storage locations: the Paducah site, the Portsmouth site, and the K-25 site.

S.3.1 Paducah Site

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River. The site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area. The city of Paducah is the largest urban area in the six counties surrounding the site. The area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) within the Paducah site occupies a 750-acre (303-ha) complex that is surrounded by a security fence. The PGDP, now operated by the USEC and previously operated by DOE, has been in operation since 1955. The Paducah site has 13 yards that are used for storage of DOE-generated depleted UF_6 cylinders; an additional 4 yards are used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Paducah site is in attainment for all six criteria pollutants; that is, the ambient air concentrations of the criteria pollutants — carbon monoxide, sulfur dioxide, particulate matter, ozone, nitrogen oxides, and lead — are within the corresponding standards. The Paducah site is also in compliance with 40 CFR 61 (National Emission Standards for Hazardous Air Pollutants, or NESHAPS), which places a maximum dose limit of 10 mrem/yr for the maximally exposed individual (MEI) of the general public from emissions of radioactive materials.

Several zones of faulting occur in the vicinity of the Paducah site. The largest earthquake in the region, with a magnitude of 7.3, occurred in 1812. The epicenter was 60 miles southwest of the site.

Big Bayou Creek and Little Bayou Creek, tributaries of the Ohio River, receive drainage from the Paducah site. All effluent discharges are regulated under the Kentucky Pollutant Discharge Elimination System. Groundwater at the Paducah site is monitored for pollutants, and

trichloroethylene has been detected at levels above the drinking water standard at several off-site locations. The radioactive isotope technetium-99 has also been detected in groundwater at the site. A municipal water supply has been provided to all residents whose wells are within the area of groundwater contamination from the site.

About 5 acres (2 ha) of jurisdictional wetland have been identified in drainage ditches scattered throughout the PGDP, and a large number of wetlands occur in the natural areas surrounding the developed center of the site where the yards are located. No federal-listed threatened or endangered species are known to occur on the Paducah site; however, several state-listed threatened and special concern terrestrial and aquatic species have been found outside the security fence of the PGDP.

The Paducah site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and low-level mixed waste (LLMW). Wastewater is discharged through permitted outfalls; nonhazardous solid waste is disposed of at an on-site landfill; and nonradioactive hazardous waste is stored on-site and sent to permitted commercial disposal facilities. The LLW is sent to a commercial facility for volume reduction; LLMW is currently stored on-site or, if appropriate, sent to the K-25 site for incineration.

Both workers and members of the general public receive small radiation doses from Paducah site operations. The estimated maximum radiation dose to a member of the general public near the site is about 2 mrem/yr, which is 2% of the DOE maximum dose limit. The 2-mrem/yr dose also represents less than a 1% increase over the 360-mrem/yr average dose from background radiation in the United States. Cylinder yard workers receive average radiation doses of about 16 to 56 mrem/yr, which is considerably below DOE's maximum dose limit of 5,000 mrem/yr for workers. Under normal operating conditions, cylinder yard workers at the Paducah site are not exposed to chemicals in amounts that exceed guideline values.

S.3.2 Portsmouth Site

The Portsmouth site is located in Pike County, Ohio, approximately 22 miles (35 km) north of the Ohio River and 3 miles (5 km) southeast of the town of Piketon. The two largest cities in the vicinity are Chillicothe, located 26 miles (42 km) north of the site, and Portsmouth, 22 miles (35 km) south. Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly over 1 mile (1.6 km) from the site boundaries.

The Portsmouth site includes the Portsmouth Uranium Enrichment Complex, a gaseous diffusion plant operated by the USEC and previously operated by DOE. The Portsmouth site occupies 3,708 acres (1,500 ha) of land, with an 800-acre (320-ha) fenced area containing the core facilities. The 2,908 acres (1,180 ha) outside the fenced area consist of restricted buffer zones, waste management areas, plant management and administrative facilities, and vacant lands. The

Portsmouth site contains two storage yards for DOE-generated depleted UF_6 cylinders; one additional yard is used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Portsmouth site is in attainment for all six criteria pollutants. The Portsmouth site is also in compliance with NESHAPS for radionuclide emissions (40 CFR 61). The Portsmouth site is drained by Big Beaver Creek and Little Beaver Creek. All site effluents are discharged either through permitted outfalls to Little Beaver Creek or downstream to the Scioto River. Groundwater is monitored at and around the Portsmouth site; several chlorinated hydrocarbons, uranium, and other metals have been detected in on-site monitoring wells.

Approximately 34 acres (13.8 ha) of wetlands occur on the Portsmouth site, excluding retention ponds. Two wetland areas near the site have been listed by the Ohio State Division of Natural Areas and Preserves as significant wetland communities. No federal-listed threatened or endangered plant or animal species are known to occur on the Portsmouth site, although the endangered Indiana bat may be present in the summer. One state-listed endangered species occurs on the site, and one threatened species occurs near the site.

The Portsmouth site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls; and nonhazardous solid waste is disposed of at an on-site landfill. Nonradioactive hazardous waste is stored on-site until treatment or disposal; solid nonradioactive hazardous waste is sent to permitted commercial disposal facilities, whereas liquid nonradioactive hazardous waste streams are sent to the approved incinerator at the K-25 site in Tennessee. The LLW is sent to off-site treatment/disposal facilities. Some LLW has been sent to the DOE Hanford site (Washington) for disposal. The LLMW is currently stored on-site or, if appropriate, sent to K-25 for incineration.

Both workers and members of the general public receive small radiation doses from Portsmouth site operations. The estimated maximum radiation dose to a member of the general public is about 0.07 mrem/yr, approximately 0.07% of the DOE maximum dose limit. Cylinder yard workers receive average radiation doses of about 55 to 196 mrem/yr, which is considerably below the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers at Portsmouth are not exposed to chemicals in amounts that exceed guideline values.

S.3.3 K-25 Site on the Oak Ridge Reservation

The K-25 site is part of the Oak Ridge Reservation, which consists of three major facilities (the K-25 site, Oak Ridge National Laboratory, and the Y-12 plant) and surrounding property in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville. The K-25 site, in the northwest part of the Oak Ridge Reservation, consists of 1,700 acres (688 ha) and contains the former Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities. The K-25 site contains three storage yards for depleted UF_6 cylinders.

The air quality region that includes the K-25 site is in attainment for all six criteria pollutants. The K-25 site is also in compliance with NESHAPS for radionuclide emissions (40 CFR Part 61). The K-25 site is drained by Poplar Creek and the Clinch River, and permitted outfalls are located on both streams. Contaminants detected in groundwater from on-site wells include trichloroethylene and radioactivity.

Numerous wetlands are found in the vicinity of the K-25 site along the creeks and rivers. No federally listed threatened or endangered species are known to occur on the K-25 site; however, several state-listed threatened or endangered plant and animal species are known to be in the vicinity of the K-25 site.

The K-25 site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls. Nonhazardous solid waste is disposed of at a landfill at the Y-12 Plant on the Oak Ridge Reservation. Solid nonradioactive hazardous waste is stored on-site in permitted facilities until it is sent to off-site permitted disposal facilities, and liquid nonradioactive hazardous waste is treated in a permitted on-site incinerator. The LLW is either treated and sent to disposal facilities on the Oak Ridge Reservation or stored for off-site disposal. The LLMW is sent to the K-25 site incinerator.

The estimated maximum radiation dose to a member of the general public from site operations is approximately 5 mrem/yr, about 5% of the DOE maximum dose limit. The average annual dose to cylinder yard workers ranges from 32 to 92 mrem/yr, much less than the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers are not exposed to chemicals in amounts that exceed guideline values.

S.3.4 Representative Environmental Settings for Future Depleted UF_6 Management Activities

Because this PEIS is an analysis of programmatic strategies, rather than specific siting alternatives, certain impacts have been assessed using representative or generic environmental settings. In particular, impacts associated with potential conversion, long-term storage, manufacturing, and disposal activities were assessed assuming representative or generic site environmental conditions. The purpose of this approach was to provide as substantive an assessment as possible and to allow for a comprehensive comparison of alternative management strategies. Therefore, the following settings were developed to provide a reasonable range of environmental conditions for impact assessment:

- For conversion and long-term storage, the range of environmental conditions present at the current storage sites was used as the representative range for purposes of analysis. Because of the large quantity of material to be shipped and the consequent costs, conversion and long-term storage facilities might be located at relatively short distances from the current storage sites. The current

storage sites have a well documented and comparable set of environmental data on both the natural environment and on operations of facilities handling depleted UF_6. Use of these data allows for a comprehensive assessment of impacts associated with potential conversion and long-term storage facilities. However, use of the current storage site settings does not imply that a conversion facility or a long-term storage facility would be located there.

- For long-term storage in a mine, a "dry" environmental setting (climatic conditions typical of the western United States) was assumed.

- For disposal, both a "wet" setting (climatic conditions typical of the eastern United States) and a dry setting were assessed. The settings were assumed to be in a rural environment (low population density).

- For manufacturing, both a rural setting (low population density) and an urban setting (high population density) were evaluated for both wet and dry conditions.

- For transportation, representative truck and rail route characteristics were defined on the basis of national statistics; however, transportation accidents were evaluated for both rural and urban locations.

S.4 SUMMARY AND COMPARISON OF IMPACTS FOR ALTERNATIVE MANAGEMENT STRATEGIES

For each of the alternative management strategies considered in the PEIS, the potential environmental consequences were estimated for a period of about 40 years, from 1999 through 2039. In addition, long-term impacts (primarily from potential groundwater contamination) were estimated for the continued storage component of all alternatives and for the disposal alternative. Consequences were evaluated in the areas of human health and safety (normal operations and accidents), air quality, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice. The assessment considered impacts that could result from construction of necessary facilities, normal operations of facilities, accidents, and transportation of materials.

The potential environmental consequences of the alternative management strategies would depend on the type and number of activities necessary to accomplish each strategy. The no action alternative (continued cylinder storage) would involve the fewest activities. It would require only limited construction of new or improved storage yards and routine monitoring and maintenance of cylinders to ensure continued safe storage. All other alternatives would involve activities in addition to continued cylinder storage. For example, the long-term storage as UF_6 alternative would require the construction and operation of a long-term cylinder storage facility. Each of the other four

alternatives would require construction and operation of a conversion facility to convert UF_6 to another chemical form. The converted material would then be stored, disposed of, or manufactured and used.

The original scope of the PEIS considered the management and processing of only DOE-generated cylinders (i.e., 46,422 cylinders). It was assumed that facilities for cylinder preparation, conversion, long-term storage, manufacture, and disposal would process this inventory over a 20-year period. The final PEIS considers the additional management of up to 15,000 USEC-generated cylinders. In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years.

A comparison of the estimated environmental impacts associated with management of the total cylinder inventory (DOE-generated plus USEC-generated cylinders) for each alternative is provided in Table S.2. To supplement the information in Table S.2, each area of impact evaluated in the PEIS is discussed separately in Sections S.4.1 through S.4.12. Major similarities and differences among the alternatives are highlighted. The preferred alternative, which combines aspects of several of the alternatives evaluated in the PEIS, is discussed separately in Section S.5.

S.4.1 Human Health and Safety — Normal Facility Operations

For all alternatives, exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations. Levels of radiation and/or chemical exposures for the general public and noninvolved workers for all alternatives during normal facility operations were estimated to be very low, with zero latent cancer fatalities (LCFs) expected among these groups over the duration of the program. Involved workers (persons directly involved in the handling of radioactive or hazardous materials) could be exposed to low-level radiation emitted by uranium during the normal course of their work activities, and this exposure could result in a slight increase in the risk for radiation-induced cancer fatality among the involved worker population. The annual number of workers so exposed could range from about 70 (under the no action alternative) to about 700 (under the use as metal alternative.) For management of DOE- and USEC-generated cylinders, the increased exposure to radiation resulted in total estimates of from 1 LCF among workers (under the no action alternative) up to 3 LCFs among workers (under the long-term storage as oxide and disposal alternatives) over the assessment period.

Possible radiological exposures from using groundwater potentially contaminated from releases from breached cylinders or facility releases were also evaluated. For all alternatives except the disposal as oxide alternative, these exposures were estimated to be within applicable public health standards and regulations. During the operational phase of the disposal as oxide alternative, exposures were also estimated to remain within standards and regulations.

TABLE S.2 Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies[a]

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b]			
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within regulatory limit of 5 rem/yr or lower	Same as NAA[c]	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among involved workers (1999–2039)	1 additional LCF	1 to 2 additional LCFs	1 to 3 additional LCFs	1 to 2 additional LCFs	1 to 2 additional LCFs	1 to 3 additional LCFs
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among noninvolved workers (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA for a disposal facility located in a dry environmental setting. In a wet environmental setting, the maximum dose from the use of groundwater was estimated to be about 100 mrem/yr within 1,000 years of facility failure.
Total health effects among members of the public (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[d]	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b] (Cont.)			
General public MEI	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA in a dry environmental setting. In a wet environmental setting, a hazard index of about 10 was estimated within 1,000 years of facility failure.
			Human Health and Safety — Facility Accidents[b]			
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999–2039)	0 fatalities; 180 injuries	1–2 fatalities; 310–1,200 injuries	1–3 fatalities; 900–2,100 injuries	2–3 fatalities; 1,600–2,600 injuries	2–3 fatalities; 1,700–2,700 injuries	1–3 fatalities; 900–2,400 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[e]						
Accident[f]	Corroded cylinder spill, dry conditions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 10 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	4 potential accidents	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	70	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Likely Cylinder Accidents (Cont.)						
Radiation exposure – public						
Dose to MEI	3 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	1 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	0.4 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	77 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	3 in 100,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	2.2 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Low Frequency-High Consequence Cylinder Accidents[h]						
Accidents[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 100,000 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	1	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	300	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	7 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	1 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	8 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	16 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Noninvolved workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h]						
Chemical accident[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	HF or NH_3 tank rupture	Same as LTSO[c]	Same as LTSO	Same as LTSO
Release	Uranium, HF	Same as NAA	HF, NH_3	Same as LTSO	Same as LTSO	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Same as LTSO	Same as LTSO	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	< 1 in 1 million years	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 50,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	41,000	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	1	Same as NAA	1,700	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	0	Same as NAA	30	Same as LTSO	Same as LTSO	Same as LTSO
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	1,100	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	300	Same as NAA	440	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	3	Same as NAA	4	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h] (Cont.)						
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Noninvolved workers[g]	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Radiological accident[f]	Vehicle-induced fire, 3 full cylinders	Same as NAA	Earthquake damage to storage building at conversion site	Earthquake damage to storage building at conversion site	Vehicle-induced fire, 3 full cylinders	Same as LTSO
Release	Uranium	Same as NAA	Uranium (U_3O_8)	Uranium (UO_2)	Uranium	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Conversion site	Conversion site	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	1 in 100,000 years	1 in 100,000 years	1 in 100,000 years	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 5,000	1 chance in 5,000	1 chance in 5,000	Same as LTSO
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	270 mrem	68 mrem	15 mrem	Same as LTSO
Risk of LCF	7 in 1 million	Same as NAA	1 in 10,000	3 in 100,000	7 in 1 million	Same as LTSO
Total dose to population	28 person-rem	Same as NAA	20 person-rem	5.1 person-rem	56 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	9,000 mrem	2,300 mrem	20 mrem	Same as LTSO
Risk of LCF	8 in 1 million	Same as NAA	1 in 250	9 in 10,000	8 in 1 million	Same as LTSO
Total dose to workers	16 person-rem	Same as NAA	840 person-rem	210 person-rem	8 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Accident risk (consequence times probability)						
General public	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO
Noninvolved workers[g]	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b]			
Major Materials Assumed to Be Transported between Sites	LLW/LLMW	UF_6 cylinders LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0	0	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Negligible	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	Negligible	2 fatalities	4 fatalities	4 fatalities	4 fatalities	4 fatalities
Maximum use of rail	Negligible	1 fatality	2 fatalities	3 fatalities	2 fatalities	2 fatalities
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Not applicable	Urban rail accident involving 4 cylinders	Same as $LTSUF_6$[c]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Release	Not applicable	Uranium, HF	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident probability (1999–2039)	Not applicable	1 chance in 10,000	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b] (Cont.)			
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	4	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Fatalities	Not applicable	0	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Radiation exposure – All workers and members of general public						
Total LCFs	Not applicable	60	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident risk (consequence times probability) – Workers and general public	Not applicable	0 fatalities	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Not applicable	Not applicable	Urban rail accident involving anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Release	Not applicable	Not applicable	Anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	Not applicable	Not applicable	1 chance in 30,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	Not applicable	30,000	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	300	Same as LTSO	Same as LTSO	Same as LTSO
Accident risk (consequence times probability)						
Irreversible adverse effects	Not applicable	Not applicable	1	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	0	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]						
Pollutant emissions during construction and operations	Not applicable	Pollutant emissions well within standards (all less than 20% of standards)	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as LTSO	Same as LTSO	Same as LTSO

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TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Water and Soil[j]			
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other parameters[k]	No change	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Surface water, groundwater, and soil quality	Not applicable	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Uranium concentration in groundwater would remain within guideline for more than 1,000 years after failure in a dry environmental setting; could exceed guideline before 1,000 years after failure in a wet setting
Other parameters[k]	No change	Site-dependent; none to moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Site-dependent; negligible to moderate impacts
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Change in topography from 210,000 to 2.1 million yd^3 of excavated material	Change in topography from 100,000 to 2.6 million yd^3 of excavated material	Not applicable	Not applicable	Change in topography from 400,000 to 3.6 million yd^3 of excavated material

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TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics[1]			
Current Storage Sites Continued storage	**Jobs:** 38 peak year, construction; 140 per year over 40 years, operations **Income:** $1.8 million peak year, construction; $6.0 million per year over 40 years, operations	**Jobs:** 38 peak year, construction; 150 per year over 26 years, operations **Income:** $1.8 million peak year, construction; $7 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Cylinder preparation	Not applicable	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years, operations **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities Conversion (Site undetermined)	Not applicable	Not applicable	**Jobs:** 340–730 peak year, construction; 330–490 per year over 26 years, operations **Income:** $16–33 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO	**Jobs:** 480–540 peak year, construction; 340–500 per year over 26 years, operations **Income:** $17–21 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics*[1] *(Cont.)			
Other Facilities (Cont.) Long-term storage (Site undetermined)	Not applicable	**Jobs:** 100–500 peak year, construction; 60-70 per year over 30 years, operations **Income:** $5–29 million peak year, construction; $4 million per year over 30 years, operations	**Jobs:** 120–410 peak year, construction; 70–80 per year over 30 years, operations **Income:** $5–20 million peak year, construction; $4–5 million per year over 30 years, operations	Not applicable	Not applicable	Not applicable
Manufacturing (Site undetermined)	Not applicable	Not applicable	Not applicable	**Jobs:** 160 peak year, construction; 470 per year over 26 years, operations **Income:** $7 million peak year, construction; $33 million per year over 26 years, operations	**Jobs:** 190 peak year, construction; 470 per year over 26 years, operations **Income:** $9 million peak year, construction; $33 million per year over 26 years, operations	Not applicable
Disposal (Site undetermined)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**Jobs:** 65–770 peak year, construction; 60–180 per year over 26 years, operations **Income:** $3.5–42 million peak year, construction; $6–18 million per year over 26 years, operations

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Ecology			
Current Storage Sites						
Habitat loss	Up to 7 acres; negligible impacts	Up to 28 acres; negligible to potential moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Wetlands and threatened or endangered species	None to negligible impacts	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Habitat loss[m]	Not applicable	**Long-term storage:** 110–170 acres; potential large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** 80—260 acres; potential moderate to large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–35 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Disposal:** 40–590 acres; potential moderate to large impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Below harmful levels for more than 1,000 years in a dry environmental setting; potential chemical effects on aquatic biota before 1,000 years after failure in a wet setting; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Not applicable	Site-dependent; avoid or mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	**Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste **Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required); potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Disposal:** Negligible to low impacts with respect to both current and projected nationwide waste generation

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Resource Requirements[n]			
All Sites	No effects on local, regional, or national availability of materials are expected	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation dependent on site location	Same as $LTSUF_6$	Same as NAA	Same as NAA	Same as $LTSUF_6$
			Land Use[m]			
Current Storage Sites	Up to 7 acres; less than 1% of available land; negligible impacts	Up to 28 acres; less than 1% of available land; negligible impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]	Not applicable	**Long-term storage:** 110–170 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts	**Conversion:** 30–40 acres; negligible impacts	**Conversion:** 30–35 acres; negligible impacts	**Conversion:** 30–40 acres; negligible impacts
			Long-term storage: 80–260 acres; potential moderate to large impacts	**Manufacturing:** 90 acres; potential moderate impacts	**Manufacturing:** 90 acres; potential moderate impacts	**Disposal:** 40–590 acres; potential moderate to large impacts
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	Impacts dependent on location; avoid and mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] LTSO = long-term storage as oxide alternative; $LTSUF_6$ = long-term storage as UF_6 alternative; NAA = no action alternative.

[d] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[e] Accidents with probabilities of occurrence greater than 0.01 per year.

[f] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[g] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[h] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[i] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[j] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g (EPA 1995a).

Footnotes continue on next page

TABLE S.2 (Cont.)

Footnotes (Cont.)

[k] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[l] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operation.

[m] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[n] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

Although design criteria are such that disposal facilities would not be expected to fail (i.e., release material to the environment) until several hundred years after closure, for purposes of analysis, it was assumed that these facilities would fail 100 years after closure. For the disposal as oxide alternative, if the disposal facility was located in a "wet" environment (typical of the eastern United States), the estimated dose from the use of groundwater at 1,000 years after the assumed failure of the facility would be about 100 mrem/yr, which would exceed the regulatory dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A for the disposal of LLW. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices would range up to 10, indicating the potential for chemically induced adverse effects from the possible use of contaminated groundwater. The groundwater analysis indicated that if disposal was in a dry environmental setting (typical of the western United States), no measurable groundwater contamination would occur at 1,000 years after failure of the disposal facility, because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.

S.4.2 Human Health and Safety — Facility Accidents

S.4.2.1 Physical Hazards

Under all alternatives, workers (including both involved and noninvolved) could be injured or killed from on-the-job accidents unrelated to radiation or chemical exposure. On the basis of accident statistics for similar industries, under the no action alternative, it was estimated that zero fatalities and about 180 injuries might occur over the period 1999 through 2039. Under all other alternatives, it was estimated that from one to three fatalities and from 310 to 2,700 injuries might occur over the same period. Accidental injuries and deaths are not unusual in industries that use heavy equipment to manipulate heavy objects and bulk materials. The differences among the alternatives reflect differences in the total number of work hours that would be required.

S.4.2.2 Facility Accidents Involving Releases of Radiation or Chemicals

Under all alternatives, accidents are possible that could release radiation or chemicals to the environment, potentially causing adverse health effects among workers and members of the public. Of all the accidents considered, those involving depleted UF_6 cylinders and those involving chemicals at a conversion facility were estimated to have the largest potential adverse effects.

Under all alternatives, accidents involving UF_6 cylinders could occur at the current storage sites because continued storage of cylinders is a component of all of the alternatives. In addition, cylinder accidents could occur at a consolidated long-term storage facility and at a conversion facility. Cylinder accidents could release UF_6 to the environment. If a release occurred, the UF_6 would combine with moisture in the air, forming gaseous HF and UO_2F_2, a soluble solid in the form

of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public to radiation and chemical effects. The amount released would depend on the severity of the accident and the number of cylinders involved. The potential consequences of cylinder accidents are presented in Table S.2 for (1) accidents that might happen at least once in 100 years (considered "likely" accidents; assumed frequency of once in 10 years for probability calculations) and (2) accidents that might happen much less frequently, from once in 10,000 to less than once in 1 million years (assumed frequency of once in 100,000 years for probability calculations).

For releases involving UF_6 and other uranium compounds, both chemical and radiological adverse effects could occur if the material was ingested or inhaled. The chemical effect of most concern associated with internal uranium exposure is kidney damage, and the radiological effect of concern is an increase in the probability of developing cancer. For uranium, chemical effects (kidney damage) occur at lower exposure levels than radiological effects. Exposure to HF from accidental releases could result in a range of health effects, from eye and respiratory irritation to death, depending on the exposure level.

Chemical and radiological exposures for involved workers (those within 100 m of the release) under accident conditions would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

For accidents involving cylinders that might happen at least once in 100 years ("likely" accidents), the off-site concentrations of HF and uranium were estimated to be considerably below levels that would cause adverse chemical effects among members of the general public from exposure to these chemicals. However, up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that three noninvolved workers might experience potential irreversible adverse effects that are permanent in nature (such as lung damage or kidney damage), with no fatalities among these workers expected. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or members of the general public for these types of accidents.

Cylinder accidents that are less likely to occur could be more severe, having greater consequences that could potentially affect off-site members of the general public. These types of accidents are considered extremely unlikely, expected to occur with a frequency of between once in 10,000 and once in 1 million per year of operations. Over the period 1999 through 2039, the probability of this type of accident would be about 1 chance in 2,500. Among all the accidents

analyzed, the accident resulting in the largest number of people with adverse effects (including mild and temporary, as well as permanent effects) was a vehicle-induced fire involving three cylinders. If this type of accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse chemical effects from HF and uranium exposure (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). More adverse effects are estimated among the general public than among noninvolved workers because of buoyancy effects of the fire on contaminant plume spread (that is, concentrations that occur are higher at points distant from the release than at closer locations).

The modeled accident resulting in the largest number of persons with irreversible adverse health effects was a corroded cylinder spill under wet conditions. If this accident occurred, it was estimated that 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage). No fatalities would be expected among the public; there would be a potential for three fatalities among noninvolved workers from chemical effects. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or the general public.

The number of persons actually experiencing adverse or irreversible adverse effects from cylinder accidents would likely be considerably fewer than those estimated for this analysis and would depend on the actual circumstances of the accident and the individual chemical sensitivities of the affected persons. For example, although exposures to releases from cylinder accidents could be life-threatening (especially with respect to immediate effects from HF inhalation), the guideline exposure level of 20 parts per million (ppm) of HF used to estimate the potential for irreversible adverse effects from HF exposure is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm, and generally, if death does not occur quickly after HF exposure, recovery is complete.

Similarly, the guideline intake level of 30 mg used to estimate the potential for irreversible adverse effects from the intake of uranium in this PEIS is that suggested in guidance given by the U.S. Nuclear Regulatory Commission (NRC). This level is somewhat conservative; that is, it is intended to overestimate rather than underestimate the potential number of irreversible adverse effects in the exposed population following uranium exposure. In over 40 years of cylinder handling activities, no accidents involving releases from cylinders containing *solid* UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers. In previous accidental exposure incidents involving *liquid* UF_6 in gaseous diffusion plants, some worker fatalities occurred immediately following the accident as a result of inhalation of HF generated from the UF_6. However, no fatalities occurred as a result of the toxicity of the uranium exposure. A few workers were exposed to estimated amounts of uranium approximately three times the guideline level (30 mg) used for assessing irreversible adverse effects, but none of these workers actually experienced such effects.

For all of the management strategies considered in the PEIS, low-probability accidents involving chemicals at a conversion facility were estimated to have the largest potential

consequences to noninvolved workers and members of the public. Conversion would be required for long-term storage as oxide, use as oxide, use as metal, and disposal. At a conversion site, accidents involving releases of chemicals, such as ammonia and HF, are possible. Ammonia is used for some conversion options, and HF can be produced as a by-product of converting UF_6 to either uranium oxide or uranium metal. The primary impacts from conversion accidents are related to potential chemical exposures to the released material.

The conversion accidents estimated to have the largest potential consequences were accidents involving the rupture of tanks containing either anhydrous HF or ammonia. Such accidents could be caused by a large earthquake and are expected to occur with a frequency of less than once in 1 million per year of operations. The probability of these types of accidents occurring during the operation of a conversion facility would be about 1 chance in 50,000. If such accidents occurred, it was estimated that up to 41,000 members of the general public around the conversion facility and 1,100 noninvolved workers might experience adverse effects from chemical exposures (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). Of these, up to 1,700 members of the general public and 440 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage), with the potential for about 30 fatalities among the public and 4 fatalities among noninvolved workers. In addition, irreversible or fatal effects among involved workers very near the accident scene are possible.

These high consequence accidents are expected to be extremely rare. The risk (defined as consequence multiplied by probability) for these accidents would be zero fatalities and zero irreversible adverse health effects expected for noninvolved workers and the members of the public combined, and one adverse health effect expected for the general public. Ammonia and anhydrous HF are commonly used chemicals for industrial applications in the United States. Industrial accident prevention and mitigative measures are well established for HF and ammonia storage tanks. These include storage tank siting principles, design recommendations, spill detection, and containment measures. These measures would be implemented, as appropriate, if conversion were required by the selected alternative.

S.4.3 Human Health and Safety — Transportation

A conservative estimate of transportation impacts was provided by assuming that continued cylinder storage, conversion, consolidated long-term storage, manufacture and use, and disposal facilities would be located at separate sites, requiring transportation of materials between these sites. The actual transportation requirements would depend on the management strategy selected in the Record of Decision and the ultimate locations of any required facilities.

Under the no action alternative, only small amounts of LLW and LLMW generated during cylinder maintenance activities would require transportation, with only negligible impacts expected. The major materials assumed to require transportation for the other alternatives are summarized in Table S.2. Most materials could be shipped by either truck or rail. For purposes of comparison

among the alternatives, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. (Transportation impacts are evaluated for a range of shipment distances in Appendix J of the PEIS). Most shipments were assumed to occur over a 26-year period, from 2009 through 2034. Impacts from transportation activities could be reduced if several facilities were located at the same site.

During normal transportation operations, radioactive material and chemicals would be contained within their transport packages. Potential health impacts to crew members (i.e., workers) and members of the general public along the route could occur if there were exposure to low-level external radiation in the vicinity of shipments of uranium materials. In addition, exposure to vehicle engine exhaust emissions could potentially cause adverse health effects from inhalation. Under all alternatives other than the no action and long-term storage as UF_6 alternatives, it was conservatively estimated that no more than one fatality would occur from these causes. Under all alternatives, members of the general public living along truck and rail transportation routes would receive extremely small doses of radiation from shipments, less than 0.1 mrem over 40 years. This would be true even if a single person were to be exposed to every shipment of radioactive material during the program.

Under all alternatives, traffic accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public either from the actual accident or from accidental releases of radioactive materials or chemicals.

Under each alternative, the total number of traffic fatalities (unrelated to the type of cargo) was estimated on the basis of national traffic statistics for shipments by both truck and rail modes. If it was assumed that shipments were predominantly by truck, it was estimated that from two to four traffic accident fatalities could occur over the duration of the program. If shipments were predominantly by rail, it was estimated that one to three traffic accident fatalities could possibly occur. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

Severe transportation accidents could also result in a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material dispersed and diluted to lower concentrations as it moved downwind.

All alternatives other than the no action alternative could involve the transportation of UF_6 cylinders between sites. For cylinder shipments, among all the accidents analyzed, a severe rail accident involving four cylinders was estimated to have the highest potential consequences. The

consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 for shipping all cylinders by rail (the actual probability would depend on the route selected). In the unlikely event that such an accident were to occur, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung damage or kidney damage) from chemical exposure to HF and uranyl fluoride generated from released UF_6, with zero fatalities expected. Over the long term, radiation effects would also be possible from exposure to the uranium released. It was estimated that approximately 60 cancer fatalities could occur in the urban population from such an accident in addition to the approximately 700,000 that would occur from all other causes (approximately 3 million persons were assumed to be exposed to low levels of uranium from the accident as the uranium dispersed in the air). The radiological risk (consequence multiplied by probability) for this accident would be zero expected LCFs.

For all other materials assumed to be transported in this PEIS, the highest potential accident consequences would be caused by a rail accident involving anhydrous HF that might be produced during conversion. Conversion would be required for the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives. Although anhydrous HF is a highly corrosive and hazardous gas, it has many industrial applications and is commonly safely transported by industry as a liquid in trucks and rail tank cars. Anhydrous HF could be produced during conversion and could potentially be transported to a user. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site could potentially experience irreversible adverse effects from chemical exposure to HF. However, the probability of such an accident occurring if all the anhydrous HF produced was transported 620 miles (1,000 km) was estimated to be only about 1 chance in 30,000. Anhydrous HF is routinely shipped commercially in the United States for industrial applications. To provide perspective, since 1971, the period covered by U.S. Department of Transportation records, there have been no fatal or serious injuries to the public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars have been reported that had no associated evacuations or injuries. The only major release (estimated at 6,400 lb of anhydrous HF) occurred in 1985 and resulted in approximately 100 minor injuries. Another minor HF release during transportation occurred in 1990. The improved safety record of transporting anhydrous HF in the past 10 years can be attributed to several practices. Such practices include installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Nonetheless, if the unlikely rail accident described above (i.e., release of HF from a railcar in a densely populated urban area under stable weather conditions) were to occur, it was estimated

that up to 30,000 persons might experience irreversible adverse effects (such as lung damage), with the potential for about 300 fatalities. If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, including one expected fatality. The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF accident would be much less under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and lower downwind concentrations. Under unstable conditions, an area of about 1 mi^2 (2 km^2) could be affected by an accident. If such an accident occurred in an urban area, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, with the potential for about 30 fatalities. If the accident occurred in a rural area under unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with zero fatalities expected. When considering the probability of an HF accident occurring, one person would be expected to experience irreversible adverse effects, and no fatalities would be expected over the shipment period.

S.4.4 Air Quality

For management of both DOE- and USEC-generated cylinders, air quality from construction and facility operations for all alternatives would be within existing regulatory standards and guidelines. All construction activities planned to support continued cylinder storage (e.g., constructing new storage yards) would be required within the first 10 years of continued storage, when all cylinders would still be in storage under each alternative. Therefore, air quality impacts from construction activities at the current storage sites would be the same across the alternatives. Estimated concentrations of particulate matter (dust) that could be generated during construction activities are close to the regulatory standard levels; these temporary emissions could be controlled by good construction practices.

If it is assumed that cylinder maintenance and painting activities would not reduce cylinder corrosion rates, it is possible that cylinder breaches could result in HF air concentrations greater than the regulatory standard level at the K-25 storage site around the year 2020; HF concentrations at the Paducah and Portsmouth sites were estimated to remain within applicable standards or guidelines. However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, air concentrations of HF would be kept within regulatory standards at all storage sites.

S.4.5 Water and Soil

For operations under all alternatives, uranium concentrations in surface water, groundwater, and soil at the three current storage sites would remain below guidelines throughout the project duration (when the EPA proposed maximum contaminant level [MCL] of 20 µg/L for drinking water

is used as a guideline for water and the EPA health-based residential soil guideline of 230 µg/g is used as a guideline for soil). Under the no action alternative, if cylinder maintenance and painting would not reduce cylinder corrosion rates, it is possible that the uranium groundwater concentration could be greater than the 20 µg/L guideline at all three sites at some time in the future (earliest about the year 2100 at the Paducah site). However, if continued cylinder maintenance and painting are effective in controlling corrosion, as expected, groundwater uranium concentrations would remain less than 20 µg/L. For all other alternatives, groundwater concentrations would remain less than 20 µg/L, even without continued cylinder maintenance and painting, because the cylinders would begin to be removed around the year 2009.

Under the disposal alternative, if a disposal facility in a dry environmental setting were to fail, groundwater impacts would be unlikely for at least 1,000 years. (No measurable groundwater contamination would have occurred because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.) For a disposal facility in a wet environmental setting, the uranium concentration in groundwater beneath the facility might be greater than 20 µg/L within 1,000 years after failure of the facility. It should be noted, however, that the disposal calculations are subject to a great deal of uncertainty, and results would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were part of the management strategy selected. If disposal was implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW.

Under all alternatives, construction activities have the potential to result in surface water, groundwater, or soil contamination through spills of construction chemicals. By following good engineering practices, concentrations in soil and wastewater (and therefore surface water and groundwater) could be kept well within applicable standards or guidelines.

Under the long-term storage as UF_6, long-term storage as oxide, and disposal as oxide alternatives, from 100,000 yd^3 to 3.6 million yd^3 (76,000 to 2.8 million m^3) of soil and rock could require excavation and surface disposal, depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was selected. The excavated material could result in changes to topography at the facilities; these changes could be mitigated, if necessary, through trucking the excavated material off-site and/or by contouring and reseeding the site. Mine storage and disposal would generally result in the largest excavation volumes. If mine storage or disposal were selected as a UF_6 management strategy, excavation volumes could also be reduced through use of a previously existing mine.

S.4.6 Socioeconomics

Socioeconomic impacts are evaluated in terms of jobs and income generated, which are considered positive impacts. The no action alternative would result in the smallest positive socioeconomic impacts of the alternatives considered, creating about 140 direct jobs and generating about $6 million in direct income per operational year. The long-term storage as UF_6 alternative would have the second smallest socioeconomic impacts because conversion would not be required; this alternative would create about 610 to 1,200 direct jobs and generate about $35 to $65 million in direct income per year. The other alternatives (long-term storage as oxide, use as oxide, use as metal, and disposal as oxide) would have similar socioeconomic impacts, creating about 970 to 1,600, 1,250 to 1,600, 1,260 to 1,600, and 900 to 2,100 direct jobs per year, respectively, and generating about $55 to $85 million, $79 to $93 million, $79 to $93 million, and $55 to $120 million in direct income per year, respectively. Under the storage and disposal alternatives, the upper ends of the ranges of jobs created and income generated correspond to options requiring mine excavation. The process of manufacturing under the use as oxide and use as metal alternatives is labor-intensive and makes the socioeconomic impacts under these two alternatives similar to those under the long-term storage and disposal alternatives.

Continued cylinder storage under all alternatives would result in negligible impacts on regional growth and housing near the three current storage sites. Such impacts would be site dependent, but would be minor for conversion and long-term storage on the basis of the analysis for representative sites.

S.4.7 Ecology

Habitat loss at the current storage sites for all alternatives would range from 0 to 7 acres (2.8 ha) for the no action alternative to 0 to 28 acres (11 ha) or less for all other alternatives, depending on whether cylinder transfer facilities at the three sites were selected as the cylinder preparation option. These habitat losses would constitute less than 1% of available land at the current sites and would have negligible impacts on biota.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. The large ranges in estimated land requirements result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. The consequences of habitat loss would be site dependent in terms of adverse impacts to threatened and endangered species and wetlands, and they would be evaluated in subsequent site-specific NEPA reviews. As a general guideline, potential moderate adverse impacts to vegetation and wildlife from habitat loss were assumed if the required land area was greater than 10 acres, and potentially large adverse impacts were assumed if the required land area was greater than 100 acres.

If a disposal facility in a wet environmental setting were to fail, the uranium concentration in groundwater beneath the facility might exceed the guideline value of 20 µg/L within 1,000 years after failure. If the groundwater discharged to nearby surface waters, aquatic biota might be exposed to elevated concentrations of uranium, possibly resulting in adverse chemical effects; however, no adverse radiological effects would occur at the concentrations estimated.

S.4.8 Waste Management

During continued storage at the current sites under all alternatives, LLMW would be generated from cylinder scraping and painting activities. The amount of LLMW generated from these activities could result in moderate impacts to waste management at the Paducah site (annual volumes could be about 30% of the current site annual LLMW generation volume of 100 m^3/yr); however, the amount is less than 1% of the current estimated annual LLMW treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr) and would have a negligible to low impact on DOE's waste management system as a whole.

The alternatives requiring conversion to oxide are long-term storage as oxide, use as oxide, and disposal as oxide. Depending on the conversion option selected, anhydrous HF or CaF_2 could be produced. Industrial experience indicates that anhydrous HF, if produced, would contain only trace amounts of depleted uranium (less than 1 part per million [ppm]). Because of the considerable market for HF (it is commonly used for many industrial applications, including the production of UF_6 from natural uranium ore), it was assumed that if anhydrous HF was produced, it would be sold for use. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use.

If an option involving CaF_2 production was selected, it is currently unknown whether CaF_2 generated in the conversion to oxide processes could be sold, whether the low uranium content would allow disposal as nonhazardous solid waste, or whether disposal as LLW would be required. The low level of uranium contamination expected (i.e., less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste would be most likely. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use. Waste management for disposal as nonhazardous waste could be handled through appropriate planning and design of the facilities. If the CaF_2 was considered to be LLW, the largest CaF_2 generation volumes (about 550,000 m^3 over the 26-year period for the conversion to oxide with neutralization of HF option) would represent about 13% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e., 4.25 million m^3) and could result in moderate impacts on waste management (if the LLW was considered to be DOE waste).

Under alternatives requiring conversion to either oxide or metal, the empty cylinders would be treated to remove the heels material and crushed. It is assumed that the treated, crushed cylinders would become part of the DOE scrap metal inventory. If a decision to dispose of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 4% addition

to the projected DOE complexwide LLW disposal volume. This would constitute a low impact on DOE's waste management system as a whole.

Under the use as metal alternative, magnesium fluoride (MgF_2) would also be produced during conversion. It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonhazardous solid waste. (It is estimated that the MgF_2 would contain uranium at a concentration of about 90 ppm.) If the MgF_2 was considered to be DOE LLW, the volume generated would represent about 8% of the projected DOE complexwide LLW disposal volume, a low to moderate impact on DOE's waste management system as a whole. Under the metal conversion option, if the HF was neutralized and the CaF_2 generated was considered to be DOE LLW, the CaF_2 would represent approximately an additional 4% of the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact on DOE's waste management system.

The LLW volumes requiring disposal under the disposal as oxide alternative represent an addition of about 3 to 10% to the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact for DOE's waste management system. The waste management impacts for all alternatives requiring conversion of UF_6 would be similar, having the potential for a moderate impact on DOE's LLW management system.

S.4.9 Resource Requirements

Resource requirements include construction materials, fuel, electricity, process chemicals, and containers. In general, all of the alternatives would have a negligible effect on the local or national availability of these resources (when both DOE- and USEC-generated cylinders are considered). However, under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during mine construction (up to 1,400 MW-yr). The availability of this electricity would depend on site location, and use of a previously existing mine would substantially decrease the electrical requirements. Also, the disposal alternative would result in permanent disposition of the depleted uranium, a material that DOE considers to be a valuable national resource. Disposal would constitute an irreversible and irretrievable commitment of this resource to a nonproductive purpose.

S.4.10 Land Use

For current sites, continued storage and cylinder preparation could require up to 28 acres (11 ha) of land for new or reconstructed cylinder yards and transfer facilities, if built. This acreage constitutes less than 1% of available land at the three sites. Furthermore, it is likely that previously developed land could be used for these needs.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres around the conversion facilities. The large ranges in the estimated land required result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. Potential land-use impacts would depend on where the facilities were sited. As a general guideline, potentially moderate land use impacts were assumed if the required land area was greater than 50 acres, and potentially large land use impacts were assumed if the required land area was greater than 200 acres.

S.4.11 Cultural Resources

Impacts to cultural resources at the current storage sites would be unlikely. Potential for impacts at new sites would depend entirely on their locations. Such impacts would be minimized through surveys conducted prior to construction activities and through consultation with state historic preservation officers.

S.4.12 Environmental Justice

No disproportionately high or adverse human health or environmental impacts would be expected to minority or low-income populations during normal facility operations for any of the alternatives (when both DOE and USEC-generated cylinders are considered). Although the consequences of facility accidents could be high if severe accidents occurred, the risk of irreversible adverse effects (including fatalities) among members of the general public from these accidents (taking into account the consequences and probability of the accidents) would be less than one. Furthermore, transportation accidents with high and adverse impacts are unlikely, their locations have not been projected, and the types of persons who would be involved cannot be reliably predicted; therefore, there is no reason to expect that minority and low-income populations would be affected disproportionately by high and adverse impacts.

S.4.13 Cumulative Impacts

The continued cylinder storage and cylinder preparation components of the depleted UF_6 management alternatives would result in environmental impacts that, even when combined with other activities that could occur at the three current storage sites, would be expected to be relatively minor. The estimated cumulative doses to members of the general public at all three sites would be below levels expected to result in a single cancer fatality over the life of the project, and the annual dose to the off-site maximally exposed individual would be considerably below the EPA maximum

standard of 10 mrem/yr from the air pathway. The cumulative collective dose to workers at the three sites would result in one to three additional cancer fatalities over the duration of the program. Cumulative demands for water, wastewater treatment, and power would be well within existing capacities at all three sites. Relatively small amounts of additional land would be needed for depleted UF_6 management at the three current storage sites. If continued cylinder maintenance and painting were effective in reducing corrosion rates, as expected, groundwater concentrations would remain below the 20-μg/L guideline level at all three sites. If continued maintenance and painting of the cylinders were not able to reduce corrosion rates, the uranium concentration in groundwater could exceed 20 μg/L at some time in the future at all three sites. In addition, if continued cylinder maintenance and painting were to be ineffective, the concentration of HF in air could exceed the regulatory standard at the K-25 site around the year 2020; HF air concentrations at the Paducah and Portsmouth sites would be expected to remain within applicable standards and guidelines.

The cumulative impacts of conversion, long-term storage, and disposal activities could not be determined because specific sites and technologies have not been designated for these options. Further analyses of cumulative impacts would be performed as required by NEPA and DOE regulations for any technology or siting proposals that would involve these facilities.

S.5 DOE'S PREFERRED ALTERNATIVE

S.5.1 Description

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors.

DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and metal products for use. Conversion to oxide or metal would generate fluorine or fluorine compounds such as HF, which would also have beneficial uses. This preferred alternative provides the flexibility to respond to changing market conditions and to the continued development of new uses for the conversion products. During the time that the depleted UF_6 inventory is being converted for long-term storage and product applications, some depleted UF_6 would also be available for other uses that might develop.

Potential uses for fluorine products exist now in the aluminum, chemical, steel, and glass industries. Large-scale uses for the depleted uranium products are under development. These uses include radiation-shielding applications, in which uranium oxide is used as a substitute for the aggregate in concrete. Concrete made with depleted uranium would be a more effective shielding material than conventional concrete and would provide the same level of radiation shielding with less thickness than conventional concrete. Among other uses, this concrete could be fabricated into casks for storage of spent nuclear fuel or HLW.

In addition to the above potential large-scale uses of the depleted UF_6, small-scale use of some depleted UF_6 is being considered in industrial applications and by other DOE program decisions and NEPA analyses, such as that for the disposition of surplus plutonium. At this time, uses being considered by other DOE programs generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy in the Record of Decision to be issued following the publication of this PEIS.

DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the *Commerce Business Daily* published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

The locations for conversion and fabrication facilities, the start-up date for conversion, the rate of conversion, and the chemical form of depleted uranium and fluorine products would be subject to follow-on (tiered) NEPA analyses and availability of any necessary federal funding. Conversion of the depleted UF_6 to uranium oxide under the preferred alternative would begin as early as practicable. DOE expects that in the future, uses will be available for some portion of the converted material. The value of depleted uranium and HF or CaF_2 for use is based on their unique qualities, the size of the inventory, and the history of uses already implemented (e.g., industrial applications for fluorine compounds). DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted uranium inventory.

Current practices for managing the depleted UF_6 cylinder inventory include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, and surveillance and maintenance of the cylinders and cylinder yards. Under the preferred alternative, these practices would continue or be modified, as necessary, to meet any changing requirements for protection of worker and public health and safety and of the environment. Safe management of the cylinder inventory would continue through conversion of 100% of the inventory for use or storage. Aggressive cylinder management will ensure that continued storage of the depleted UF_6 cylinders prior to conversion will be consistent with DOE's policy of safe, effective material management.

S.5.2 Impacts of the Preferred Alternative

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. Most of the inventory would likely require interim storage as depleted uranium oxide pending use. The impacts of the 100% use as oxide alternative, 100% use as metal alternative, and 100% long-term storage as oxide alternative are described in detail in Sections 5.3, 5.4, and 5.5 of the PEIS for the DOE-generated cylinders. The impacts of adding the USEC cylinders under these alternatives are described in Sections 6.3.3, 6.3.4, and 6.3.5 of the PEIS. The impacts of these three alternatives may be considered representative for the preferred alternative. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was also analyzed. The potential impacts of this combination strategy are discussed in detail in Section 5.7 and Section 6.3.7 of the PEIS. A tabular summary of the potential impacts of this combination strategy that is representative of the preferred alternative is shown in Table S.3.

For the four alternative management strategies considered representative of the preferred alternative (100% use as oxide; 100% use as metal; 100% long-term storage as oxide; and combination 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide), potential environmental impacts for many technical areas are very similar (Tables S.2 and S.3). With respect to human health and safety impacts of normal facility operations, the strategies have similar impacts; that is, radiological and chemical exposures for the general public and workers would remain well within regulatory limits and public health standards under all four strategies. Also, the maximum-consequence accidents would be similar under all four strategies. Impacts to air quality, water and soil quality, and waste management would also be similar for the four management strategies representative of the preferred alternative.

Potential differences in impacts arise under the 25% use as oxide, 25% use as metal, 50% long-term storage as oxide combination strategy because of increased requirements for workforce, acreage, and construction and operational materials associated with the potential need for two conversion facilities, two manufacturing facilities, two cylinder treatment facilities, and a long-term storage facility. The resources required for these facilities are nonlinear with throughput; that is, the resources required to build and operate a 25%-capacity or a 50%-capacity facility are more than one-quarter or one-half the resources required to build and operate one 100%-capacity facility. This situation results in some increased impacts for the combination strategy. For example, the estimated number of worker fatalities and injuries for construction and operation under the combination strategy (4 to 5 fatalities; 2,900 to 4,100 injuries) is about 1.5 times that estimated for the 100% use as oxide and 100% use as metal strategies, separately. Similarly, required jobs and income produced under the combination strategy are greater than they are under the 100% use strategies. If the combination strategy resulted in construction of separate conversion, manufacturing, cylinder

TABLE S.3 Summary of Potential Environmental Consequences of a Combination Management Strategy Representative of the Preferred Alternative[a]

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Normal Facility Operations[b]	
Radiation Exposure	
Involved Workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	2 to 3 additional LCFs
Noninvolved Workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General Public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[c]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[b]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	4–5 fatalities; 2,900–4,100 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[d]	
Accident[e]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	4 potential accidents

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[f]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[g]	
Accident[e]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – Noninvolved workers[f]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g]	
Chemical accident[e]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[f]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident[e]	Earthquake damage to storage building at conversion site
Release	Uranium (U_3O_8)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	270 mrem
Risk of LCF	1 in 10,000
Total dose to population	20 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[f]	
Dose to MEI	9,000 mrem
Risk of LCF	1 in 250
Total dose to workers	840 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[b]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	5 fatalities
Maximum use of rail	2 fatalities

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Transportation[b] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequency-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[h]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Water and Soil[i]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[j]	No change
Other Facilities[h]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[j]	Site-dependent; none to moderate impacts
Excavation of soil for long-term storage	Change in topography from 51,000 yd^3 to 1.3 million yd^3 of excavated material
Socioeconomics[k]	
Current Storage Sites	
Continued storage	**Jobs:** 38 peak year, construction; 150 per year over 26 years of operation **Income:** \$1.8 million peak year, construction; \$7 million per year over 26 years of operation
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years of operation **Income:** \$0–26 million peak year, preoperations; \$19–25 million per year over 26 years of operation
Other Facilities[h]	
Conversion	**Jobs:** 670–960 peak year, construction; 510–720 per year over 26 years of operation **Income:** \$28–41 million peak year, construction; \$30–41 million per year over 26 years of operation

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Socioeconomics*[k] *(Cont.)
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 26 years of operation **Income:** $13 million peak year, construction; $30 million per year over 26 years of operation
Long-term storage	**Jobs:** 60-210 peak year, construction; 39–46 per year over 30 years of operation **Income:** $3–10 million peak year, construction; $3–4 million per year over 30 years of operation
	Ecology
Current Storage Sites	
Habitat loss[l]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[h]	
Habitat loss[l]	**Conversion:** Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 79 acres at a single site; total of 160 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** About 61 acres; potential moderate impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Waste Management	
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation
Other Facilities[h]	
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
Long-term storage	Negligible impacts with respect to current regional or nationwide waste generation
Resource Requirements[m]	
All Sites	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation depend on site location
Land Use	
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[h]	
Conversion	Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts
Manufacturing	Up to 79 acres at a single site; total of 160 acres; potential moderate impacts
Long-term storage	About 61 acres; potential moderate impacts
Cultural Resources	
Current Storage Sites	Impacts unlikely
Other Facilities[h]	Impacts depend on location; avoid and mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Environmental Justice
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[d] Accidents with probabilities of occurrence greater than 0.01 per year.

[e] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[f] In addition to noninvolved worker impacts, involved worker injuries and fatalities are possible from chemical, radiological, and/or physical forces of accidents. Chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[g] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[h] Other facilities are facilities for conversion, manufacturing, and storage.

[i] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

[j] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[k] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operations.

[l] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[m] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 µm or less; UF_6 = uranium hexafluoride.

treatment, and long-term storage facilities, total land use requirements could almost double, also resulting in an increased potential for adverse ecological impacts.

For the purposes of analysis of the combination strategy, it was assumed that independent conversion, manufacturing, and storage facilities would be constructed. However, in practice, such facilities may be located together, which would reduce the resource needs of the combination strategy.

S.6 SUMMARY OF ISSUES RELATED TO LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the PEIS. The potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready to be decided upon at this time. Issues related to the potential life-cycle impacts associated with depleted uranium management are summarized here.

The management of depleted uranium beyond the year 2039 would depend on the management strategy in place at that time. If depleted uranium was in long-term storage in 2039, the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and then used or disposed of. Continued storage may require refurbishment or replacement of facilities and containers as their design lifetimes are exceeded.

Depleted uranium might also require management after use, depending on the type of product and nature of the use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or treated and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time. Disposal after use may also require further treatment or processing, such as conversion to a suitable chemical form. Some uses might also result indirectly in the permanent disposal of the material. For example, it is possible that casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or high-level radioactive waste in a geologic repository.

1 INTRODUCTION

The U.S. Department of Energy (DOE) is analyzing strategies for the long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. DOE has determined that the selection and implementation of a long-term management strategy for depleted UF_6 is a major federal action with the potential to significantly affect the natural and human environment; thus, preparation of an environmental impact statement (EIS) is required. Because selection of a management strategy is a broad agency action setting the course of a program, this EIS is a programmatic EIS (PEIS). It describes alternative strategies (including current management, storage, use, and disposal) that could be employed in the long-term management of depleted UF_6 and analyzes the potential environmental consequences of implementing each alternative strategy for the period from 1999 through 2039. The PEIS has been prepared in accordance with the *National Environmental Policy Act* of 1969 (NEPA), as presented in the *United States Code* (42 USC 4321 et seq.), and applicable NEPA implementing regulations listed in the *Code of Federal Regulations* (40 CFR Parts 1500-1508 and 10 CFR Part 1021). It is anticipated that one or more follow-on NEPA reviews will be conducted after the Record of Decision for this PEIS to address site selection, technology selection, and facility construction and operation activities.

1.1 BACKGROUND INFORMATION

Uranium is the fuel used in most nuclear reactors and is also a component of nuclear weapons. Uranium is a naturally occurring radioactive element consisting of several isotopes: uranium-238 (99.3%), uranium-235 (0.7%), and uranium-234 (0.005%). These isotopes differ in the number of neutrons in their nuclei. The use of uranium for nuclear weapons and as a fuel in light water nuclear reactors, such as the reactors used to produce electricity in the United States, requires increasing the proportion of the uranium-235 isotope found in natural uranium through an isotopic separation process called enrichment. An enrichment process called gaseous diffusion is currently used in the United States.

The gaseous diffusion process requires uranium in the form of UF_6. UF_6 is a chemical compound consisting of one atom of uranium combined with six atoms of fluorine. It can be a solid, liquid, or gas, depending on its temperature and pressure. (See Appendix A of the PEIS for additional information on the properties of UF_6.) It is used for the gaseous diffusion process primarily because it can conveniently be used as a gas for processing, as a liquid for filling or emptying containers or equipment, and as a solid for storage. At atmospheric pressure, UF_6 is a solid below a temperature of 134°F (57°C) and a gas at temperatures above 134°F. Solid UF_6 is a white, dense, crystalline material that resembles rock salt. Liquid UF_6 is formed only at temperatures greater than 147°F (64°C) and at a pressure somewhat greater than atmospheric pressure.

UF_6 does not react with oxygen, nitrogen, carbon dioxide, or dry air, but it does react with water or water vapor. (For this reason, UF_6 is always handled in leaktight containers and processing equipment.) When UF_6 comes into contact with water, such as water vapor in the air, the UF_6 and water react, forming hydrogen fluoride (HF) and a uranium-fluoride compound called uranyl fluoride (UO_2F_2).

The characteristics of UF_6 pose potential health risks, and the material is handled accordingly. Uranium is radioactive, and UF_6 in storage emits low levels of gamma and neutron radiation. The radiation levels measured on the outside surface of filled depleted UF_6 storage cylinders are typically about 2 to 3 millirem per hour (mrem/h), decreasing to about 1 mrem/h at a distance of 1 ft (0.3 m). In addition, if UF_6 is released to the atmosphere, the uranium compounds and HF that are formed by reaction with moisture in the air can be chemically toxic. Uranium is a heavy metal that, in addition to being radioactive, can have toxic chemical effects (primarily on the kidneys) if it enters the bloodstream by means of ingestion or inhalation. HF is an extremely corrosive gas that can damage the lungs and cause death if inhaled at high enough concentrations. The potential health risks associated with these substances are discussed in further detail in Chapter 4, Sections 4.3.1 and 4.3.2.

The enrichment of uranium by gaseous diffusion requires several steps (Figure 1.1). In the first step, uranium oxide is extracted from natural uranium ore and sent to an industrial facility where it is combined with anhydrous HF and fluorine gas to form UF_6. The product UF_6 is placed into steel cylinders and shipped as a solid to a gaseous diffusion plant for enrichment. The gaseous diffusion process takes a stream of heated UF_6 gas and separates it into two parts, one "enriched" with uranium-235 (i.e., uranium that contains more than 0.7% uranium-235) and the other "depleted" of uranium-235 (i.e., uranium that contains less than 0.7% uranium-235). The enriched UF_6 is generally used to manufacture fuel for nuclear reactors. The depleted UF_6 is stored as a solid in large metal cylinders at the enrichment facility.

The first large-scale uranium enrichment effort in the United States began as part of the atomic bomb development by the Manhattan Project during World War II. Later, enrichment for both civilian and military uses continued under the auspices of the U.S. Atomic Energy Commission and its successor agencies, including DOE. Three large gaseous diffusion plants were constructed to produce enriched uranium, first at the K-25 site[1] on the Oak Ridge Reservation near Oak Ridge, Tennessee, and subsequently at the Paducah site near Paducah, Kentucky, and the Portsmouth site near Portsmouth, Ohio (Figure 1.2). The K-25 plant ceased operations in 1985; however, depleted UF_6 from past operations is currently stored there in large steel cylinders. Depleted UF_6 from past operations at the Paducah and Portsmouth sites is also stored at those two sites in cylinders.

Uranium is still enriched at the Paducah and Portsmouth sites by the United States Enrichment Corporation (USEC). In 1993, the U.S. government created USEC pursuant to the

[1] The K-25 site is now called the East Tennessee Technology Park but is referred to as the K-25 site throughout this PEIS.

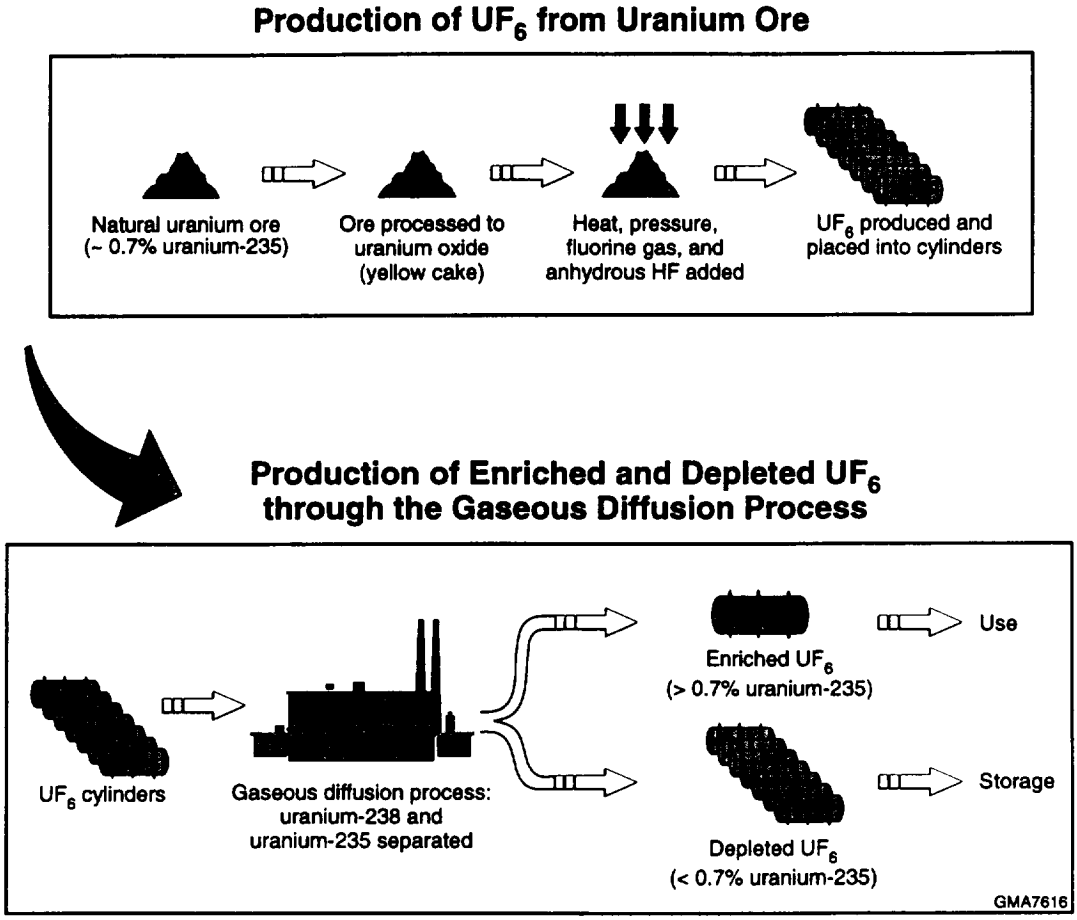

FIGURE 1.1 Schematic Depiction of UF_6 Production and Uranium Enrichment

Energy Policy Act of 1992 (Public Law 102-186) and began the process of privatizing the two operating gaseous diffusion plants. However, after the formation of USEC, DOE retained responsibility for 46,422 cylinders that contained depleted UF_6 produced before 1993 and were being stored at the three sites (28,351 at Paducah, 13,388 at Portsmouth, and 4,683 at K-25). The *USEC Privatization Act* (Public Law 104-134), signed into law on April 26, 1996, provides for the transfer of ownership of USEC from the government to private investors. This act provides for the allocation of USEC's liabilities between the U.S. Government (including DOE) and the new private corporation, including those liabilities for UF_6 cylinders generated by USEC before privatization. The allocation of responsibilities for this depleted uranium is described in a memorandum of agreement (MOA) between the USEC and DOE that was signed in May 1998 (DOE and USEC 1998a). This MOA transfers ownership of approximately 9,400 depleted UF_6 cylinders from USEC to DOE. A second MOA, signed in June 1998, transfers ownership of approximately 2,000 additional depleted UF_6 cylinders to DOE (DOE and USEC 1998b). The total cylinder inventory for which DOE currently has management responsibility consists of approximately 58,000 cylinders. (Additional details about the cylinder inventory are provided in Section 1.5.2).

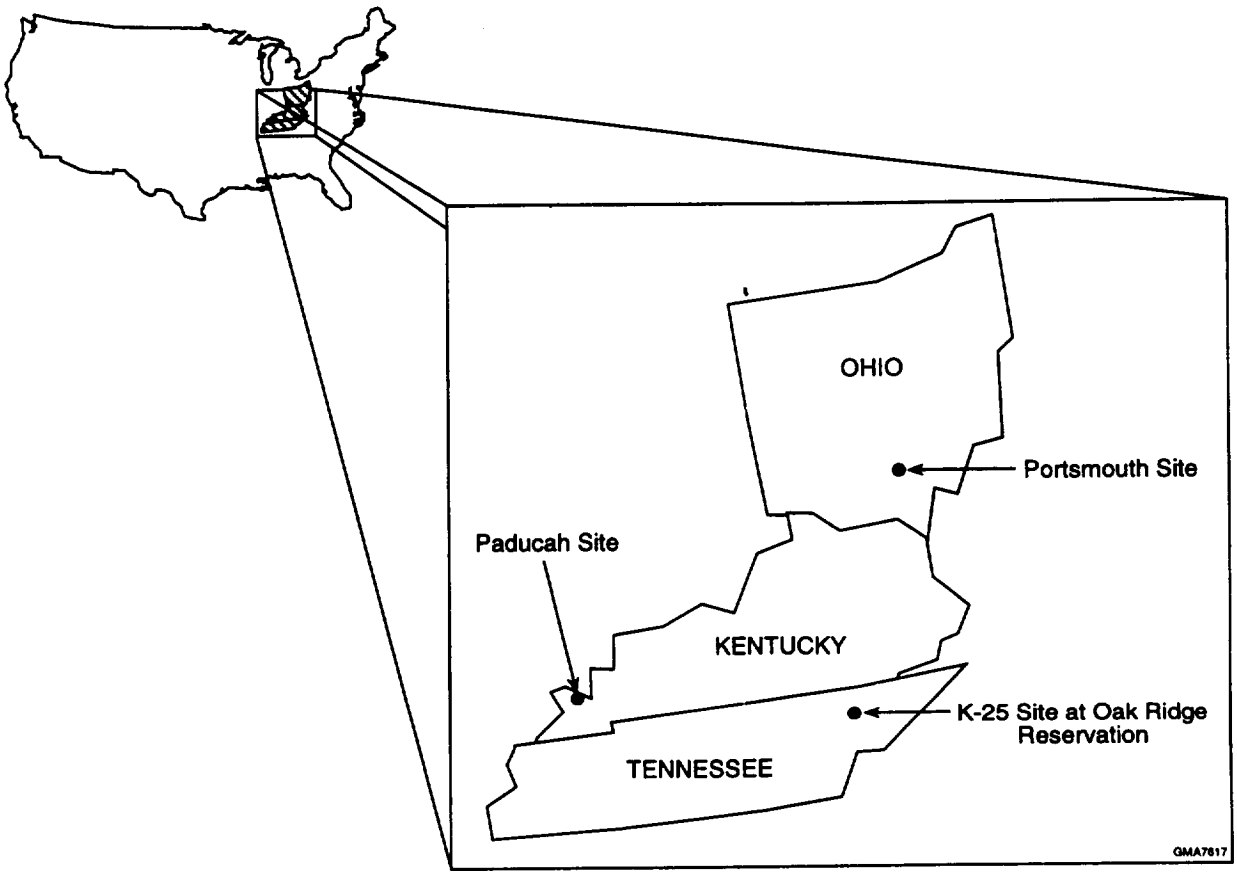

FIGURE 1.2 Depleted UF_6 Storage Locations

Depleted UF_6 has been stored at all three storage sites since the 1950s in large steel cylinders. Several different cylinder types are in use, although the vast majority of cylinders have a 14-ton (12-metric ton) capacity. Two typical cylinder types are shown in Figure 1.3. The 14-ton-capacity cylinders are 12 ft (3.7 m) long by 4 ft (1.2 m) in diameter, with most having a wall thickness of 5/16 in. (0.79 cm) of steel. The cylinders have external stiffening rings that provide support. Lifting lugs for handling are attached to the stiffening rings. A small percentage of the cylinders have skirted ends (extensions of the cylinder walls past the rounded ends of the cylinder), as shown in Figure 1.3. Each cylinder has a single valve for filling and emptying located on one end at the 12 o'clock position. Similar, but slightly smaller, cylinders with a capacity of 10 tons (9 metric tons) are also in use. Cylinders are manufactured in accordance with an American National Standards Institute standard (ANSI N14.1, *American National Standard for Nuclear Materials — Uranium Hexafluoride — Packaging for Transport*) as specified in 49 CFR 173.420, the federal regulations governing transport of depleted UF_6.

Cylinders are initially filled with liquid depleted UF_6, which is allowed to cool over several days. As the liquid UF_6 cools, it contracts, forming a solid that fills approximately 60% of the internal cylinder volume. During storage, a cylinder contains solid UF_6 in the bottom and UF_6 gas

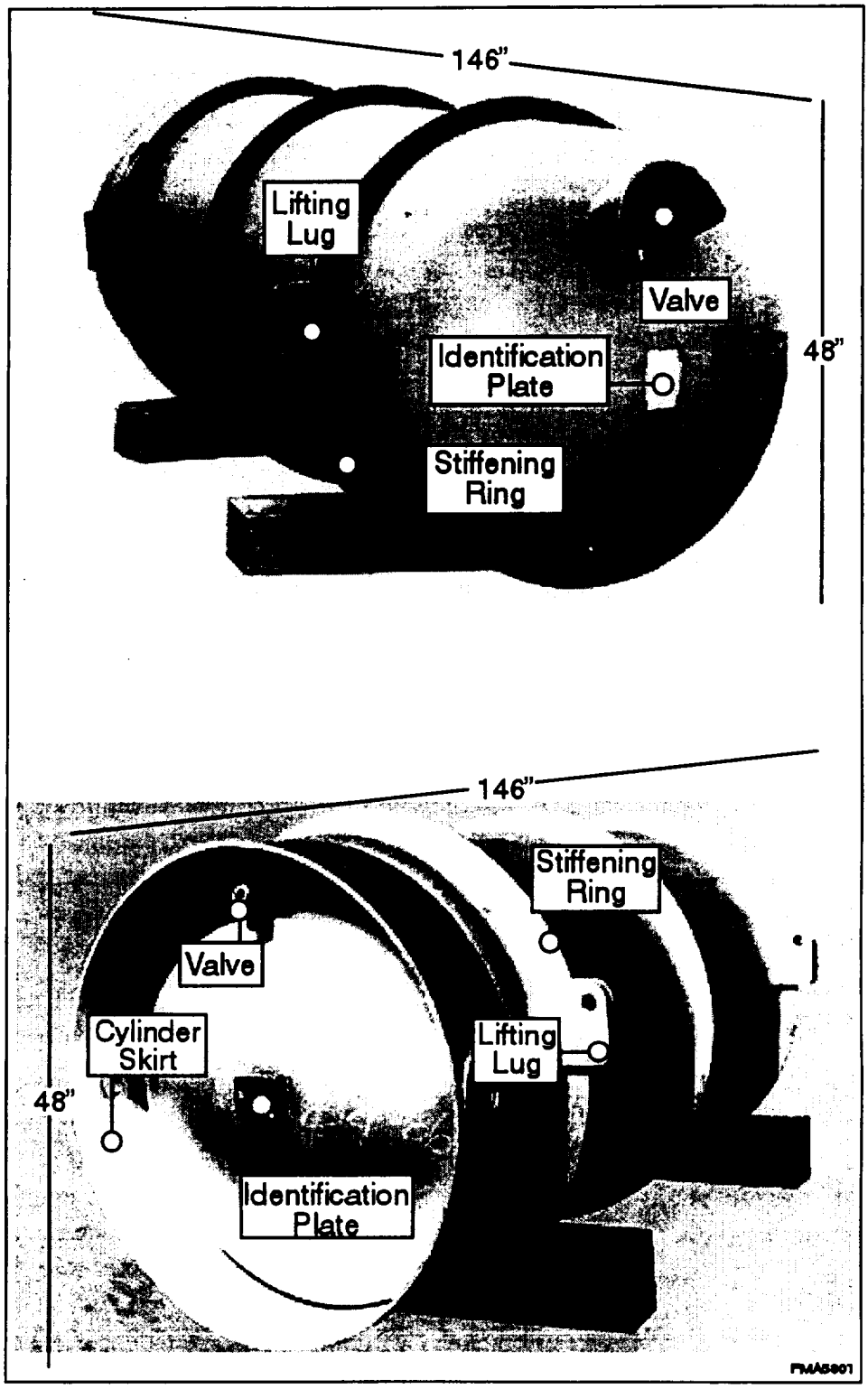

FIGURE 1.3 Typical Depleted UF_6 Storage Cylinders (Cylinders are constructed of steel, with the majority of cylinders having a 14-ton capacity. The bottom cylinder shows a "skirted" end.)

at less than atmospheric pressure in the top. The UF_6 inside the cylinder combines with the iron on the inner surfaces to form a surface layer of iron fluoride that inhibits internal corrosion. Because the pressure within the cylinders is less than atmospheric pressure, if a leak develops, air rushes into the cylinder until the pressure is equalized; UF_6 gas is not released initially, but HF gas is slowly released because moisture in the incoming air reacts with the UF_6.

The depleted UF_6 cylinders managed by DOE at the three sites are typically stacked two cylinders high in large areas called yards (Figure 1.4). Current management of this material requires safe storage, with minimum risks to workers, members of the general public, and the environment. Because storage began in the early 1950s, many of the cylinders now show evidence of external corrosion. Before 1998, seven cylinders (one at Paducah, two at Portsmouth, and four at K-25) had been identified to have developed holes (breaches), generally around spots previously damaged by handling activities. Because the depleted UF_6 is a solid at ambient temperatures and pressures, it is not readily released from a cylinder following a leak or "breach." When a cylinder is breached, moist air reacts with the exposed UF_6 solid and iron, resulting in the formation of a dense plug of solid uranium and iron compounds. The plug tends to block the breach for a period of time, so that release of uranium compounds and HF gas occurs very slowly. When the cylinder breaches are identified, either the breaches are repaired or the cylinder contents are transferred to new cylinders as soon as possible.

DOE maintains an active cylinder management program to improve storage conditions in the cylinder yards, monitor cylinder integrity, conduct routine inspections for breaches, and maintain and repair cylinders as needed. (Details of DOE's cylinder management program are provided in Appendix D.) In 1998, one additional cylinder breach occurred during the course of cylinder maintenance operations (i.e., cylinder painting); previous corrosion modeling had predicted that some additional cylinder breaches might be detected or occur during such activities. (Details on corrosion modeling predictions and breached cylinders are given in Appendix B.) The cylinder management program includes provisions for patching newly identified breached cylinders to eliminate releases of material.

DOE has responsibility for continued management of the depleted UF_6 cylinders stored at the Paducah, Portsmouth, and K-25 sites. The management plan in place during much of the preparation of this PEIS was to continue safe storage of the cylinders and, if no alternative uses for the depleted uranium were found to be feasible by about the year 2010, take steps to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020. The U_3O_8, which is more chemically stable than UF_6,would be stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste (LLW). This plan was based on reserving depleted UF_6 for future defense needs and other potential productive and economically viable purposes, including possible reenrichment in an atomic vapor laser isotope separation plant, conversion of UF_6 to depleted uranium metal for fabrication of penetrators (anti-tank weapons) for military use, and use as fuel in advanced liquid metal nuclear reactors.[2]

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[2] Further details of the former management plan are described in Sewell (1992).

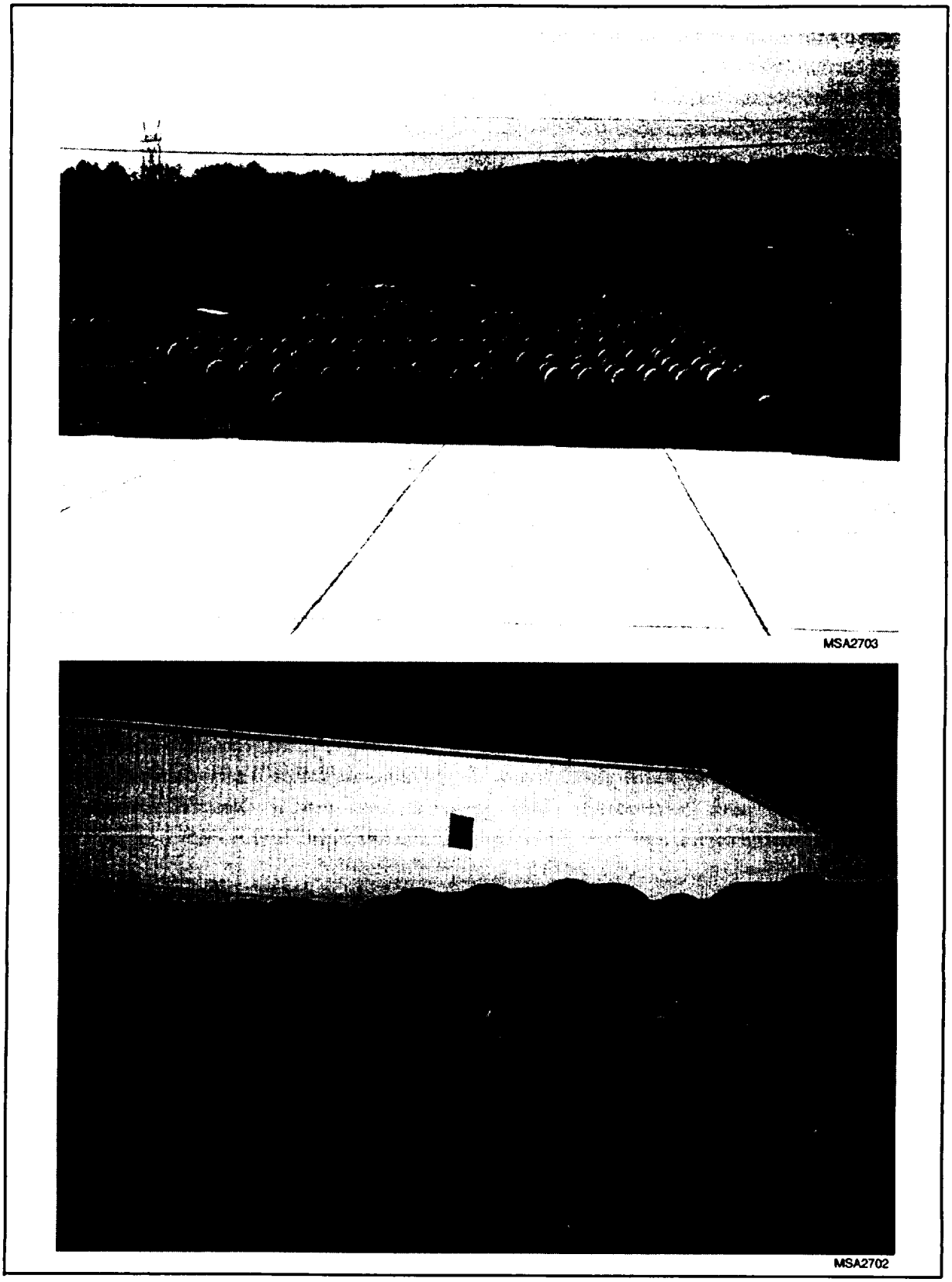

FIGURE 1.4 Depleted UF_6 Cylinders in Storage Yards

Since the former plan was put in place, several developments have occurred that suggest this plan should be revised. For example, the *Energy Policy Act of 1992* assigned responsibility for uranium enrichment and development of atomic vapor laser isotope separation to the USEC, the demand for penetrators has diminished, and the advanced liquid metal nuclear reactor program has been canceled. In addition, stakeholders near the current cylinder storage sites have expressed concerns regarding potential environmental, safety, health, and regulatory issues associated with the continued storage of the depleted UF_6 inventory. The Ohio Environmental Protection Agency issued a Notice of Violation to DOE (which has since been resolved), and the Defense Nuclear Facilities Safety Board (DNFSB) provided a recommendation to the Secretary of Energy regarding improvements in the management of depleted UF_6 (DNFSB 1995).

DOE also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the depleted UF_6 stored at the K-25 site. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from K-25 or complete the conversion of their contents by December 31, 2009.

In July 1998, the President signed Public Law 105-204 which provides, in part, the following (see Appendix N for the complete text of Public Law 105-204):

> *(a) PLAN. – The Secretary of Energy shall prepare, and the President shall include in the budget request for fiscal year 2000, a Plan and proposed legislation to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to commence construction of, not later than January 31, 2004, and to operate, an onsite facility at each of the gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio, to treat and recycle depleted uranium hexafluoride consistent with the National Environmental Policy Act.*

DOE provided its initial plan for the conversion of depleted UF_6, responsive to Public Law 105-204, to Congress on March 12, 1999. In addition, it issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999 (U.S. Department of Commerce 1999). Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

At this time, DOE has not recommended to the President that any additional legislation be proposed. Any proposal to proceed with the location, construction, and operation of a facility or facilities will involve additional review under NEPA.

1.2 PURPOSE AND NEED

The purpose of this PEIS is to reexamine DOE's management strategy for depleted UF_6 and alternatives to that strategy; DOE needs to take action in response to current economic, environmental, and legal developments. This PEIS examines the environmental consequences of alternative strategies of long-term storage, use, and disposal of the depleted UF_6 inventory. A long-term management strategy will be selected in the Record of Decision, which is scheduled to be issued no sooner than 30 days after the issuance of this PEIS.

1.3 PROPOSED ACTION

The proposed action assessed in this PEIS is DOE's selection of a long-term management strategy for depleted UF_6 that will be implemented following the Record of Decision. A strategy is a set of activities or steps for managing depleted UF_6, from its current storage at the three DOE storage sites to ultimate use, long-term storage, or disposal. The alternative strategies considered in the PEIS evaluate options for continued storage of cylinders, conversion of the UF_6 to other chemical forms, use of the uranium as a metal or an oxide, long-term storage, disposal, and/or transportation. The time period for which activities were assessed for all strategies was approximately 40 years: generally 10 years for siting, design, and construction of any required new facilities; about 26 years for operations; and, when appropriate, about 4 years for monitoring.[3] In addition, for the continued storage component of all alternatives and for the disposal alternative, long-term impacts (primarily from potential groundwater contamination) were estimated. The actual implementation schedule would depend on the ultimate strategy selected in the Record of Decision and on other considerations, and activities could continue beyond the 40-year period. DOE will conduct additional NEPA reviews for such activities as appropriate. The alternative management strategies assessed in this PEIS are described and compared in Chapter 2.

The PEIS provides a broad environmental analysis of the various programmatic management strategies available to DOE. DOE identified a preferred management strategy in the draft PEIS and modified the strategy in this final PEIS (see Section 2.5) on the basis of public comments received on the draft PEIS.

1.4 DEPLETED URANIUM HEXAFLUORIDE MANAGEMENT PROGRAM

The Office of Nuclear Energy, Science and Technology within DOE is responsible for the management of the depleted UF_6 generated by enrichment activities and currently stored at the Paducah, Portsmouth, and K-25 sites. To accomplish long-term management, a Depleted Uranium Hexafluoride Management Program was established that includes two sequential

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[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

phases: (1) selection of a strategy for long-term management of depleted UF_6 followed by (2) implementation of the strategy selected, including selection of specific technologies, locations, facilities, and processes that may be required. The first program phase, strategy selection, is currently proposed and is the subject of this PEIS. A Record of Decision for this PEIS is expected to be published in the *Federal Register* (FR) no sooner than 30 days after the issuance of this PEIS. The Record of Decision for Phase I will be based on the results of this PEIS, as well as other information, including the information presented in a cost analysis report and an engineering analysis report (Figure 1.5). The Record of Decision will document the management strategy selected and will describe how it was selected from among several alternatives. One consideration in selecting a strategy is the assessment of potential environmental impacts associated with the alternatives.

A Two-Phased Approach: Two Levels of Decision Making

The Depleted Uranium Hexafluoride Management Program is pursuing a two-phased approach to long-term management of depleted uranium hexafluoride (UF_6).

Phase I is the subject of this PEIS and concerns the selection of a long-term management strategy. A strategy is a general approach to managing depleted UF_6, such as long-term storage, use, or disposal of some or all of the material. The strategy selected in Phase I will be announced in a Record of Decision to be issued no sooner than 30 days after the issuance of this PEIS. The selected strategy will identify major management activities required for ultimate disposition of depleted UF_6. Specific sites or technologies to be used would be identified in the next phase.

Phase II will begin following the Record of Decision and will involve the evaluation and selection of specific sites and technologies necessary to implement the strategy selected in Phase I. Phase II will include appropriate NEPA reviews for site and technology selection activities.

To support the evaluation of alternative management strategies for Phase I, DOE conducted engineering analyses to identify the technical characteristics associated with various potential management alternatives. The engineering analyses resulted in the preparation of two reports: the technology assessment report, *Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride*, which was released on June 30, 1995 (Lawrence Livermore National Laboratory [LLNL] 1995); and the engineering analysis report, *Depleted Uranium Hexafluoride Management Program; Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* (LLNL 1997a), which was released in May 1997.

Prior to preparing these two reports, DOE issued a Request for Recommendations (59 FR 56324) on November 10, 1994, soliciting suggestions for potential uses of depleted UF_6 and for any technologies that could facilitate the long-term management of depleted UF_6. The responses were evaluated by independent technical reviewers and documented in the technology assessment report. The technology assessment report evaluates the potential feasibility of uses for the depleted UF_6 and of technologies for converting the material to other chemical forms, and provides a consolidation of the reviewers' evaluations of all recommendations received. These evaluations, along with other considerations, were used to develop representative technology options considered in this PEIS.

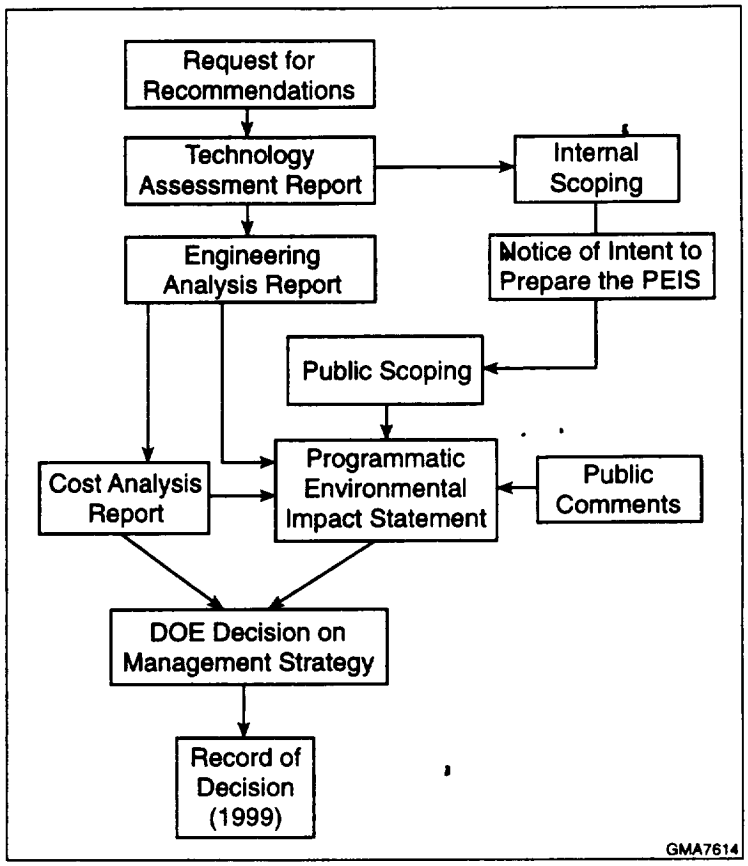


FIGURE 1.5 First Phase of the Depleted Uranium Hexafluoride Management Program

The engineering analysis report (LLNL 1997a) provides a more detailed, in-depth technical analysis of representative management options identified in the technology assessment report. It provides design and operational data for several different types of activities, including options for the preparation of UF_6 cylinders for shipment, conversion of UF_6 to other chemical forms, long-term storage of uranium material, manufacture and use of products containing uranium, and disposal. The engineering analysis report is the primary source of technical data and information for the alternatives evaluated in this PEIS and is incorporated by reference. The engineering analysis report includes descriptions of facility layouts, resource requirements, and construction requirements; estimates of effluents, wastes, and emissions during operations; and descriptions and estimated frequencies for a range of potential accident scenarios. These facility design data, as well as environmental setting information, were used as input to the calculational models or "tools" for estimating potential environmental impacts that could result under each alternative. LLNL's summary of the engineering analysis report is included in its entirety in Appendix O.

DOE also initiated a separate study of the costs of various technology options. The engineering analysis, including the technology assessment report and engineering analysis report, serves as the basis for the cost analysis, which provides estimates of the life-cycle costs associated

with long-term management strategies for depleted UF_6. The cost analysis report (LLNL 1997b) was released in May 1997.

Following publication of its Record of Decision, DOE plans to begin a process for selecting sites and technologies necessary to implement the selected strategy. This latter activity is referred to throughout this PEIS as the "second tier," or "Phase II," of DOE decisions regarding depleted UF_6 management. The second tier will include the appropriate NEPA analyses and reviews needed for decisions on site selection, selection of specific technologies for management activities, type and design of facilities, and vendors' industrial processes, as required by the selected alternative.

1.5 SCOPE OF THIS PEIS

Scope refers to the range of actions, alternatives, and impacts to be considered in an EIS. An agency generally determines scope through a two-part process: internal scoping and public scoping. Internal scoping refers to efforts within the agency to identify potential alternatives, identify important issues, and determine the analyses to be included in an EIS. Public scoping refers to the request for public comments on the proposed action and on the results of internal scoping. Public scoping includes consultation with federal, state, and local agencies as well as requests for comments from stakeholder organizations and members of the general public.

On the basis of input received during the public scoping process, the federal agency responsible for the proposed action (DOE) prepares a draft EIS and makes it available to the public for their review and comment. The "public" is broadly defined and includes any and all interested or affected parties, including interested or affected private citizens; state, local, and tribal governments; environmental groups; and civic and community organizations. The responsible agency evaluates the comments received and revises the EIS before issuing it as a final document. The public scoping process for this PEIS is summarized in Section 1.5.1.1. The public review of the draft PEIS and major changes made to the draft before the issuance of the final PEIS are outlined in Section 1.5.1.2.

1.5.1 Public Participation

1.5.1.1 Summary of Public Scoping for the Draft PEIS

DOE published a Notice of Intent to prepare this PEIS, entitled *Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, on January 25, 1996 (61 FR 2239), beginning a 60-day scoping period. The Notice contained DOE's preliminary results of internal scoping, including a description of the proposed action, alternatives, and approach to EIS preparation. In addition to providing information on the PEIS, the Notice of Intent invited public participation in determining the scope of the PEIS. Comments were requested by correspondence and by participation in one or more public scoping meetings.

Three PEIS public scoping meetings were held between February 13 and February 20, 1996 — one near each depleted UF_6 storage site. A total of 300 persons attended the meetings, and 169 comments were received. DOE also provided several alternative means for public involvement. A fact sheet titled "Overview of the Programmatic Environmental Impact Statement" was mailed to more than 3,800 individuals and organizations identified by the three current storage sites and through the DOE stakeholder mailing list as parties potentially interested in the PEIS. The fact sheet requested comments and gave directions on how comments should be sent to DOE. In addition, a World Wide Web site was developed, which included an overview of the project, fact sheets, links to other useful Internet sites (e.g., DOE's NEPA Internet site), and directions on how to comment.

The public scoping process generated a total of 235 comments on the proposed scope of the PEIS. These comments were examined to finalize the proposed scope of the PEIS. Comments were related primarily to nine major issues: (1) general environmental concerns, (2) current management, (3) storage, (4) conversion, (5) use, (6) cost, (7) disposal, (8) transportation, and (9) policy issues. Appendix L of this PEIS provides a summary of these comments and a discussion of the comments' effects on the scope of the PEIS, including where scope was changed and where change in scope was inappropriate.

1.5.1.2 Public Review of the Draft PEIS

The draft PEIS was mailed to stakeholders in mid-December 1997, and a notice of availability was published by the U.S. Environmental Protection Agency (EPA) in the *Federal Register* on December 24, 1997. In addition, the entire PEIS was also made available on the World Wide Web at the same time. Stakeholders were encouraged to provide comments on the draft PEIS during a 120-day review period, from December 24, 1997, until April 23, 1998. Comments could be submitted by a toll-free number, by fax, by letter, by e-mail, or through the World Wide Web site. Comments could also be submitted at four public hearings held during a period from February 19, 1998, to March 10, 1998. Public hearings were held near each of the three current storage sites (Paducah, Kentucky; Oak Ridge, Tennessee; and Portsmouth, Ohio) and another in Washington, D.C.

A total of about 600 comments were received during the comment period. The comments received and DOE's responses to those comments are presented in Volume 3 of this PEIS. Several revisions were made to the draft PEIS on the basis of the comments received. A summary of the major issues raised by the reviewers of the draft PEIS and DOE's resolution of these issues are as follows:

- *Comments related to the preferred alternative.* Many of the reviewers questioned DOE's preference for beginning to convert the depleted UF_6 inventory to uranium oxide or uranium metal only as uses for these materials became available. Several reviewers expressed a desire for DOE to start conversion as soon as possible. Conversion to U_3O_8 was the option most often

cited as preferred, although several reviewers thought conversion to metal would be more advantageous. In addition, many reviewers expressed doubt about the prospects for any widespread uses for depleted uranium now or in the future.

After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Section 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under this revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal products become available. The impacts of the preferred alternative are discussed in Sections 2.5.2, 5.7, and 6.3.7 of the PEIS.

- *Comments related to seismic hazards at the Paducah site.* Several reviewers commented that the draft PEIS did not adequately address the seismic hazards at the Paducah site. They requested that DOE review new information that came to light very recently and reevaluate the risks associated with potential earthquakes at Paducah.

  In response, DOE reviewed those references that were available at the time this final PEIS was prepared. DOE determined that the analyses performed as part of the safety analysis reports recently completed at the three current storage sites (including Paducah) and for this PEIS were adequate. However, one reference identified in a comment from the State of Kentucky was not available in time to be considered in the preparation of the final PEIS. DOE will review that reference and any other data when they become available and take appropriate action to maintain the safety basis of its cylinder management program. In addition, if new facilities are to be constructed at Paducah or any other site, the latest information concerning seismic hazards at that site would be factored into the design of the new facilities.

- *Comments related to potential life-cycle impacts.* Several reviewers stated that depleted uranium and products made from using depleted uranium in various chemical forms would eventually need to be disposed of. They requested that the PEIS include a discussion of impacts for the disposal of these materials following long-term storage and use. The draft PEIS had included a discussion of potential impacts from management activities through the year 2039 for all alternatives and evaluation of long-term impacts (primarily from groundwater contamination) from the continued storage component of all alternatives and for the disposal alternative.

  In response to commentors' requests for life-cycle impact analysis, a new section was added to this PEIS (Section 5.9) to discuss issues related to the

potential impacts of the long-term (beyond 2039) management of materials containing depleted uranium under all alternatives. However, because of the uncertainties associated with the events that would occur far into the future and with the regulatory atmosphere at that time, the discussion is limited to issues that would need to be considered and the options that would be available for managing the material beyond 2039.

- *Comments related to the cylinder inventory.* Several reviewers questioned the accuracy of the reported number of DOE-owned cylinders of depleted UF_6 (46,422) considered in the draft PEIS. Other reviewers requested that USEC-generated cylinders also be included within the scope of the PEIS.

  Upon review, confusion related to the size of the DOE cylinder inventory appears to have resulted because the numbers published in various DOE reports sometimes included only the full cylinders of depleted UF_6 and other times included not only the full cylinders but also heel cylinders and cylinders containing natural UF_6. Although the number 46,422 that is used in the draft PEIS was accurate at the time the document was published, subsequent privatization of USEC and transfer of some cylinders from USEC to DOE changed the inventory of depleted UF_6 that falls within the scope of the PEIS (see Section 1.5.2). Chapter 6 has been added to the PEIS and Chapter 2 and the Summary have been revised so the PEIS includes the impacts associated with the management of additional USEC-generated cylinders. The heels cylinders are also included in the scope of the PEIS (see Section 1.5.2).

- *Comments related to current cyclinder management.* Several reviewers raised questions and concerns about the current management of the cylinders at the three DOE locations.

  In response to these concerns, it has been emphasized that DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision-making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion, and regular inspection and surveillance of the cylinders and storage yard conditions.

The changes made in response to public comments, including the inclusion of up to 15,000 USEC cylinders, did not affect the types or overall significance of the environmental impacts presented in the draft PEIS. Although the estimated impacts did increase by up to 30% in some assessment areas, this increase was generally not significant because the impacts were typically small to begin with. Many impacts did not change at all as a result of including the USEC cylinders

because these impacts were related to factors that were unaffected by the inventory increase. For example, the consequences of potential accidents did not increase, because accidents generally involve only a limited amount of material that would be available, regardless of the overall inventory. In addition, other impacts did not change because they were related to the annual material processing rates, which were assumed to remain the same when the USEC cylinders were included. Consequently, it was not necessary to recirculate the draft PEIS for additional public review. The nature and magnitude of changes in environmental impacts resulting from the addition of USEC cylinders are discussed in Sections 2.4, 2.5, and Chapter 6 of this PEIS.

1.5.2 Cylinder Inventory

This PEIS considers the depleted UF_6 inventory stored at the Paducah site, Portsmouth site, and K-25 site on the Oak Ridge Reservation for which DOE has management responsibility. This inventory includes depleted UF_6 generated by DOE before the formation of USEC in July 1993 as well as depleted UF_6 generated by USEC that has been or will be transferred to DOE. Specifically, the PEIS considers the management of 46,422 cylinders generated by DOE and up to 15,000 cylinders generated by USEC.

The depleted UF_6 inventory generated by DOE before July 1993 consists of 46,422 cylinders that contain approximately 560,000 metric tons of UF_6; of these, 28,351 cylinders are located at Paducah (342,000 metric tons), 13,388 are at Portsmouth (161,000 metric tons), and 4,683 are at K-25 (56,000 metric tons).

In addition to the DOE cylinder inventory, management responsibility for approximately 11,400 depleted UF_6 cylinders (about 137,000 metric tons) was transferred from USEC to DOE by the signing of two MOAs. The MOA between DOE and USEC related to depleted uranium generated before the privatization date was signed in May 1998 (DOE and USEC 1998a). It transferred management responsibility for approximately 9,400 cylinders (about 6,600 cylinders stored at Paducah and about 2,800 stored at Portsmouth) from USEC to DOE. A second MOA between DOE and USEC related to depleted uranium, signed in June 1998, transfers approximately 2,000 depleted UF_6 cylinders from USEC to DOE between 1999 and 2004 (DOE and USEC 1998b). (The locations of these cylinders are not specified in this second agreement.)

To account for uncertainties related to the management of depleted UF_6 generated by USEC in the future, the analysis in the PEIS considers management of up to 15,000 USEC-generated cylinders (approximately 180,000 metric tons). For the purposes of analysis, it was assumed that 12,000 of the USEC-generated cylinders would be managed at Paducah and 3,000 would be managed at Portsmouth.

Also included in the scope of this PEIS is a total of approximately 200 cylinders at the three sites that contain small amounts of material. These cylinders, which are termed "heels" cylinders, contain a total of about 2,300 lb of depleted UF_6, less than 0.0002% of the inventory. A cylinder heel

is defined as the residual amount of nonvolatile material remaining in a cylinder after removal of the depleted UF_6. For this PEIS, it has been assumed that the heels cylinders will continue to be safely stored under the cylinder management program. If a management strategy that involves conversion is selected, these existing heels cylinders will be treated in the same way as the heels cylinders that would be generated from the conversion process. Details on the treatment of heels cylinders are given in Appendix F, Section F.2.

1.5.3 Alternative Management Strategies and Types of Activities

The alternatives that are evaluated and compared in this PEIS represent the consensus of both DOE and the general public regarding reasonable strategies for the long-term management of depleted UF_6. The alternative management strategies were developed and announced in the Notice of Intent to prepare this PEIS. The following alternatives are assessed in the PEIS: the no action alternative, which considers continuation of current cylinder storage and management practices indefinitely; two long-term storage alternatives; two use alternatives; and one disposal alternative. These alternatives, as well as DOE's preferred alternative, are described in detail in Chapter 2.

In addition to the management strategies considered in this PEIS, the use of some depleted UF_6 is being considered pursuant to other DOE programs, such as the disposition of surplus plutonium. Uses being considered by other DOE programs, which are subject to future decisions and other NEPA reviews, would generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy.

At the time of public scoping, the no action alternative was based on the course of action outlined by Sewell (1992) (Section 1.1). This course of action included chemical conversion of depleted UF_6 to the oxide U_3O_8, beginning in the year 2020 and continuing for 20 years, followed by storage of the U_3O_8. After public scoping and based on internal DOE reviews, the no action alternative was modified to be the continued storage of UF_6 cylinders indefinitely at the three current storage sites.

Each alternative consists of several management activities. The types of management activities included in the alternatives have been grouped into seven major categories, as shown in Figure 1.6. Within each category, several representative options, consisting of either design or technology variations, were considered. It is important to note that the options are representative in nature and were selected to provide a basis for comparing broad, programmatic management strategies. These seven categories of activities formed the main building blocks for evaluating all of the alternatives in the PEIS — each alternative strategy is composed of a combination, or series, of several of these management activities. The following categories of activities were included:

- ***Continued Cylinder Storage:*** Depleted UF_6 cylinders would continue to be stored in yards at the three current storage sites for some period of time for all

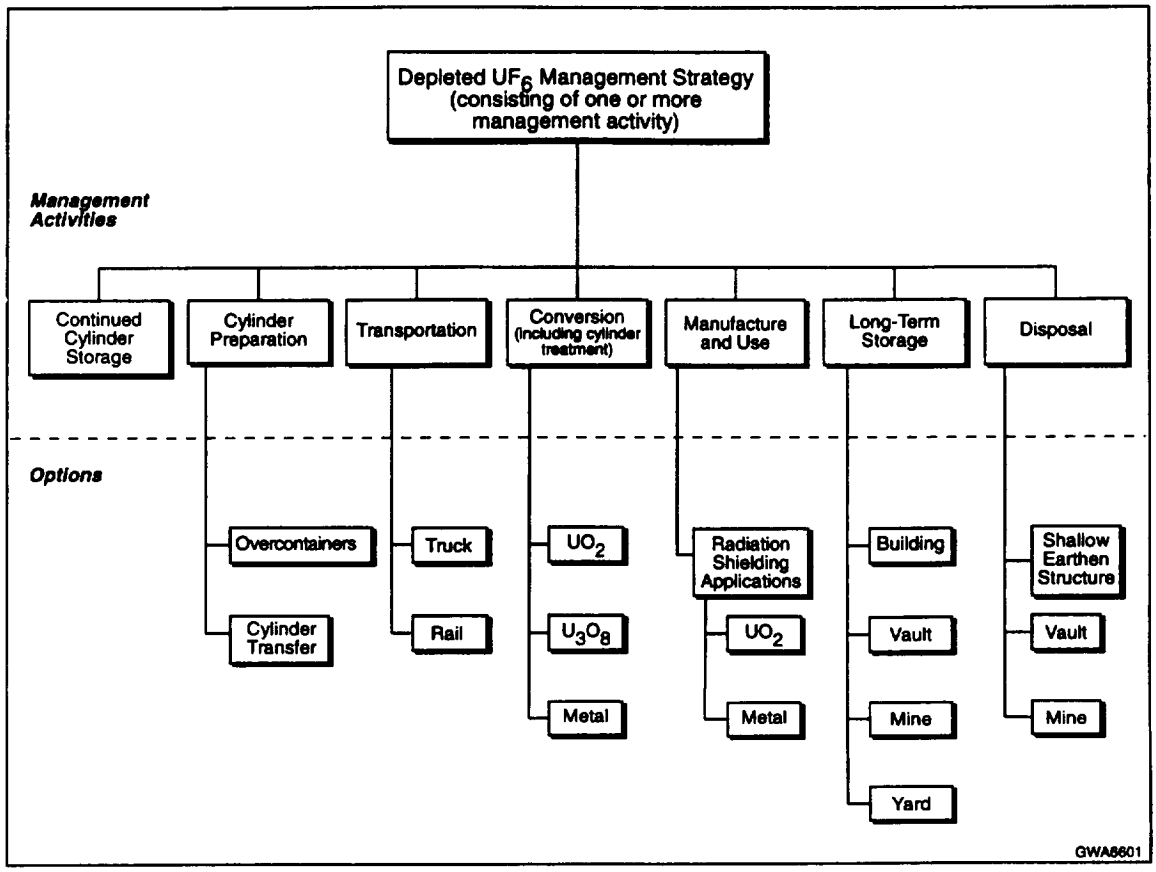


FIGURE 1.6 Options for Depleted UF_6 Management Activities (All alternative strategies consist of some combination of these activities.)

alternatives. During that time, current cylinder management practices would continue to ensure that cylinders were maintained in a safe condition.

- ***Cylinder Preparation Options:*** If depleted UF_6 cylinders were to be shipped from the current storage sites, some cylinders might require preparation to make them suitable for transportation. Two options were considered for these activities: (1) use of overcontainers, which are large metal containers certified to meet U.S. Department of Transportation (DOT) shipping requirements, into which cylinders could be placed, and (2) use of a cylinder transfer facility, which could be used to transfer the UF_6 contents from old cylinders to new cylinders.

- ***Transportation Options:*** It is possible that the cylinders might have to be transported from the current storage sites, depending on the ultimate locations selected for conducting future management activities. Therefore, the transport of cylinders by both truck and rail was evaluated. Also considered was the

transport of all other materials that might be required for or produced by the different alternative strategies.

- ***Conversion Options:*** Some alternatives would involve the conversion of depleted UF_6 into another chemical form prior to long-term storage, use, or disposal. The different chemical forms of uranium considered include two uranium oxides — U_3O_8 and uranium dioxide (UO_2) — and uranium metal. The treatment of emptied cylinders is also considered.

- ***Manufacture and Use Options:*** Depleted UF_6 could potentially be used to manufacture products with beneficial applications. The analysis in this PEIS considered, as a representative application, the use of a converted form of depleted UF_6 to manufacture a dense material to be used for shielding against gamma radiation. The selection of shielding as a representative use option is not intended to imply that the PEIS will be used to select a specific end-use or will preclude other uses.

- ***Long-Term Storage Options:*** Depleted UF_6 cylinders or uranium oxide (following conversion) could be placed into long-term storage. Four different long-term storage options were considered: buildings, belowground vaults, mines, and yards.

- ***Disposal Options:*** Depleted UF_6 could be disposed of as LLW following conversion to an oxide form. Three disposal facility options were considered: shallow earthen structures, belowground vaults, and mines.

Impacts resulting from the decontamination and decommissioning of any required facilities are expected to be relatively small when compared with the impacts resulting from the construction and operation of these facilities. Inclusion of the decontamination and decommissioning impacts would not affect the comparison of the programmatic alternatives analyzed and the conclusions reached in this PEIS. The decontamination and decommissioning impacts would be considered in the follow-on site-specific and facility-specific environmental planning and analysis documents.

1.5.4 Environmental Setting Considerations

Because this PEIS is an analysis of programmatic strategies, rather than specific siting alternatives, certain impacts have been assessed using representative or generic environmental settings. In particular, impacts associated with potential conversion, long-term storage, manufacturing, transportation, and disposal activities were assessed assuming representative or generic site environmental conditions. The purpose of this approach was to provide as substantive an assessment as possible and to allow for a comprehensive comparison of alternative management strategies. The activities that would normally take place at the current storage sites (Paducah, Portsmouth, and K-25)

were assessed using site-specific data. These activities include continued cylinder storage and cylinder preparation for off-site shipment.

After the Record of Decision, DOE would evaluate potential facility locations and whether the facilities would be owned or operated by the private sector or the federal government. Depending on the strategy selected, DOE would evaluate a range of reasonable alternatives to select the sites for potential conversion, long-term storage, manufacturing, and disposal facilities. These subsequent analyses would be performed using site-specific environmental data.

Site selection activities would include an evaluation of site characteristics, such as the site's potential response to seismic events, potential for flooding, and geology, to ensure that suitable locations were chosen. Following site selection, any new facilities would be designed and built to meet engineering and construction standards and requirements appropriate for the selected location and the mission of the facility.

Environmental Settings Used in the PEIS Analysis

Existing site environmental settings were used for analysis of continued cylinder storage activities for all alternatives. Site-specific data were also used for analysis of cylinder preparation activities for off-site shipment of cylinders. The depleted UF_6 cylinders are currently located at the Paducah site, Portsmouth site, and K-25 on the Oak Ridge Reservation.

Generic environmental settings were used for analysis of manufacturing, disposal, and long-term storage in mines. These settings were selected on the basis of generalized environmental characteristics — such as a wet (or eastern United States) location and a dry (or western United States) location.

Representative environmental settings were used for analysis of conversion and long-term storage in yards, buildings, and vaults. These settings were selected on the basis of conditions at sites that, although not proposed for that activity, might be somewhat similar to an eventual site. In this PEIS, the conditions at the current storage sites were used to define a range of representative environmental settings. For the transportation analysis, representative route characteristics were based on national-average data.

1.5.5 Human Health and Environmental Issues

This PEIS evaluates and compares the potential impacts on human health and the environment for the alternative management strategies considered. In general, the PEIS emphasizes those impacts that may differentiate among alternatives or are of special interest to the general public (such as potential radiation effects). The assessment of potential environmental impacts is based primarily on the preliminary engineering data included in the engineering analysis report (LLNL 1997a). That report contains data on cylinder preparation and transportation, conversion, manufacturing, long-term storage, and disposal. The report includes descriptions of facility layouts; discussion of resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios for the depleted UF_6 management options considered in this PEIS (see Appendix O for a summary of the engineering analysis report).

The PEIS includes the assessment of impacts to human health and safety, air, water, soil, biota, socioeconomics, cultural and archeological sites, site waste management capabilities, resource requirements, and environmental justice. Issues judged by DOE to be of greatest concern or public interest, and receiving more detailed analysis, include impacts to human health and safety, air and water, waste management capabilities, and socioeconomics. These issues are consequently treated in greater detail in the PEIS.

The environmental impacts for each alternative were determined by combining, as appropriate, the potential impacts associated with each of the individual activities that would be required to implement the alternative. The level of analysis conducted depended on the specific activity considered. The potential impacts during continued cylinder storage and cylinder preparation for shipment activities were evaluated for the environmental settings at the three current storage sites; potential impacts of conversion, manufacture and use, long-term storage, transportation, and disposal activities were evaluated for representative or generic environmental settings (see Chapter 3 for descriptions of the affected environments of these settings). The intent of the analysis at representative or generic environmental settings was to estimate a reasonable range of potential impacts to allow for a meaningful comparison of alternative strategies. Subsequent analysis with site-specific environmental data will be performed during the Phase II studies and NEPA reviews.

Estimating environmental impacts for alternative approaches to depleted UF_6 management is subject to uncertainty, primarily as a consequence of the (1) preconceptual nature of facility designs, (2) unknown location of future facilities, and (3) characteristics of the methods used to estimate impacts. This impact assessment was designed to ensure — through selection of assumptions, models, and input parameters — that impacts would not be underestimated and that relative comparisons among the alternatives would be valid and meaningful. This approach was developed by uniformly applying common assumptions to each alternative and by choosing assumptions intended to produce conservative estimates of impacts — that is, assumptions that would lead to overestimates of the expected impacts. Although uncertainty may characterize estimates of the absolute magnitude of impacts, a uniform approach to impact assessment enhances the ability to make valid comparisons among alternatives. This uniform approach was implemented in the analyses conducted for the PEIS to the extent practicable.

1.6 RELATIONSHIP TO OTHER NEPA REVIEWS

DOE has prepared, or is in the process of preparing, other NEPA reviews that are related to the management of depleted UF_6 or to the three current depleted UF_6 storage sites. These NEPA reviews are as follows:

- *Disposition of Surplus Highly Enriched Uranium, Final Environmental Impact Statement* (DOE 1996a): This EIS addresses the disposition of a nominal 200 metric tons of highly enriched uranium declared surplus to the national security needs of the United States. Alternatives include several

approaches for blending down the highly enriched material to make it nonweapons-usable and suitable for fabrication into fuel for use in commercial nuclear reactors. Commercial use alternatives included transferring up to 50 metric tons of highly enriched uranium to USEC facilities for blending with natural uranium. The draft EIS was issued in October 1995 and the final EIS in June 1996. The Record of Decision (August 5, 1996) calls for blending, over time, as much material as possible (up to 85%) for commercial use, and blending the remainder for disposal as low-level waste. This EIS is related to the Depleted UF_6 PEIS in that USEC facilities are located at two of the current storage sites for depleted UF_6, Paducah and Portsmouth. The cumulative impacts analysis in the Depleted UF_6 PEIS takes into account the results of this EIS on disposition of highly enriched uranium.

- *Proposed Sale of Radioactively Contaminated Nickel Ingots Located at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Environmental Assessment* (DOE 1995b): This environmental assessment evaluates the impacts of the sale of radioactively contaminated materials, primarily nickel, that have potential value as a resource. These materials are stored at the Paducah Gaseous Diffusion Plant on the Paducah site. The final environmental assessment and Finding of No Significant Impact were issued in October 1995. This environmental assessment is related to the Depleted UF_6 PEIS because Paducah is currently a storage site for depleted UF_6. The cumulative impacts analysis in the Depleted UF_6 PEIS takes into account the results of this environmental assessment.

- *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a): This EIS comprises a complexwide evaluation of reasonable alternatives for managing existing and reasonably foreseeable amounts of spent nuclear fuel within the DOE inventory through the year 2035. This inventory includes the spent nuclear fuel currently stored at Oak Ridge National Laboratory on the Oak Ridge Reservation. This EIS contains an analysis of the transportation of spent nuclear fuel. That analysis has been referenced where relevant to the transportation analysis for the Depleted UF_6 PEIS. It is also related to the Depleted UF_6 PEIS because if a use alternative were selected, uranium-shielded casks could be used to store spent nuclear fuel. The final EIS was issued in April 1995, and a Record of Decision selecting three regionalized DOE locations for management of spent nuclear fuel (Hanford, Idaho National Engineering Laboratory, and the Savannah River Site) was issued in June 1995.

- *Refurbishment of Uranium Hexafluoride Cylinder Storage Yards C-745-K, L, M, N, and P and Construction of a New Uranium Hexafluoride Cylinder Storage Yard (C-745-T) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Environmental Assessment* (DOE 1996e): This environmental assessment addresses improvements to depleted UF_6 cylinder storage conditions at the Paducah site. It includes both refurbishment of existing storage yards and construction of a new storage yard. A Finding of No Significant Impact has been issued for these activities. In the Depleted UF_6 PEIS, the upgrades planned to occur prior to 1999 are considered to be part of the affected environment for the Paducah site.

- *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (DOE 1996c): This EIS evaluates the potential environmental impacts resulting from activities associated with nuclear weapons research, design, development, and testing, as well as assessing and certifying their safety and reliability. The stewardship portion of the document analyzes the development of three new facilities to provide enhanced experimental capability. The stockpile management portion of this EIS concerns producing, maintaining, monitoring, refurbishing, and dismantling the nuclear weapons stockpile at eight possible sites, including the Oak Ridge Reservation. The final PEIS was released in November 1996, and the Record of Decision was issued on December 26, 1996 (61 FR 68014). A decision was made to downsize certain facilities at the Y-12 Plant on the Oak Ridge Reservation. This EIS is related to the Depleted UF_6 PEIS only because the K-25 site is part of the Oak Ridge Reservation. The cumulative impacts analysis in the Depleted UF_6 PEIS takes into account the results of this EIS on stockpile stewardship.

- *Storage and Disposition of Weapons-Usable Fissile Materials, Final Programmatic Environmental Impact Statement* (DOE 1996d): This EIS evaluates the environmental impacts of alternative approaches for the long-term storage and disposition of weapons-usable fissile materials — that is, highly enriched uranium and weapons-usable plutonium. Alternatives for long-term storage included the no action alternative, upgrade at multiple sites, consolidation of plutonium at one site, and colocation of plutonium or highly enriched uranium at one site. In a Record of Decision issued in January 1997, DOE decided, in part, to store highly enriched uranium in upgraded and consolidated facilities at the Y-12 Plant on the Oak Ridge Reservation. This EIS relates to the Depleted UF_6 PEIS because the K-25 site is also located on the Oak Ridge Reservation. The cumulative impacts analysis in the Depleted UF_6 PEIS takes into account the results of this EIS on storage and disposition of weapons-usable fissile materials.

- *Environmental Assessment for the DOE Sale of Surplus Natural and Low Enriched Uranium* (DOE 1996b): This environmental assessment reviews DOE's proposed action for the sale of about 35.7 million lb (16.2 million kg) U_3O_8 of uranium for subsequent enrichment and fabrication into commercial nuclear reactor fuel. The uranium is currently in the forms of natural and low-enriched UF_6, which is stored at the Paducah and Portsmouth sites (the material considered in this environmental assessment is different than the depleted UF_6 considered in the Depleted UF_6 PEIS). The natural and low enriched UF_6 would be sold to various entities, which could include USEC, currently the only domestic provider of uranium enrichment services; over 60 electric utilities in the United States and abroad; converters; traders; and uranium producers. This environmental assessment is related to the PEIS because of potential cumulative impacts at the Paducah and Portsmouth sites, which are also current depleted UF_6 storage sites. The cumulative impacts analysis of the Depleted UF_6 PEIS takes into account the results of this environmental assessment.

- *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997a): This EIS (referred to herein as WM PEIS) evaluates the impacts of different approaches to the treatment, storage, and disposal of the existing and projected DOE inventory of certain types of waste management programs wastes over the next 20 years. The WM PEIS considers radioactive low-level, high-level, transuranic, and mixed wastes, as well as toxic and hazardous wastes. The amounts of wastes analyzed for treatment, storage, or disposal range from thousands to millions of cubic meters and include wastes generated at the DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. The WM PEIS does not evaluate management of depleted UF_6 because that material is considered a source material, not a waste. The draft PEIS was issued in September 1995 and the final PEIS in May 1997.

  The WM PEIS considers the impacts of waste management at Paducah, Portsmouth, and the Oak Ridge Reservation based on the existing and projected inventories of waste generated during site operations. The three sites are also considered as candidate sites for regionalized waste management sites, and waste management impacts are evaluated for these scenarios as well. Cumulative impacts of current operations, waste management, and proposed future operations are also assessed for the three sites in the WM PEIS. Both the waste management analysis and cumulative impacts analysis in the Depleted UF_6 PEIS take into account the results of the WM PEIS.

- *Surplus Plutonium Disposition Draft Environmental Impact Statement* (DOE 1998a). This EIS examines reasonable alternatives and potential

environmental impacts for the proposed siting, construction, and operation of three types of facilities for plutonium disposition. One of the facilities would fabricate plutonium oxide and depleted uranium oxide into mixed oxide fuel. The mixed oxide fuel fabrication facility would be located at either Hanford, Idaho National Engineering and Environmental Laboratory, Pantex, or the Savannah River Site.

This EIS analyzes the use of approximately 1,000 tons of existing DOE stocks of depleted UF_6. The depleted UF_6 would be shipped from current locations to a commercial facility for conversion to uranium oxide. This material would then be shipped to the mixed oxide fuel fabrication plant. Mixed oxide fuel would be used in existing commercial light water reactors in the United States, with subsequent disposal of the spent fuel in accordance with the *Nuclear Waste Policy Act*. This EIS is related to the PEIS in that it could possibly use a small portion of the depleted UF_6 inventory.

- *Final Environmental Assessment for the Lease of Land and Facilities within the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 1997b). This environmental assessment was issued in November 1997 and evaluates the potential environmental impacts of leasing land and facilities at the K-25 site in Oak Ridge, Tennessee. The leasing program examined represents a reindustrialization effort by DOE, making vacant, underutilized, and/or inactive facilities available to private sector firms or other organizations for industrial, commercial, office, research and development, and manufacturing uses. In addition to increasing the use of DOE-owned resources, the program assessed in this document would reduce costs to DOE by lessening surveillance and maintenance requirements and, in some cases, by having lessees decontaminate facilities on the site. This environmental assessment is related to the PEIS because of potential cumulative impacts at the K-25 site, currently also a depleted UF_6 storage site. The cumulative impacts analysis of the PEIS takes into account the results of this environmental assessment.

- *Draft Environmental Assessment for the Proposed Treatment of Mixed Wastes at the Paducah Gaseous Diffusion Plant Using the Vortec Vitrification System* (DOE 1998b). This environmental assessment, issued as a draft in March 1998, evaluates the potential environmental impacts of building and operating a facility for the Vortec Cyclone Melting System™ at the Paducah site. This system may treat some portion of the LLW, low-level mixed waste (LLMW), and wastes regulated under the *Toxic Substances Control Act* (TSCA) that are stored at the Paducah Gaseous Diffusion Plant, thereby enabling their removal from storage to disposal. This environmental assessment is related to the PEIS because of potential cumulative impacts at the Paducah site, currently also a

depleted UF_6 storage site. The cumulative impacts analysis of the PEIS takes into account the results of this environmental assessment.

1.7 OTHER DOCUMENTS AND STUDIES RELATED TO DEPLETED UF_6 MANAGEMENT

The management of the depleted UF_6 inventory has been independently reviewed by several other agencies and organizations external to the DOE Office of Nuclear Energy, and reports have been released by these groups summarizing their findings. The following is a list of the reports reviewed as a part of the preparation of this PEIS; the results of these reports were included in the PEIS analyses, as appropriate.

- *Defense Nuclear Facilities Safety Board Recommendation 95-1* (DNFSB 1995): In May 1995, the DNFSB issued Recommendation 95-1 regarding the storage of the depleted UF_6 cylinders. This recommendation addressed three items: (1) start of an early program to review the protective coating of cylinders containing the tails (i.e., depleted UF_6) from the historical production of enriched uranium, (2) exploration of the possibility of additional measures to protect these cylinders from the damaging effects of exposure to the elements as well as any additional handling that might be called for, and (3) institution of a study to determine whether a more suitable chemical form should be selected for long-term storage of depleted uranium.

  DOE accepted Recommendation 95-1 in June 1995 and emphasized the following focus areas for its response: removing cylinders from ground contact and keeping cylinders from further ground contact, relocating all cylinders into adequate inspection configurations, repainting cylinders as needed to avoid excessive corrosion, updating handling and inspection procedures and site-specific safety analysis reports (SARs), and completing an ongoing study that would include an analysis of alternative chemical forms for the material. Since 1995, actions have been taken to address each of these focus areas. Several cylinder yards have been reconstructed or newly constructed, and many of the cylinder relocations required to achieve adequate inspection configurations and removal from ground contact have been completed. A cylinder painting program has been initiated; the site-specific SARs have been updated (Lockheed Martin Energy Systems, Inc. [LMES] 1997a,b,c); and a Cylinder Project Management Plan with updated cylinder handling and inspection procedures has been completed (LMES 1997i). In addition, this PEIS, which analyzes alternative management strategies, including various chemical forms of depleted uranium, has been prepared partially in response to the DNFSB recommendation. This PEIS incorporates the information provided in the Cylinder Project Management Plan in its

analysis of the impacts of continued cylinder storage and incorporates the results of the SARs in its cylinder accident impact analyses.

The DNFSB reviews DOE's progress in achieving the objectives of Recommendation 95-1 regularly. Additionally, the Board visits the storage sites on a regular basis and has a resident member in Oak Ridge.

- "Disposition of the DUF_6" (National Research Council 1996): A chapter in a book addressing opportunities for cost reduction in the decontamination and decommissioning of the nation's uranium enrichment facilities was devoted to the problems associated with management of the depleted UF_6 inventory. The main conclusion of the report was that if significant new uses had not been identified by 1998, the conversion of the depleted UF_6 inventory to U_3O_8 for long-term storage should begin, and that conversion should start with cylinders in poor condition. The report also concluded that use of a process in which "recyclable" HF would be produced would be the most feasible approach to liquidation of the large inventory. This PEIS addresses questions similar to those examined in the National Research Council report, but it addresses them in the form of alternative management strategies and in the context of the affected environment, as required under NEPA.

- *Depleted Uranium: A DOE Management Challenge* (DOE 1995c): This report examines the technical feasibility and costs of using depleted uranium for shielding in the form of either metal or a concretelike oxide aggregate. It also addresses the alternative recommending disposal of the inventory.

- *The Ultimate Disposition of Depleted Uranium* (Lemmons et al. 1990): This document concludes that it is desirable to maintain working inventories in the form of depleted UF_6 as long as there is a potential for it to be used and as long as cylinders and storage facilities are adequately monitored and maintained. However, at the time the report was written, it appeared that it would be viable to use only a small portion of the inventory, so the report recommended that the majority of the inventory be converted to U_3O_8 for long-term storage or disposal.

In addition to the above documents, the *Final Environmental Impact Statement for the Construction and Operation of Claiborne Enrichment Center, Homer, Louisiana* (U.S. Nuclear Regulatory Commission [NRC] 1994b) was reviewed for its applicability to analyses conducted for this PEIS. The purpose of the NRC document was to assess the impacts of a gaseous centrifuge uranium enrichment facility. Of interest with respect to this PEIS, the NRC document included an analysis of the impacts from a generic facility for converting depleted UF_6 to U_3O_8, and an analysis of the impacts from disposing of the U_3O_8. The findings of the NRC analysis were similar to the findings of the analyses for this PEIS; specifically, that (1) environmental impacts from the

construction and operation of a generic uranium conversion facility would be small; (2) external doses from airborne releases would be about one million times less than internal doses; (3) disposal of the U_3O_8 in a near-surface facility in a wet environment could lead to radiological exposure doses that exceed the 25 mrem/yr limit given in DOE Order 5820.2A and 10 CFR Part 61 ("Licensing Requirements for Land Disposal of Radioactive Waste"); and (4) disposal of the U_3O_8 in a generic deep disposal site (such as a mine) would not lead to radiological exposure doses that exceed the 10 CFR Part 61 limit. However, the NRC disposal analyses differed from those in this PEIS with respect to environmental conditions at the sites; the NRC analysis did not differentiate between disposal facilities in wet and dry environmental settings. In this PEIS, analyses were conducted separately for disposal in dry and wet environments. Under the assumptions used in this PEIS, disposal in near-surface and deep disposal facilities in a wet environment was found to lead to radiological doses in excess of 25 mrem/yr; disposal in near-surface and deep disposal facilities in a dry environment did not lead to doses in excess of 25 mrem/yr. Further details on the potential long-term impacts of disposal of uranium oxide are given in Section 5.6 and in Section I.4 of Appendix I.

1.8 ORGANIZATION OF THIS PEIS

The Depleted UF_6 PEIS consists of 11 chapters, 15 appendices, and comments/responses from the public review. Brief summaries of the main components of the PEIS are as follows:

1.8.1 Volume 1 — Main Text

- Chapter 1 introduces the PEIS, discussing pertinent background information, purpose and need for the DOE action, scope of the assessment, related NEPA reviews, other related reports and studies, and EIS organization.

- Chapter 2 defines the alternative management strategies considered in the PEIS and presents a summary comparison of the estimated environmental impacts. The DOE preferred alternative is identified and discussed.

- Chapter 3 discusses the environmental setting at the three DOE facilities currently storing depleted UF_6. Chapter 3 also presents the environmental characteristics of representative and generic environmental settings assumed for the assessment of long-term storage, manufacture and use, conversion, and disposal activities.

- Chapter 4 addresses the assumptions on which the PEIS and its analyses are based, defines the approaches to environmental impact assessment taken in development of the PEIS, and describes the methods of analysis.

- Chapter 5 presents the environmental impacts of the alternatives, including the no action alternative, from managing the inventory of DOE-generated cylinders. This chapter also discusses potential cumulative impacts at the Paducah, Portsmouth, and K-25 sites; issues related to potential life-cycle impacts associated with the alternatives; possible mitigation of adverse impacts that are unavoidable; irreversible commitment of resources; the relationship between short-term use of the environment and long-term productivity; and pollution prevention and waste minimization.

- Chapter 6 presents the environmental impacts associated with the management of up to 15,000 USEC-generated cylinders.

- Chapter 7 identifies the major laws, regulations, and other requirements applicable to implementing any of the alternatives.

- Chapter 8 is an alphabetical listing of all the references cited in the PEIS. All cited references are available to the public.

- Chapter 9 lists the name, education, and experience of persons who helped prepare the PEIS. Also included are the subject areas for which each preparer was responsible.

- Chapter 10 presents brief definitions of the technical terminology used in the PEIS.

- Chapter 11 is a subject-matter index for Volumes 1 and 2 that provides page numbers where important terms and concepts are discussed.

1.8.2 Volume 2 — Appendices

- Appendix A discusses the chemical forms and characteristics of uranium and its compounds.

- Appendix B examines the issues of corrosion of depleted UF_6 cylinders and material loss from breached cylinders, including causes of corrosion and the experience with corrosion at the three current storage sites.

- Appendix C presents a detailed description of the analytical methods used to conduct the impact assessments for the PEIS.

- Appendices D through J address the impacts of options for the activities that make up the alternative management strategies. The impacts are presented for the following:

  - Continued cylinder storage — Appendix D,
  - Preparation of cylinders for shipment — Appendix E,
  - Conversion of UF_6 to an oxide or metal and treatment of heels cylinders and empty cylinders — Appendix F,
  - Long-term storage — Appendix G,
  - Manufacture and use — Appendix H,
  - Disposal — Appendix I, and
  - Transportation — Appendix J.

- Appendix K provides the results of the parametric analysis, which examines the differences in potential environmental impacts if facilities were smaller than full-sized. Appendix K also includes a summary of impacts for several combinations of alternative strategies.

- Appendix L summarizes the comments received during public scoping and discusses how these comments affected the scope of this PEIS.

- Appendix M contains the contractor disclosure statement.

- Appendix N provides the full text of Public Law 105-204.

- Appendix O contains the summary of the engineering analysis report.

1.8.3 Volume 3 — Responses to Public Comments

- Chapter 1 provides an overview of the public participation and comment process.

- Chapter 2 contains copies of the actual letters or other documents that transmitted public comments on the draft PEIS to DOE.

- Chapter 3 lists DOE's responses to written comments received through the mail or electronic media.

- Chapter 4 lists DOE's responses to comments received verbally at the public hearings.

- Chapter 5 consists of two indexes for Volume 3 that provide page numbers where comments and responses are located. One index is organized by commentor name and the other by document number.

2 DESCRIPTION AND COMPARISON OF ALTERNATIVES

Alternative strategies have been evaluated for the management of DOE's inventory of depleted UF_6 cylinders currently located at three storage sites. The alternative management strategies (also termed "alternatives") considered in this PEIS are no action (continuation of DOE's current management practices for depleted UF_6), long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal.

This chapter defines these alternatives in detail and discusses the types of activities that would be required under each, including descriptions of the representative facility designs and processing technologies considered. Alternatives (other than no action) are defined broadly to account for variations in the chemical form of uranium, technology choices, and facility design options that could be selected. A summary comparison of the potential environmental impacts of the alternatives is provided in Section 2.4, based on the environmental setting information in Chapter 3 and the detailed assessment results presented in Chapter 5 and Chapter 6.

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors. The identification of a preferred alternative does not represent a decision by DOE; rather, it reflects DOE's preference on the basis of existing information. Because the preferred

Alternative Management Strategies Considered in the PEIS*

No Action — Continued storage of depleted UF_6 cylinders indefinitely in yards at the Paducah, Portsmouth, and K-25 sites.

Long-Term Storage as UF_6 — Storage as UF_6 cylinders in yards, buildings, or a mine at a consolidated site.

Long-Term Storage as Uranium Oxide — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by storage in buildings, belowground vaults, or a mine at a consolidated site.

Use as Uranium Oxide — Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded spent nuclear fuel or high-level waste storage containers (casks).

Use as Uranium Metal — Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded spent nuclear fuel or high-level waste storage containers (casks).

Disposal — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

alternative combines aspects of several of the PEIS alternatives, it is discussed in detail separately in Section 2.5.

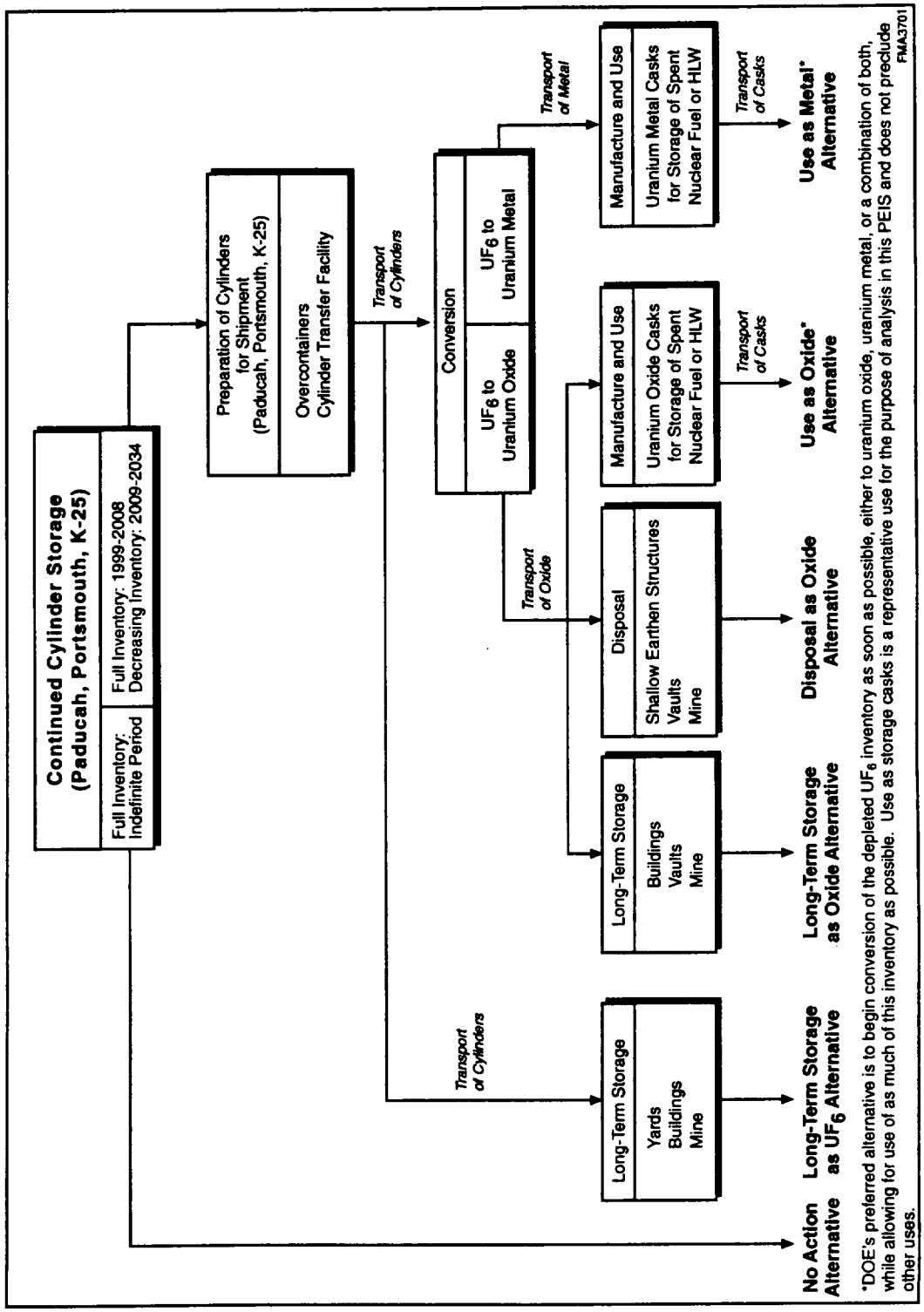
2.1 DEVELOPMENT OF ALTERNATIVE MANAGEMENT STRATEGIES

The alternative management strategies evaluated in detail in this PEIS were developed by considering that there are two possible permanent dispositions for depleted uranium, use or disposal, or the material could be kept in long-term storage. Each of these three options — use, disposal, or long-term storage — could potentially require a chemical form of uranium other than UF_6. Consequently, chemical form was also considered in defining the alternative strategies. These considerations resulted in the definition of alternatives that cover a range of reasonable management strategies, including the no action alternative.

The alternative management strategies were developed and announced in the Notice of Intent to prepare the PEIS, published in the *Federal Register* on January 25, 1996 (61 FR 2239). At the time of the Notice of Intent and public scoping, the no action alternative was based on the course of action outlined by Sewell (1992) (see Section 1.1). This course of action included eventual chemical conversion of UF_6 to uranium oxide followed by storage. After public scoping and on the basis of internal DOE reviews, it was determined that the no action alternative should consider the continued storage of UF_6 cylinders indefinitely at the three current storage sites.

Each alternative evaluated in the PEIS involves a series of management steps or activities that would take place over a number of years. The activities assumed to be required for each alternative are shown in Figure 2.1. For analysis purposes, the types of management activities were grouped into seven broad categories: continued cylinder storage at the current sites, cylinder preparation for shipment, conversion, long-term storage, manufacture and use, disposal, and transportation (see Section 1.5.2). To analyze potential impacts of these activities, several representative options, which are different ways that each activity could be accomplished, were considered for most activities (Figure 2.1). The PEIS will be used to select a broad management strategy on the basis of these representative options; specific facility designs, technologies, and processes will be evaluated following the Record of Decision for this PEIS in the Phase II studies and NEPA reviews.

The representative options were defined by technical experts on the basis of suggestions from the general public. DOE solicited suggestions from the public regarding potential uses or technologies that would facilitate management of depleted UF_6 in "Management of Depleted Uranium Hexafluoride: Request for Recommendations" published in the *Federal Register* in November 1994 (59 FR 56324). The responses to this request, together with DOE's preliminary list of options, were reviewed by technical experts. The results of this evaluation are summarized in the *Technology Assessment Report* (LLNL 1995). This report forms the basis for defining the representative options assessed in this PEIS. Descriptions of the representative options evaluated for each of the seven activity categories are given in Appendices D through J. Each appendix summarizes the different options considered for a specific type of activity and discusses the potential environmental impacts estimated for each option.



*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Use as storage casks is a representative use for the purpose of analysis in this PEIS and does not preclude other uses.

FIGURE 2.1 Major Components of the Alternative Management Strategies

The approach used to analyze the environmental impacts of each alternative was to evaluate the impacts of each individual activity required by the alternative and then combine them, as appropriate, to arrive at the total impacts. For example, the impacts of disposal would include impacts during continued storage of cylinders for some period, preparation of cylinders for shipment, transport of cylinders, conversion, treatment of empty cylinders, and disposal. In cases where more than one option was available to accomplish a single activity — such as disposal in shallow earthen structures, vaults, or a mine — the impacts of the alternative are presented as a range encompassing all the relevant options. For activities known to occur at the three current storage sites, the impacts were evaluated using environmental setting data for the actual site. For activities for which the locations will be decided in the future during Phase II of the Depleted Uranium Hexafluoride Management Program, impacts were evaluated by using representative or generic environmental settings (see Sections 3.4 and 4.2).

For assessment purposes, the environmental impacts of the alternative management strategies were evaluated and compared for the period 1999 through 2039 (41 years): about 10 years for siting, design, and construction of required facilities; about 26 years for operations; and, when appropriate, 4 years for monitoring.[1] In addition, long-term impacts (primarily from potential groundwater contamination) were estimated for the continued storage component of all alternatives and for the disposal alternative. Because actions to be taken beyond 2039 are considered highly uncertain and speculative, no assumptions were made regarding management beyond 2039. Actions beyond that date would be subject to appropriate NEPA reviews and decisions in the future. However, issues associated with potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9 of this PEIS.

For alternatives other than no action, to provide a basis for impact calculations, schedules for facility construction and operations were determined on the basis of engineering judgment (LLNL 1997a) and were used consistently. Schedules were not differentiated for DOE or private facilities. For the treatment of DOE-generated cylinders, it was generally assumed in the engineering analysis report that new facilities — such as those for conversion, manufacturing, long-term storage, and disposal — would begin operations by 2009 and continue for a period of 20 years.[1] To account for the processing of up to 15,000 USEC-generated cylinders, processing was assumed to be extended an additional 6 years, resulting in an overall operational period of 26 years. Following the Record of Decision, activities such as technology selection, facility design, site selection and preparation, facility construction, procurement, and appropriate safety and NEPA analyses would be required prior to facility start-up. Although the actual schedule for implementation of a selected alternative might differ from that assumed for the PEIS analyses, the impact estimates and conclusions reached in the PEIS would remain essentially the same.

Finally, to provide a conservative estimate of potential impacts, it was assumed for the PEIS that new facilities would be constructed for conversion, consolidated long-term storage,

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[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

manufacturing, and disposal, as required by the alternatives. To provide a conservative estimate of transportation and construction impacts, it was also assumed that these facilities would be located at separate sites, requiring transportation between them. The actual facilities, technologies, and sites that would be used will be evaluated in the Phase II studies and NEPA reviews after a management strategy is selected in the Record of Decision for this PEIS.

2.2 ALTERNATIVE MANAGEMENT STRATEGIES

2.2.1 No Action Alternative

Under the no action alternative, depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites indefinitely. Potential environmental impacts were estimated through the year 2039. In addition, long-term impacts (i.e., occurring after 2039) from potential groundwater contamination were assessed.

No Action Alternative

Continued storage of the UF_6 cylinders indefinitely at the Paducah, Portsmouth, and K-25 sites.

The environmental impacts of the no action alternative depend on the cylinder management activities that would take place at the sites in the future. Current detailed cylinder management plans extend through the year 2002 (LMES 1997i). The ongoing and planned activities are designed to ensure continued safe storage of cylinders. These activities include cylinder inspections, cylinder yard upgrades, cylinder painting, and cylinder maintenance and repair. Beyond 2002, a set of assumptions about future cylinder management was needed to define the activities that would likely occur at the sites through 2039 so that the potential impacts could be estimated. It was assumed that the types of activities occurring beyond 2002 would be similar to those that are now ongoing or planned (Parks 1997).

Specifically, the activities assumed to occur at the sites under the no action alternative include a comprehensive cylinder monitoring and maintenance program, with routine cylinder inspections, ultrasonic testing of cylinder wall thicknesses, radiological surveys, cylinder painting to prevent corrosion, cylinder yard surveillance and maintenance, construction of new or improved storage yards, and relocation of some cylinders to the new or improved yards. Cylinders were assumed to be painted every 10 years, which is consistent with current plans. These activities are described in greater detail in Appendix D.

The occurrence of future cylinder breaches, caused by either corrosion or handling damage, is an important concern when the potential impacts of continued cylinder storage are evaluated. For the assessment of the no action alternative, it was assumed that the current cylinder maintenance and painting program would maintain the cylinders in protected condition and control further corrosion

(Pawel 1997). After the initial painting, some cylinder breaches were assumed to occur in the future from handling damage. Although unlikely, for analytical purposes the cylinder breaches were assumed to go undetected for 4 years (the inspection interval for most cylinders) and to release some uranium and HF to the environment. Details concerning the current understanding of cylinder corrosion and the assumptions made for the purposes of this PEIS are provided in Appendix B.

Because the effectiveness of painting in controlling cylinder corrosion and the future painting schedule are somewhat uncertain, an assessment was also conducted on the basis of the assumption that external corrosion would not be halted by improved storage conditions, cylinder maintenance, and painting. Estimates were made of the time frames over which continued storage of cylinders would begin to raise regulatory concerns if corrosion rates were to continue at the historical rate (poor storage yard conditions and no routine cylinder painting).

2.2.2 Long-Term Storage as Depleted UF_6

In contrast to the no action alternative, the long-term storage as depleted UF_6 alternative was based on the assumption that storage would be consolidated at a single location and could involve storage of cylinders in newly constructed yards, buildings, or an underground mine. The location of such a long-term storage facility could be elsewhere than at a current storage site. To estimate potential environmental impacts, the alternative was assumed to consist of the following activities:

- Continued storage of UF_6 cylinders at the three current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);
- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of cylinders to a long-term storage facility by truck or rail;
- Construction and operation of a long-term cylinder storage facility, including yards, buildings, or an underground mine; and
- Transportation and disposal of any waste created from the activities listed above.

Long-Term Storage as UF_6 Alternative

Storage of UF_6 cylinders in newly constructed yards, buildings, or a mine at a consolidated site.

Figure 2.2 shows each of the activities assumed to occur under the long-term storage as UF_6 alternative and their relationship to one another. The entire cylinder inventory was assumed to be stored at the three current storage sites

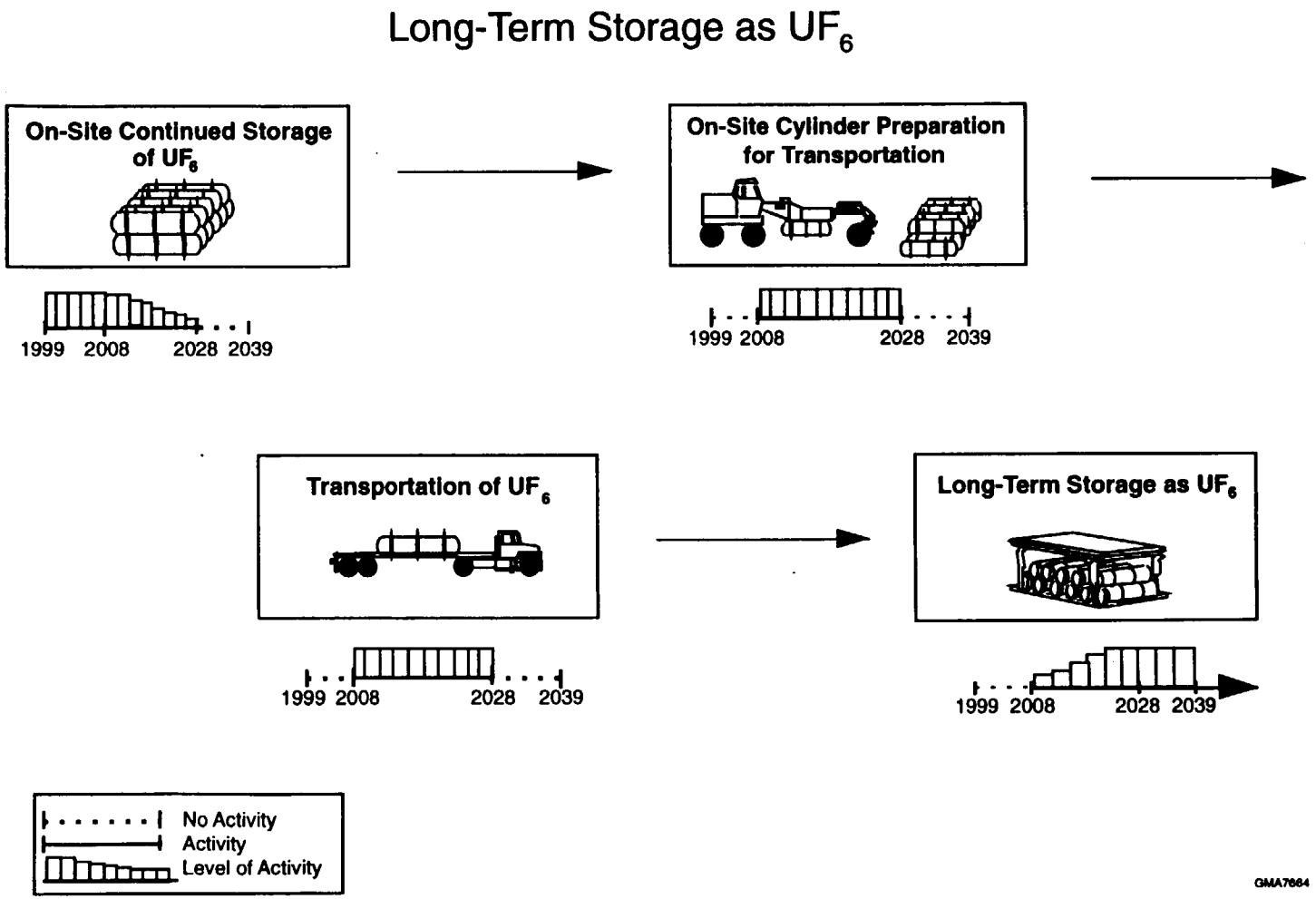

FIGURE 2.2 Conceptual Schematic of the Long-Term Storage as UF_6 Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

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through 2008, with the site inventory decreasing from 2009 through 2034 as cylinders were shipped off-site to a consolidated storage facility. The activities assumed to occur at the current storage sites during this time would include a comprehensive cylinder monitoring and maintenance program, including routine inspections and cylinder painting to control corrosion, and the construction and relocation of cylinders to new or improved cylinder yards. These activities are generally similar to those described for the no action alternative, although slight variations in maintenance and painting schedules were made to account for the decreasing cylinder inventory. Continued cylinder storage activities for this alternative are discussed in more detail in Appendix D.

Although the locations of facilities will be evaluated in Phase II studies and NEPA reviews, to provide a conservative estimate of potential transportation impacts, all cylinders were assumed to be transported from the three current storage sites to a consolidated long-term storage facility. Truck and rail shipment modes were considered as two representative transportation options, as described in detail in Appendix J.

Preparing the cylinders for off-site transportation was assumed to occur at the three current storage sites. Some cylinders might not be suitable for off-site transportation because they might not meet DOT requirements (see Appendix E). These cylinders would thus require some type of preparation prior to off-site shipment. Two cylinder preparation options were considered for these cylinders: (1) a cylinder overcontainer option, in which cylinders not meeting transportation requirements would be placed into a larger container approved for transportation, and (2) a cylinder transfer option, in which the contents of cylinders not suitable for transportation would be transferred to new cylinders. The cylinder overcontainer option would not require the construction of new facilities at the current sites; for the cylinder transfer option it was assumed that a transfer facility would be constructed at each site.

The three long-term storage options evaluated were storage in yards, buildings, and an underground mine. Descriptions of these representative long-term storage facilities are provided in Appendix G. All storage facilities were assumed to be newly constructed, stand-alone, single-purpose facilities consisting of a central receiving building/warehouse surrounded by storage areas, all within a security fence. Once placed in storage, the cylinders would be subject to routine monitoring and maintenance activities. The storage facilities would be designed to protect the cylinders from the environment and prevent potential releases of material to the environment.

2.2.3 Long-Term Storage as Uranium Oxide

Long-Term Storage as Uranium Oxide Alternative

Conversion of UF_6 to uranium oxide, either UO_2 or U_3O_8, followed by storage of drums of oxide in buildings, vaults, or a mine at a consolidated site.

Under the long-term storage as uranium oxide alternative, depleted UF_6 would be chemically converted from UF_6 to uranium oxide before placement in long-term storage. Storage in a retrievable form in a facility designed for indefinite, low-maintenance operation would

preserve access to the depleted uranium. Storage in the form of an oxide would be attractive in view of long-term stability and might be the form of material preferred for use or disposal at a later date.

Conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone plant dedicated to the conversion process. Two forms of uranium oxide, U_3O_8 and UO_2, were considered. Both oxide forms have low solubility in water and are relatively stable over a wide range of environmental conditions (see Appendix A). Two representative conversion technologies were assessed for conversion to U_3O_8 and three for conversion to UO_2. A detailed discussion of the conversion options is presented in Appendix F. Conversion options and other chemical forms for storage that were considered but not analyzed in detail are discussed in Section 2.3.

In addition to producing uranium oxide, conversion could result in the production of considerable quantities of HF. Anhydrous HF, a chemical that is toxic to humans if exposed to high-enough concentrations, is a commercially valuable chemical commonly used for industrial applications, including use for the production of UF_6 from natural uranium ore. HF is typically stored and transported as a liquid, and that produced from the conversion process could potentially be sold for use. Alternatively, the HF could be neutralized by the addition of lime to form a solid fluoride salt, calcium fluoride (CaF_2), which is much less toxic than HF. The CaF_2, a solid material, potentially could be sold for commercial use or could be disposed of in either a landfill or LLW disposal facility, depending on the uranium concentration and applicable disposal regulations at the time of disposal. Use of HF and CaF_2 would be subject to DOE or NRC review and approval, depending on the specific use. The environmental impacts of both options (production of anhydrous HF for commercial use and neutralization of HF to CaF_2) were considered in this PEIS.

Following conversion, the uranium oxide was assumed to be stored in drums in buildings, belowground vaults, or an underground mine. The storage facilities would be designed to protect the stored material from the environment and prevent potential releases of material to the environment. Once placed in storage, the containers would require only routine monitoring and maintenance activities. Additional details related to long-term storage options are provided in Appendix G.

Figure 2.3 depicts the activities assumed to occur under the long-term storage as uranium oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);
- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of depleted UF_6 to a conversion facility by truck or rail;

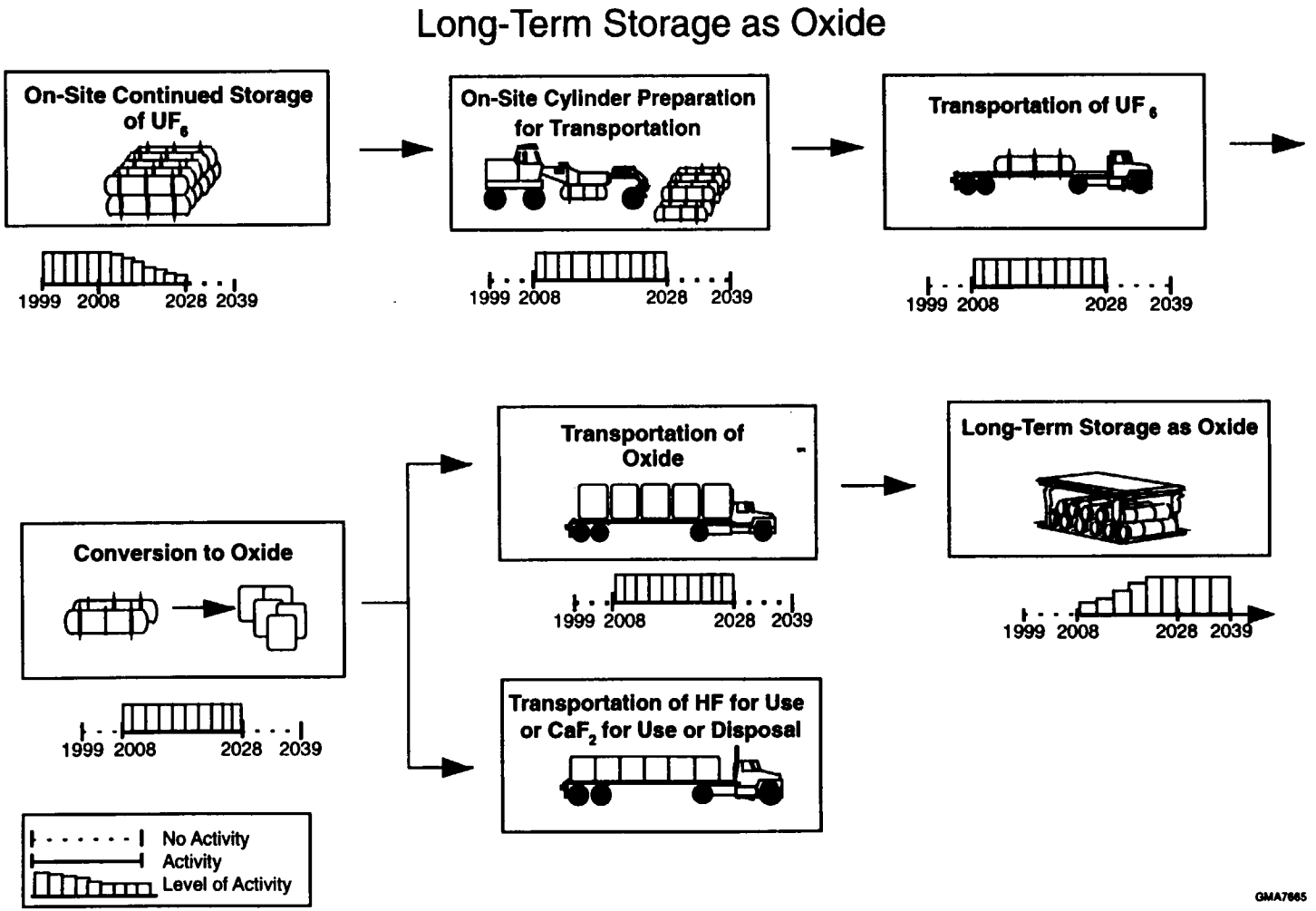

FIGURE 2.3 Conceptual Schematic of the Long-Term Storage as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

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- Construction and operation of a conversion facility, and conversion to either U_3O_8 or UO_2;
- Transportation of the uranium oxide to a long-term storage facility by truck or rail;
- Transportation of either HF for use or CaF_2 for use or disposal;
- Construction and operation of a long-term storage facility, including buildings, belowground vaults, or an underground mine; and
- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years (when USEC-generated cylinders are considered), cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted UF_6 alternative. The depleted UF_6 would be converted to oxide from 2009 through 2034, and the oxide would be transported to a long-term storage facility.[2] If HF were produced, it was assumed to be transported elsewhere for use. If a fluoride salt were produced, it was assumed to be transported for use or disposal. Following placement of the last container of oxide in the long-term storage facility, monitoring would continue indefinitely. However, for purposes of analysis and comparison with other alternatives, only the period through 2039 was evaluated. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the conversion and long-term storage facilities were assumed to be located at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

2.2.4 Use as Uranium Oxide

Under the use as uranium oxide alternative, depleted UF_6 would first be chemically converted to uranium oxide. There are a variety of current and potential uses for depleted uranium, including use as radiation shielding, use in dense material applications other than shielding (such as ballast or tank armor), use in light water reactor fuel cycles, and use in advanced reactor fuel cycles. Radiation shielding was selected as the representative use option for detailed analysis in the PEIS (potential uses not considered in detail are discussed in Section 2.3.2). Use as shielding was selected to provide a basis for comparing the broad programmatic management strategies. This selection was not intended to imply that the PEIS will be used to select a specific end use or preclude other uses

[2] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

in the future. Specific issues, such as licensing, associated with potential uses would be considered and evaluated in more detail in future planning and environmental analyses once a management strategy is selected.

Use as Uranium Oxide Alternative

Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded casks for use as spent nuclear fuel or HLW storage containers.

For assessment purposes, it was assumed that depleted UF_6 would be converted to UO_2, which in turn would be used to make the primary shielding material in casks designed to contain spent nuclear fuel or high-level radioactive waste (HLW).[3] The high density of uranium makes it an excellent radiation shield for gamma radiation. (Shielding is any material that is placed between a source of radiation and people, equipment, or other objects to absorb the radiation and thereby reduce radiation exposure.) If UO_2 was used to make concrete (called depleted-uranium-concrete), the same shielding performance could be achieved with approximately half the thickness required of normal concrete. The uranium oxide would be substituted for the coarse aggregate in conventional concrete and would be enclosed between the stainless steel shells making up the body of the casks. Additional details concerning the representative use option are provided in Appendix H.

A conversion facility would be required to convert UF_6 to oxide, similar to that described for the long-term storage as oxide alternative (see also Appendix F). The stand-alone facility would convert UF_6 to UO_2 and would also produce either anhydrous HF or CaF_2. If HF were produced, it was assumed to be transported elsewhere for use; if CaF_2 were produced, it was assumed to be transported for either use or disposal.

The manufacture of depleted-uranium-shielded casks was assumed to take place at a stand-alone industrial plant dedicated to the cask manufacturing process (see Appendix H). The plant would be capable of receiving packages of UO_2 on trucks or railcars from a conversion facility, manufacturing casks, and storing the casks until shipment by rail to a user, such as a nuclear power plant or DOE facility.

Figure 2.4 depicts the activities assumed to occur under the use as uranium oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);

[3] Such casks are typically used for purposes of storage or transportation (or both) of spent nuclear fuel and high-level waste; certification generally would be required from the U.S. Nuclear Regulatory Commission prior to use, pursuant to 10 CFR Parts 71 and 72.

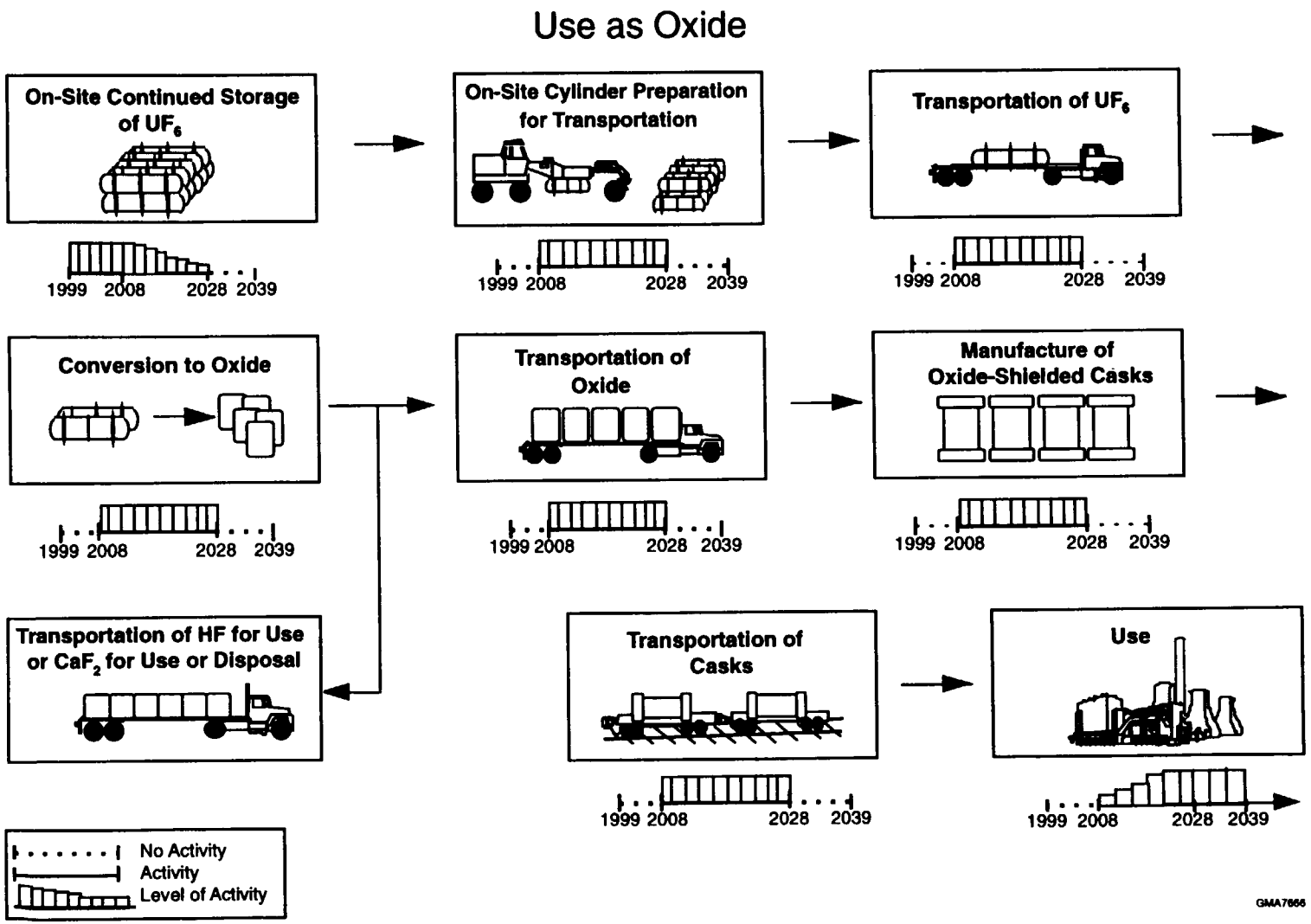

FIGURE 2.4 Conceptual Schematic of the Use as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of depleted UF_6 to a conversion facility by truck or rail;
- Construction and operation of a conversion facility, and conversion to UO_2;
- Transportation of the UO_2 to a cask manufacturing facility by truck or rail;
- Transportation of either HF for use or CaF_2 for use or disposal;
- Construction and operation of a cask manufacturing facility, and manufacture of depleted-uranium-concrete casks;
- Transportation of depleted-uranium-concrete casks to a user by rail; and
- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years, cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted UF_6 alternative. The depleted UF_6 would be converted to UO_2 from 2009 through 2034, and the UO_2 would be transported to a facility that manufactures depleted-uranium-concrete casks.[4] Manufacture and use of the casks would take place between 2009 and 2034. It was assumed that casks would be in use at user facilities through at least 2039. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the facilities for conversion, manufacturing, and use were assumed to be at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

Because actions beyond 2039 are considered highly uncertain and speculative, no assumptions were made regarding the fate of depleted-uranium-concrete casks following use. However, issues related to potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9.

[4] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

2.2.5 Use as Uranium Metal

Use as Uranium Metal Alternative

Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded casks for use as spent nuclear fuel or HLW storage containers.

Under the use as uranium metal alternative, depleted UF_6 would first be chemically converted to uranium metal. As discussed for the use as oxide alternative, there are a variety of current and potential uses for depleted uranium. As a representative use for the PEIS analysis, uranium metal was assumed to be used as the primary shielding material in casks designed to contain spent nuclear fuel or HLW (see footnote 1). (Several other uses considered but not analyzed in detail are discussed in Section 2.3.2.) The uranium metal would be enclosed between the stainless steel shells making up the body of the casks. Additional details concerning the representative use option are provided in Appendix H.

A conversion facility would be required to convert UF_6 to uranium metal (see Appendix F). The conversion facility would also produce either anhydrous HF or CaF_2. If HF were produced, it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for either use or disposal. As described in Appendix F, metal conversion technologies would also produce large quantities of magnesium fluoride (MgF_2). The MgF_2 would be disposed of in either a sanitary landfill or LLW disposal facility, depending on the uranium concentration and applicable disposal regulations at the time of disposal.

The manufacture of depleted-uranium-metal casks was assumed to take place at a stand-alone industrial plant dedicated to the cask manufacturing process (see Appendix H). The plant would be capable of receiving uranium metal from a conversion facility, manufacturing casks, and storing the casks until shipment by rail to a user, such as a nuclear power plant or DOE facility.

The activities required for the use as uranium metal alternative would be the same as those for the use as uranium oxide alternative, except that the UF_6 would be converted to metal instead of oxide. Figure 2.5 depicts the activities assumed to occur under the use as uranium metal alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);
- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of depleted UF_6 to a conversion facility by truck or rail;

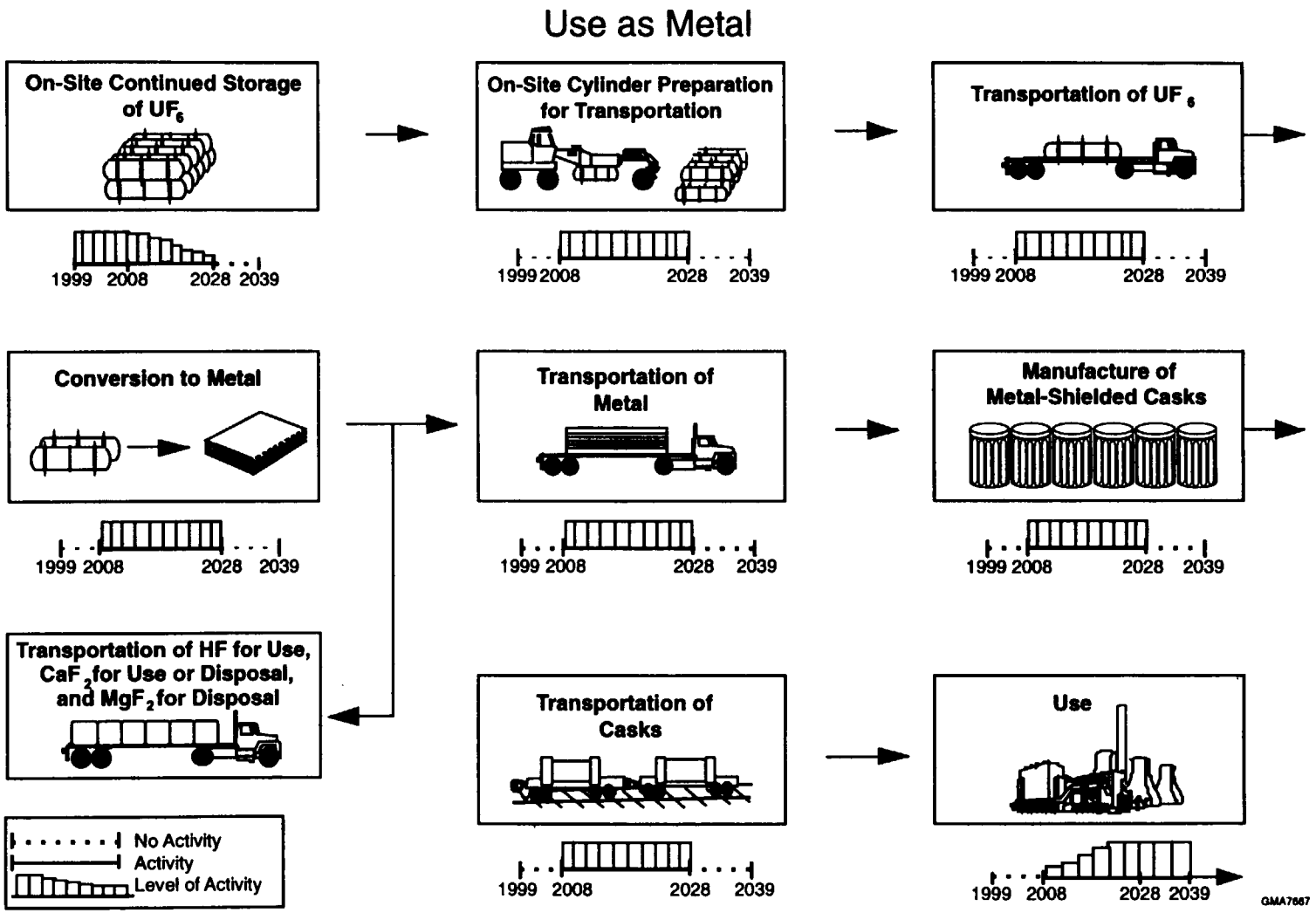

FIGURE 2.5 Conceptual Schematic of the Use as Metal Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

- Construction and operation of a conversion facility, and conversion to uranium metal;
- Transportation of the uranium metal to a cask manufacturing facility by truck or rail;
- Transportation of either HF for use or CaF_2 for use or disposal, and MgF_2 for disposal;
- Construction and operation of a cask manufacturing facility, and manufacture of depleted-uranium-metal casks;
- Transportation of depleted-uranium-metal casks to a user by rail; and
- Transportation and disposal of any waste created from the activities listed above.

The assumptions for the use as uranium metal alternative are the same as those discussed in Section 2.2.4 for the use as uranium oxide alternative. No assumptions were made regarding the fate of casks after use; however, issues related to potential life-cycle impacts are summarized in Section 2.6 and discussed in more detail in Section 5.9.

2.2.6 Disposal

Disposal as Oxide Alternative

Conversion of UF_6 to uranium oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

Under the disposal as uranium oxide alternative, depleted UF_6 would be chemically converted to a more stable oxide form and disposed of belowground as LLW. Disposal is defined as the emplacement of material in a manner designed to ensure isolation for the foreseeable future. Compared with long-term storage, disposal is considered to be permanent, with no intent to retrieve the material for future use. In fact, considerable and deliberate effort would be required to regain access to the material following disposal.

Prior to disposal, conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone plant dedicated to the conversion process (see Appendix F). This activity would be identical to that described in Section 2.2.3 for long-term storage as oxide. Potential impacts were evaluated for U_3O_8 and UO_2, which both have low solubility in water and are relatively stable over a wide range of environmental conditions. The conversion facility would convert UF_6 to oxide and would also produce either anhydrous HF or CaF_2. If HF were produced,

it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for either use or disposal.

Several disposal options were considered, including disposal in shallow earthen structures, belowground vaults, and an underground mine (see Appendix I). In addition, two physical waste forms were considered in the PEIS, ungrouted waste and grouted waste. Ungrouted waste refers to U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process. This bulk material would be disposed of in drums. Grouted waste refers to the solid material obtained by mixing the uranium oxide with cement and repackaging it in drums. Grouting is intended to increase structural strength and stability of the waste and to reduce the solubility of the waste in water. However, because cement would be added to the uranium oxide, grouting would increase the total volume requiring disposal. Grouting of waste was assumed to occur at the disposal facility. Disposal options considered but not analyzed in detail are discussed in Section 2.3.4.

Figure 2.6 depicts the activities assumed to occur under the disposal as oxide alternative, including the following:

- Continued storage of UF_6 cylinders at the current storage sites (existing cylinder management of the entire cylinder inventory through 2008 and of a decreasing inventory through 2034);
- Cylinder preparation for shipment at the three current storage sites (transfer to new cylinders or placement of cylinders in overcontainers);
- Transportation of depleted UF_6 to a conversion facility by truck or rail;
- Construction and operation of a conversion facility, and conversion to either U_3O_8 or UO_2;
- Transportation of the uranium oxide to a disposal facility by truck or rail;
- Transportation of either HF for use or CaF_2 for use or disposal;
- Construction and operation of a disposal facility, including shallow earthen structures, belowground vaults, or an underground mine; and
- Transportation and disposal of any waste created from the activities listed above.

Storage of the entire cylinder inventory at the three current storage sites was assumed to continue through 2008. Beginning in 2009, and continuing for up to 26 years, cylinders would be prepared for transportation and transported to a conversion facility. Cylinders would be subject to the same monitoring and maintenance practices as described for the long-term storage as depleted

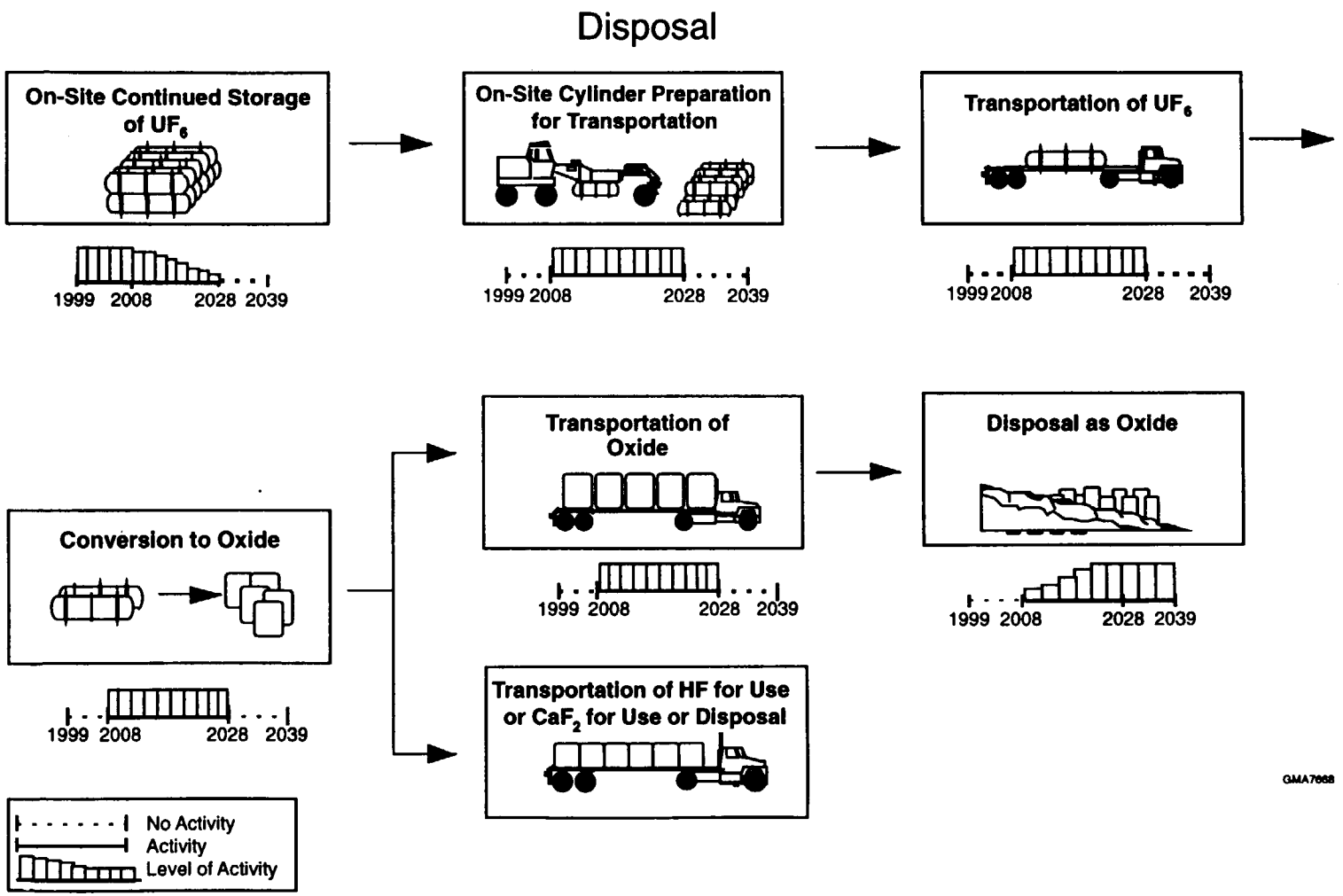

FIGURE 2.6 Conceptual Schematic of the Disposal as Oxide Alternative (The management of an additional 15,000 USEC-generated cylinders would extend continued storage, cylinder preparation, conversion, manufacturing, and transportation activities through 2034. Note that the timetable presented was meant to provide a consistent analytical basis for the evaluation of all of the PEIS alternatives and does not represent a definitive schedule.)

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UF_6 alternative. The depleted UF_6 would be converted to oxide from 2009 through 2034, and the oxide would be transported to a disposal facility.[5] If HF were produced, it was assumed to be transported elsewhere for use; if a fluoride salt were produced, it was assumed to be transported for use or disposal. Although facility locations will be evaluated in Phase II studies and NEPA reviews, the conversion and disposal facilities were assumed to be at locations other than the three current cylinder storage sites to provide a conservative estimate of potential transportation impacts.

The potential impacts of disposal were evaluated for both the operational period of the facility (through 2039) and the long term because long-term impacts from disposal are reasonably foreseeable. Long-term impacts were estimated up to 1,000 years after the disposal facility had ceased operations. In addition, these impacts were estimated for both wet environmental settings (typical of the eastern United States) and dry environmental settings (typical of the western United States) (see Sections 3.4 and 4.2).

2.3 ALTERNATIVE MANAGEMENT STRATEGIES AND OPTIONS NOT ANALYZED IN DETAIL

This PEIS evaluates a range of reasonable management strategies based on representative facility, technology, and process options. During DOE's internal scoping and solicitation of recommendations, a number of promising technologies were recommended that were considered unsuitable for detailed analysis in this PEIS. With few exceptions, these technologies are in the early stages of either conceptualization or development, entail time frames beyond those included in the current analysis, or involve uses of insignificant amounts of depleted uranium. However, any technology that is not analyzed in depth in this PEIS may still be appropriate for consideration in the later Phase II studies and NEPA reviews that will provide a basis for selecting specific technologies and sites. A more detailed description of options considered but not analyzed in detail is presented in the engineering analysis report (LLNL 1997a).

2.3.1 Conversion

In response to the Request for Recommendations, many promising future conversion technologies were identified; however, with few exceptions, these technologies are now in the early stages of either conceptual development or design. In addition, key design aspects are proprietary for a number of these submittals. From an environmental perspective, these conversion processes would be generally similar to those included in the PEIS (see Appendix F); they all begin with processing major quantities of depleted UF_6 and end with a product containing fluorine. The impacts of conversion, including the chemical hazard of the fluorine in UF_6 and HF, are adequately addressed in the analysis of storage, handling, and transportation presented in the PEIS.

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[5] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

2.3.2 Use

Three options for use were not analyzed in depth: (1) light water reactor fuel cycles, (2) advanced reactor fuel cycles, and (3) dense material applications other than shielding.

Use of depleted uranium in the light water reactor fuel cycle would generally require reenrichment of depleted uranium (refeed), which could conserve natural uranium resources. However, the amount of energy required to obtain a unit quantity of enriched uranium from depleted uranium would be greater than the amount required if natural uranium feed were enriched using gaseous diffusion, which is currently the only available enrichment technology in the United States. Depending on the fuel mix (coal, nuclear, or hydro) used to generate the electricity for running the diffusion plant, the environmental emissions of air pollutants might also be greater under the refeed scenario than if natural uranium were used. In addition, the quantity of depleted UF_6 that would still require management after refeed would be essentially the same as it is now. If a more efficient enrichment technology — such as gas centrifugation or atomic vapor laser isotope separation — becomes commercially available in the future, using depleted UF_6 to make reactor fuel might also become more advantageous than using natural uranium. The long-term storage alternatives analyzed in the PEIS would preserve the option of the future development of a more efficient enrichment technology. The advantages and disadvantages of using depleted UF_6 for reenrichment are discussed further in White (1997) and Gillette (1997).

An additional potential use of depleted uranium in light water reactor fuel cycles could involve the conversion of UF_6 to UO_2, which could then be mixed with plutonium oxide to produce mixed oxide fuel or mixed with highly enriched uranium to produce commercial reactor fuel. These potential uses are being evaluated in the *Surplus Plutonium Disposition Draft Environmental Impact Statement* (DOE 1998a) and the *Disposition of Surplus Highly Enriched Uranium, Final Environmental Impact Statement* (DOE 1996a) (see Section 1.6); however, the amount of depleted uranium being considered for this type of application would be very small compared with the available inventory.

Use of depleted uranium in advanced reactor fuel cycles, most notably in a future generation of fast breeder reactors, was one of DOE's original reasons for continuing to store the material. In advanced reactor fuel cycles, the depleted uranium inventory could represent hundreds of years of electrical power at the current U.S. consumption rate. Implementation of an advanced reactor fuel cycle would require a change in national policy. The United States now uses a once-through fuel cycle derived from natural uranium. All existing fast breeder reactors use either highly enriched uranium, plutonium from recycling and reprocessing of spent nuclear fuel, or both. However, plutonium recycling and reprocessing are not currently practiced in the United States. The possibility of pursuing this option in the future would be retained under the long-term storage alternatives.

Dense material applications include existing uses of depleted uranium metal, such as armor-piercing munitions (penetrators), vehicle armor, and industrial ballasts. Potential new commercial applications that were identified in response to the Request for Recommendations are energy storage

flywheels and drill collars, well penetrators, industrial counterweights, and shape charge perforators for the petroleum industry. Because the manufacturing processes associated with these applications would be similar for all dense material applications, the environmental impacts of new manufacturing facilities to accommodate expansion of existing uses or major new uses for dense materials would be similar to those for the representative facility assessed in the PEIS for the manufacture of uranium metal radiation shielding.

2.3.3 Long-Term Storage

Options for storage as elemental uranium metal and storage as uranium tetrafluoride (UF_4) were considered but not analyzed in depth. The chemical forms for storage analyzed in the PEIS (UF_6, U_3O_8, and UO_2) provide planning flexibility and allowed a spectrum of environmental and cost trade-offs to be considered. Storage of depleted uranium implies a significant chance that it will be used at a later date. The uranium chemical forms analyzed for storage encompass a range of important factors, including which future use options are considered most likely, storage space requirements, costs, potential environmental effects, and suitability of the chemical form for eventual disposal.

Green salt, or UF_4, is an intermediate form in the process of converting UF_6 to the metal form or converting uranium oxide to UF_6. Although UF_4 is more stable than UF_6, it has no identified direct use, offers no obvious advantage in required storage space, and is less stable than oxide forms. Conversion of UF_6 into uranium-bearing minerals such as soddyite and uranotile for subsequent storage or disposal were not analyzed because development of chemical conversion processes would be required, as well as examination of the suitability of such forms for storage or disposal.

Because of its high density, uranium metal would need less storage space than the other forms analyzed for storage. However, disadvantages include higher conversion cost, lower chemical stability than the oxides, and uncertainty about the suitability of the metal form for eventual disposal. Unless it is protected from the environment, bulk uranium metal slowly oxidizes. Metal fines or chips ignite spontaneously with a rapid energy release. Hydrogen is generated in the reaction between moisture and uranium metal, and care must be taken to avoid accumulation of hydrogen in closed storage containers. These safety issues would necessitate specialized packaging and enhanced facility maintenance. If the depleted UF_6 was converted to another chemical form for storage, it would be desirable for this form to be acceptable for disposal to avoid a later additional chemical conversion step. Consequently, long-term storage as metal was considered but not analyzed in detail in the PEIS.

2.3.4 Disposal

Options for disposal of depleted uranium as UF_6, as uranium metal, and as UF_4 were considered but not analyzed in detail. Factors that are important and were analyzed in determining

the preferred chemical form for disposal of depleted uranium are potential for release, physical characteristics, and toxicity in drinking water. With regard to UF_6, because it is soluble in water and not as stable as other chemical forms, it was not considered suitable for disposal. To a lesser degree, UF_4 is also soluble in water and not as stable as oxide forms, and it was thus not analyzed.

This PEIS does not analyze disposal of uranium metal because it is reactive. Water attacks bulk uranium metal slowly at room temperature and rapidly at higher temperatures; UO_2 and U_3O_8 are formed, heat is generated, and the metal swells and disintegrates. Additionally, current DOE Orders restrict the disposal of uranium metal at DOE disposal sites, and no commercial disposal facilities are available for disposal of the inventory in the metal form (Hertzler et al. 1994). Relaxation of current waste acceptance criteria would likely be needed for disposal of metal to occur. Because of its higher conversion costs, reactivity, and the current regulatory restrictions, disposal as uranium metal was considered but not analyzed in detail in the PEIS.

Vitrification of depleted uranium oxides prior to disposal was another option considered. However, technologies for vitrification of depleted uranium oxides are in the early stages of development, and vitrification would likely increase the volume of the material by 100 to 400% compared with a 50 to 100% increase for grouting. Also, the capability of vitrification to reduce the already low leachability of uranium oxide compounds is unknown. For the purposes of the PEIS, grouted waste was considered representative of immobilized waste forms with low leach rates. The feasibility of vitrification of uranium oxides resulting from conversion of depleted UF_6 is further discussed in Swanstrom et al. (1997).

2.3.5 Transportation

Truck and rail were considered as representative transport modes for the shipment of materials. Transportation by barge was considered but not analyzed in detail because the locations of potential conversion, manufacturing, storage, or disposal facilities will be evaluated in Phase II studies and NEPA reviews, and accessibility to points of entry for barge transportation are uncertain. All three existing storage sites currently rely predominantly on ground transportation, and ground transportation would be necessary between the current storage locations and any barge facility and between the receiving barge facility and the disposal site. Barge transportation is a site-specific consideration that can be better analyzed in the later Phase II analyses supporting a facility siting decision.

2.3.6 Disposition of Empty Cylinders

Under most of the alternatives considered in this PEIS, the depleted UF_6 would be removed from some of the steel cylinders that are currently in use. The only exceptions would be the no action alternative and the long-term storage as UF_6 alternative, under which some or all of the cylinders might not need to be emptied until after 2039. Therefore, disposition of the empty cylinders would

be part of most of the alternative management strategies. The treatment (i.e., cleaning and washing) of empty cylinders is considered in detail in this PEIS (see Appendix F). The disposition of clean, emptied cylinders is analyzed in detail in a PEIS support document (Nieves et al. 1997). This PEIS assumes that after treatment, the cylinders would become part of the DOE scrap metal inventory and managed as such.

The document by Nieves et al. (1997) analyzes the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle into LLW disposal containers, reuse as LLW containers, free release for remelting, and disposal (i.e., burial) as LLW. Health endpoints assessed include chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing 46,422 cylinders ranged from 0.1 to 0.8 total fatality for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts because of the land allocations required and the removal of the metal mass from any further usefulness. The health impacts associated with the disposition of 61,422 cylinders (46,422 DOE-generated cylinders plus up to an additional 15,000 USEC-generated cylinders) over a 26-year period would be expected to be approximately 30% greater than for the DOE-generated cylinders alone.

2.3.7 Combinations of Alternatives

The alternatives assessed in this PEIS were based on the assumption that all facilities would be designed to either convert, store, manufacture and use, or dispose of all of the depleted UF_6 in the inventory. This approach was intended to provide an estimate of the maximum impacts that could result from each of the alternatives considered. However, as described for the preferred alternative in Section 2.5, it is possible for DOE to select a long-term management strategy that is a combination of the alternatives evaluated explicitly in the PEIS. For example, DOE could select a strategy to convert 50% of the depleted UF_6 to an oxide for use and convert the remaining 50% to metal for use. In this case, facilities could be designed to process or accommodate only a fraction of the depleted UF_6 inventory, and the resulting potential environmental impacts might be different than those evaluated for full-scale facilities. Consequently, the PEIS includes an analysis of potential environmental impacts for a range of facility sizes to allow for an evaluation of combinations of alternatives. The results of this "parametric" analysis are presented in Appendix K.

The intent of the parametric analysis was to show how the potential environmental impacts calculated for the full-scale facilities (i.e., 100% cases) would be affected by reductions in facility size and/or throughput. "Throughput" is a general term that refers to the amount of material handled or processed by a facility in 1 year. Appendix K presents the potential environmental impacts for the conversion, long-term storage, manufacture and use, disposal, and transportation options for facilities designed to process between 25 and 100% of the DOE-generated cylinder inventory. The parametric analysis would also allow for the evaluation of impacts associated with multiple facilities with fixed total throughput. (The impacts of the cylinder preparation options for various throughputs are not included in Appendix K but are addressed in Appendix E.) The basic assessment approach, areas of

impact, and methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases.

2.4 COMPARISON OF ALTERNATIVES

The PEIS evaluates the potential environmental consequences of a range of alternatives, including no action. Table 2.1 presents a summary comparison of the management activities considered under the different alternatives. The preferred alternative, which is a combination of the alternatives discussed in this section, is discussed in Section 2.5. No alternative is unique in the activities required to accomplish it. A number of management activities are shared by two or more alternatives, as follows:

- Continued cylinder storage would continue at the three current storage sites under all alternatives. Under the no action alternative, continued cylinder storage was assumed to continue indefinitely. Under the other alternatives, cylinders were assumed to be removed from the sites over the period 2009 through 2034 for consolidated long-term storage or conversion.

- Preparation of cylinders for off-site transportation was considered at each of the three current storage sites for all alternatives other than no action.

- Conversion of UF_6 to another chemical form (oxide or metal) and treatment of the empty cylinders are activities considered under the long-term storage as oxide, use as uranium oxide, use as metal, and disposal alternatives (as well as the preferred alternative).

- Consolidated long-term storage is an activity in the long-term storage as UF_6 alternative and long-term storage as oxide alternative as well as the preferred alternative.

- Manufacture of radiation shielding (for use in casks for spent nuclear fuel or HLW) is an activity considered in the use as uranium oxide and use as uranium metal alternatives (as well as the preferred alternative).

Table 2.1 also contains a summary of the materials assumed to be transported between sites for each alternative. Because the locations of conversion, manufacture and use, long-term storage, and disposal sites will be decided in Phase II studies and NEPA reviews, it was assumed that these sites would be at separate locations, requiring transportation of materials between them. This approach was intended to provide a conservative estimate of potential transportation impacts.

The potential environmental impacts for the PEIS alternatives that are presented and compared in this section are taken from the more detailed environmental consequence assessments

TABLE 2.1 Comparison of Activities under the PEIS Alternatives (Note that DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Continued Cylinder Storage at Paducah, Portsmouth, and K-25			
The entire cylinder inventory would continue to be stored indefinitely at the Paducah, Portsmouth, and K-25 sites (impacts were evaluated from 1999 through 2039). Cylinders would be subject to a comprehensive monitoring and maintenance program, which would include routine inspections, cylinder painting, and cylinder yard upgrades.	The entire cylinder inventory would continue to be stored at the three current storage sites from 1999 through 2008. The inventory at each site was assumed to decrease to zero cylinders over the period 2009 through 2034 as cylinders were shipped to an off-site location.[a] During storage at current locations, cylinders would be subject to similar management activities as under no action.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Cylinder Preparation for Transportation			
Not applicable. The cylinders would remain at the three current storage sites.	The cylinders would be prepared at each current storage site for off-site shipment. Cylinders not suitable for shipment would either be provided with over-containers or the contents would be transferred to new cylinders.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Conversion			
Not applicable.	Not applicable.	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to the oxide UO_2 at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium metal at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]

TABLE 2.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Consolidated Long-Term Storage			
Not applicable. Cylinders would remain at the three current storage sites.	UF_6 cylinders would be stored for the long term in yards, buildings, or a mine at a site to be determined in the future. Cylinders would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Oxide (either U_3O_8 or UO_2) would be stored for the long term in drums in buildings, belowground vaults, or a mine at a site to be determined in the future. Material would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Not applicable.	Not applicable.	Not applicable.
		Manufacture and Use			
Not applicable.	Not applicable.	Not applicable.	Depleted uranium oxide (UO_2) would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Depleted uranium metal would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Not applicable.
		Disposal of Uranium			
Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Uranium oxide (either U_3O_8 or UO_2) would be disposed of as LLW at a site to be determined in the future. Disposal was considered for grouted (immobilized) and ungrouted oxide (in drums) in shallow earthen structures, belowground vaults, and a mine.

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TABLE 2.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
			Transportation[b]		
Small amounts of LLW and LLMW would be shipped from the current storage sites to treatment/disposal site(s).	UF_6 cylinders would be shipped from the current storage sites to a long-term storage site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.
	LLW/LLMW would be shipped from storage sites to a disposal/treatment site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a long-term storage site.	Uranium oxide (UO_2) would be shipped from a conversion site to a manufacturing site.	Uranium metal would be shipped from a conversion site to a manufacturing site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a disposal site.
		HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.
		CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.
		NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.
		LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.
			Casks would be shipped from a manufacturing site to a user site.	Casks would be shipped from a manufacturing site to a user site.	
				MgF_2 would be shipped from a conversion site to a disposal site.	

[a] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

[b] Because the locations of conversion, manufacture, long-term storage, and disposal sites will be decided in future studies, it was assumed that these sites were at separate locations, requiring transportation between them. This approach was intended to provide a conservative estimate of potential transportation impacts. Colocation of facilities would reduce transportation impacts.

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

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presented in Chapter 5 and Chapter 6. Chapter 5 evaluates the potential impacts associated with the management of DOE-generated UF_6 (i.e., 46,422 cylinders), which was the original scope of the PEIS. Chapter 6, which was added to the PEIS following the public comment period, discusses the potential impacts that would result from the additional management of up to 15,000 USEC-generated cylinders. In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years. In most cases, the impacts associated with this processing were estimated by extrapolating the results determined for the DOE-generated inventory. (See Chapter 6 for more details.)

The potential environmental impacts for each alternative have been estimated in the areas of human health and safety (normal operations and accidents), air quality, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice. The assessment considered impacts that could result from construction of necessary facilities, normal operations of facilities, facility accidents, and transportation (including routine and accident conditions) of materials. Potential impacts during continued cylinder storage and cylinder preparation for shipment activities were evaluated for the site-specific conditions at the three current storage sites. Potential impacts of conversion, manufacture and use, long-term storage, and disposal activities were evaluated for representative or generic environmental settings. The environmental setting for each site is described in Chapter 3, and the methods used to evaluate each resource area are described in Chapter 4.

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for the period 1999 through 2039 for all alternatives. In addition to this analysis, an evaluation of the long-term impacts from disposal (up to a period of 1,000 years beyond the assumed failure of a disposal facility) was included in the PEIS because such impacts are reasonably foreseeable. Long-term impacts from potential groundwater contamination were also evaluated for the continued storage component of all alternatives.

For all alternatives other than disposal, depleted uranium would require continued management beyond the time frame of approximately 40 years considered in this PEIS. However, a quantitative life-cycle evaluation was not considered at this time because actions to be taken beyond the time period considered in the analysis are considered highly uncertain and speculative. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium is summarized in Section 2.6 and discussed in more detail in Section 5.9.

A comparison of the estimated environmental impacts associated with management of the DOE-generated cylinders only and for the total cylinder inventory (DOE-generated plus USEC-generated) for each alternative is provided in Table 2.2. Table 2.3 summarizes separately the additional impacts that would be associated with the management of up to 15,000 USEC-generated cylinders. The preferred alternative, which combines aspects of several of the alternatives evaluated

TABLE 2.2 Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies[a]

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b]			
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within regulatory limit of 5 rem/yr or lower	Same as NAA[c]	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among involved workers (1999–2039)	1 additional LCF	1 additional LCF [1 to 2 additional LCFS]	1 to 2 additional LCFs [1 to 3 additional LCFs]	1 to 2 additional LCFs	1 to 2 additional LCFs	1 to 2 additional LCF [1 to 3 additional LCFs]
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA for a disposal facility located in a dry environmental setting. In a wet environmental setting, the maximum dose from the use of groundwater was estimated to be about 100 mrem/yr within 1,000 years of facility failure.
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[d]	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Normal Facility Operations[b] (Cont.)			
General public MEI	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA in a dry environmental setting. In a wet environmental setting, a hazard index of about 10 was estimated within 1,000 years of facility failure.
			Human Health and Safety — Facility Accidents[b]			
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999–2039)	0 fatalities; 140 injuries [0 fatalities; 180 injuries]	0–1 fatality; 240–900 injuries [1–2 fatalities; 310–1,200 injuries]	1–2 fatalities; 700–1,600 injuries [1–3 fatalities; 900–2,100 injuries]	2–3 fatalities; 1,300–2,000 injuries [2–3 fatalities; 1,600–2,600 injuries]	2–3 fatalities; 1,300–2,100 injuries [2–3 fatalities; 1,700–2,700 injuries]	1–3 fatalities; 700–1,800 injuries [1–3 fatalities; 900–2,400 injuries]
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[c]						
Accident[f]	Corroded cylinder spill, dry conditions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 10 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	4 potential accidents	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	70	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

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TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Likely Cylinder Accidents[c] (Cont.)						
Radiation exposure – public						
Dose to MEI	3 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	1 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	0.4 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	77 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	3 in 100,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	2.2 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Low Frequency-High Consequence Cylinder Accidents[h]						
Accidents[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 100,000 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	1	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	300	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	7 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	1 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	8 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	16 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Noninvolved workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h]						
Chemical accident[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	HF or NH_3 tank rupture	Same as LTSO[c]	Same as LTSO	Same as LTSO
Release	Uranium, HF	Same as NAA	HF, NH_3	Same as LTSO	Same as LTSO	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Same as LTSO	Same as LTSO	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	< 1 in 1 million years	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 50,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	41,000	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	1	Same as NAA	1,700	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	0	Same as NAA	30	Same as LTSO	Same as LTSO	Same as LTSO
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	1,100	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	300	Same as NAA	440	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	3	Same as NAA	4	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Facility Accidents[b] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h] (Cont.)						
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Noninvolved workers[g]	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Radiological accident[f]	Vehicle-induced fire, 3 full cylinders	Same as NAA	Earthquake damage to storage building at conversion site	Earthquake damage to storage building at conversion site	Vehicle-induced fire, 3 full cylinders	Same as LTSO
Release	Uranium	Same as NAA	Uranium (U_3O_8)	Uranium (UO_2)	Uranium	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Conversion site	Conversion site	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	1 in 100,000 years	1 in 100,000 years	1 in 100,000 years	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 5,000	1 chance in 5,000	1 chance in 5,000	Same as LTSO
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	270 mrem	68 mrem	15 mrem	Same as LTSO
Risk of LCF	7 in 1 million	Same as NAA	1 in 10,000	3 in 100,000	7 in 1 million	Same as LTSO
Total dose to population	28 person-rem	Same as NAA	20 person-rem	5.1 person-rem	56 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	9,000 mrem	2,300 mrem	20 mrem	Same as LTSO
Risk of LCF	8 in 1 million	Same as NAA	1 in 250	9 in 10,000	8 in 1 million	Same as LTSO
Total dose to workers	16 person-rem	Same as NAA	840 person-rem	210 person-rem	8 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Accident risk (consequence times probability)						
General public	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO
Noninvolved workers[g]	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b]			
Major Materials Assumed to Be Transported between Sites	LLW/LLMW	UF_6 cylinders LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0	0	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Negligible	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	Negligible	2 fatalities	4 fatalities	4 fatalities	3 fatalities [4 fatalities]	4 fatalities
Maximum use of rail	Negligible	1 fatality	2 fatalities	2 fatalities [3 fatalities]	1 fatality [2 fatalities]	2 fatalities
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Not applicable	Urban rail accident involving 4 cylinders	Same as $LTSUF_6$[c]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Release	Not applicable	Uranium, HF	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident probability (1999–2039)	Not applicable	1 chance in 10,000	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b] (Cont.)			
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	4	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Fatalities	Not applicable	0	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Radiation exposure – All workers and members of general public						
Total LCFs	Not applicable	60	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident risk (consequence times probability) – Workers and general public	Not applicable	0 fatalities	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Not applicable	Not applicable	Urban rail accident involving anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Release	Not applicable	Not applicable	Anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	Not applicable	Not applicable	1 chance in 30,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	Not applicable	30,000	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	300	Same as LTSO	Same as LTSO	Same as LTSO
Accident risk (consequence times probability)						
Irreversible adverse effects	Not applicable	Not applicable	1	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	0	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]						
Pollutant emissions during construction and operations	Not applicable	Pollutant emissions well within standards (all less than 20% of standards)	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as LTSO	Same as LTSO	Same as LTSO

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Water and Soil[j]			
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other parameters[k]	No change	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Surface water, groundwater, and soil quality	Not applicable	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Uranium concentration in groundwater would remain within guideline for more than 1,000 years after failure in a dry environmental setting; could exceed guideline before 1,000 years after failure in a wet setting
Other parameters[k]	No change	Site-dependent; none to moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Site-dependent; negligible to moderate impacts
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Change in topography from 160,000 to 1.8 million yd^3 of excavated material [210,000 to 2.1 million yd^3]	Change in topography from 81,000 to 2.2 million yd^3 of excavated material [100,000 to 2.6 million yd^3]	Not applicable	Not applicable	Change in topography from 300,000 to 2.6 million yd^3 of excavated material [400,000 to 3.6 million yd^3]

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
		Socioeconomics[1]				
Current Storage Sites						
Continued storage	**Jobs:** 30 peak year, construction; 110 per year over 40 years, operations [38 peak year, construction; 140 per year over 40 years, operations]	**Jobs:** 30 peak year, construction; 120 per year over 20 years, operations [38 peak year, construction; 150 per year over 26 years, operations]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
	Income: $1.4 million peak year, construction; $5.1 million per year over 40 years, operations [$1.8 million peak year, construction; $6.0 million per year over 40 years, operations]	**Income:** $1.4 million peak year, construction; $6 million per year over 20 years, operations [$1.8 million peak year, construction; $7 million per year over 26 years, operations]				
Cylinder preparation	Not applicable	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years, operations [over 26 years, operations]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
		Income: $0–26 million peak year, preoperations; $19–25 million per year over 20 years, operations [over 26 years, operations]				

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics*[1] *(Cont.)			
Other Facilities Conversion (Site undetermined)	Not applicable	Not applicable	**Jobs:** 340–730 peak year, construction; 330–490 per year over 20 years, operations [over 26 years, operations] **Income:** $16–33 million peak year, construction; $20–28 million per year over 20 years, operations [over 26 years, operations]	Same as LTSO	**Jobs:** 480–540 peak year, construction; 340–500 per year over 20 years, operations [over 26 years, operations] **Income:** $17–21 million peak year, construction; $20–28 million per year over 20 years, operations [over 26 years, operations]	Same as LTSO
Long-term storage (Site undetermined)	Not applicable	**Jobs:** 100–500 peak year, construction; 50–60 per year over 30 years, operations [60–70 per year over 30 years, operations] **Income:** $5–29 million peak year, construction; $3 million per year over 30 years, operations [$4 million per year over 30 years, operations]	**Jobs:** 120–410 peak year, construction; 60–70 per year over 30 years, operations [70–80 per year over 30 years, operations] **Income:** $5–20 million peak year, construction; $3–4 million per year over 30 years, operations [$4–5 million per year over 30 years, operations]	Not applicable	Not applicable	Not applicable

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics[1] *(Cont.)*			
Other Facilities (Cont.)						
Manufacturing (Site undetermined)	Not applicable	Not applicable	Not applicable	**Jobs:** 160 peak year, construction; 470 per year over 20 years, operations [over 26 years, operations] **Income:** $7 million peak year, construction; $33 million per year over 20 years, operations [over 26 years, operations]	**Jobs:** 190 peak year, construction; 470 per year over 20 years, operations [over 26 years, operations] **Income:** $9 million peak year, construction; $33 million per year over 20 years, operations [over 26 years, operations]	Not applicable
Disposal (Site undetermined)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**Jobs:** 65–770 peak year, construction; 60–180 per year over 20 years, operations [over 26 years, operations] **Income:** $3.5–42 million peak year, construction; $6–18 million per year over 20 years, operations [over 26 years operations]

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Ecology			
Current Storage Sites Habitat loss	Up to 7 acres; negligible impacts	Up to 28 acres; negligible to potential moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Wetlands and threatened or endangered species	None to negligible impacts	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i] Habitat loss[m]	Not applicable	**Long-term storage:** 96–144 acres; potential moderate to large impacts to vegetation and wildlife [110–170 acres; potential large impacts]	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** 75–210 acres; potential moderate to large impacts to vegetation and wildlife [80–260 acres; moderate to large impacts]	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–35 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Disposal:** 30–470 acres; potential moderate to large impacts to vegetation and wildlife [40–590 acres; moderate to large impacts]
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Below harmful levels for more than 1,000 years in a dry environmental setting; potential chemical effects on aquatic biota before 1,000 years after failure in a wet setting; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Not applicable	Site-dependent; avoid or mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation [increase of about 30% in LLMW generation at the Paducah site]	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	**Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste **Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required); potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Disposal:** Negligible to low impacts with respect to both current and projected nationwide waste generation

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Resource Requirements[m]			
All Sites	No effects on local, regional, or national availability of materials are expected	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation dependent on site location	Same as $LTSUF_6$	Same as NAA	Same as NAA	Same as $LTSUF_6$
			Land Use[m]			
Current Storage Sites	Up to 7 acres; less than 1% of available land; negligible impacts	Up to 28 acres; less than 1% of available land; negligible impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]	Not applicable	**Long-term storage:** 96–144 acres; potential moderate impacts [110–170 acres; potential moderate impacts]	**Conversion:** 30–40 acres; negligible impacts **Long-term storage:** 75–210 acres; potential moderate to large impacts [80–260 acres; moderate to large impacts]	**Conversion:** 30–40 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–35 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts **Disposal:** 30–470 acres; potential moderate to large impacts [40–590 acres; potential moderate to large impacts]
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	Impacts dependent on location; avoid and mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE 2.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

[a] In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] LTSO = long-term storage as oxide alternative; $LTSUF_6$ = long-term storage as UF_6 alternative; NAA = no action alternative.

[d] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[e] Accidents with probabilities of occurrence greater than 0.01 per year.

[f] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[g] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[h] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[i] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[j] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 μg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 μg/g.

Foonotes continue on next page.

TABLE 2.2 (Cont.)

Foonotes (Cont.)

[k] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[l] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[m] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[n] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

TABLE 2.3 Additional Impacts Associated with the Management of up to 15,000 USEC-Generated Cylinders[a]

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Human Health and Safety	
Normal Operations	Under all alternatives, an increase in the total level of radiation exposure of about 30% could result in 0 to 1 additional latent cancer fatality for involved workers. For noninvolved workers and the general public, the increased level of exposure would not be large enough to cause appreciable increases in the potential health impacts.
Facility Accidents • Physical Hazards (on-the-job fatalities and injuries)	The total estimated fatalities and injuries would increase by about 30%, resulting in 0 to 1 additional fatality and 40 to 1,000 additional on-the-job injuries under all alternatives.
• Accidents Involving Releases of Radiation or Chemicals	Under all alternatives, accident consequences would be the same as those predicted for the DOE-generated cylinders only (see Table 2.2), because a limited amount of material would be at risk regardless of the number of cylinders in storage. The frequencies of some facility accidents could increase; however, this increase would not be enough to change the overall expected frequency of specific accidents from the broad ranges used for analysis.
Transportation	The estimated numbers of fatalities from truck and rail accidents would increase by about 30%, which would result in 0 to 1 additional fatality under each alternative. No increase in the number of fatalities from radiological exposures or vehicle emissions during routine operations would be expected. The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those predicted for the shipment of DOE-generated cylinders, because the shipment sizes would not change (Table 2.2). The total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.
Air Quality	At the Paducah and Portsmouth sites, predicted air concentrations of HF could increase as a result of the continued storage of the USEC-generated cylinders. These increases would not result in exceedance of standards or guidelines. Concentrations of criteria pollutants would not exceed guidelines. Under alternatives involving conversion, long-term storage, manufacture, or disposal, the annual uranium emissions would remain unchanged, although total uranium emissions would increase by about 30% as a result of the lengthened period of operations. However, the increase in uranium emissions would not increase the estimated number of adverse health effects.

TABLE 2.3 (Cont.)

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Water and Soil	At the current storage sites, the estimated maximum groundwater concentrations of uranium that would result from releases from hypothetical cylinder breaches would be the same as the bounding values estimated for the DOE-generated cylinders only. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent; however, on the basis of evaluations of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels under all alternatives. For disposal, the estimated groundwater concentrations of uranium during the postclosure (long-term) time frame could increase by about 20% over those estimated for the DOE cylinders only. This increase would not change the overall impact assessment (i.e., guidelines could be exceeded in a wet environment before 1,000 years, but would not be exceeded in a dry environment for more than 1,000 years). Under alternatives involving long-term storage or disposal, soil excavation volumes would increase by about 35% for some options.
Socioeconomics	At the current storage sites, the number of direct jobs and income would increase by about 30%. The annual impacts for conversion, manufacturing, and disposal facilities would not change, but the period of operations would increase by about 6 years. For long-term storage and disposal facilities, the period of construction would also increase by about 6 years. Also, surveillance and maintenance impacts for long-term storage facilities would increase by about 30%.
Ecology	Concentrations of uranium in soil, groundwater, or surface water would remain below benchmark values for toxic and radiological effects under all alternatives except the disposal alternative (in a wet environment). The adverse impact from disposal would be present whether or not the USEC cylinders are included. Under alternatives involving long-term storage or disposal, additional habitat loss would result from additional land use requirements. However, the overall impacts assessment (i.e, negligible, moderate, or large impacts to vegetation or wildlife) would not change under any of the alternatives.
Waste Management	Total waste generation would increase by about 30% as a result of the operation of facilities for 6 additional years. However, the general waste management impacts under each alternative would be the same as those estimated for the DOE cylinders only. For example, waste management impacts when considered in terms of national and regional waste management capabilities would still be low to moderate under alternatives involving conversion and/or disposal because of the potential disposal of CaF_2, MgF_2, and depleted uranium oxides as LLW.

TABLE 2.3 (Cont.)

Impact Area	Impacts Associated with Management of USEC-Generated Cylinders
Resource Requirements	In general, no change in impacts would occur with respect to resource requirements, because the construction and operational requirements would not be resource intensive, and the resources required would not be considered rare or unique. Already large electrical requirements for mine construction would be increased by approximately 15%, but the impacts of the electrical requirements would be site-specific.
Land Use	Under alternatives involving long-term storage or disposal, additional land use requirements would range from 9 to 33% for the various options. However, the overall impacts assessment (i.e, negligible, moderate, or large impacts) would not change under any of the alternatives.
Cultural Resource	The impacts assessment for cultural resources would be the same as that presented for management of DOE-generated cylinders (Table 2.2).
Environmental Justice	The impacts assessment for environmental justice would be the same as that presented for management of DOE-generated cylinders (Table 2.2).

[a] In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years. In most cases, the impacts associated with this processing were estimated by extrapolating the results determined for the DOE-generated inventory. (See Chapter 6 for more details.)

in the PEIS, is discussed separately in Section 2.5. (Detailed discussions of the impacts of the preferred alternative are provided in Section 5.7 and Section 6.3.7.)

To supplement the information in Tables 2.2 and 2.3, each area of impact evaluated in the PEIS is discussed separately in Sections 2.4.1 through 2.4.12. Major similarities and differences among the alternatives are highlighted. The impacts associated with the processing of DOE-generated cylinders are generally discussed first, followed by a summary of the total impacts considering the processing of USEC-generated cylinders. Chapter 5 provides additional details related to management of the DOE-generated cylinders for each alternative, as well as discussions of potential mitigative measures, cumulative impacts, issues related to potential life-cycle impacts, irreversible and irretrievable commitment of resources, the relationship between short-term use of the environment and long-term productivity, pollution prevention, and waste minimization. Chapter 6 provides details related to the additional impacts associated with the management of the USEC-generated inventory and the impacts of managing the total inventory (DOE-generated plus USEC-generated inventory). Changes in cumulative impacts are also discussed in Chapter 6.

2.4.1 Human Health and Safety — Normal Facility Operations

For all alternatives, exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations. Levels of radiation and/or chemical exposures for the general public and noninvolved workers for all alternatives during normal facility operations were estimated to be very low, with zero latent cancer fatalities (LCFs) expected among these groups over the duration of the program. Involved workers (persons directly involved in the handling of radioactive or hazardous materials) could be exposed to low-level radiation emitted by uranium during the normal course of their work activities, and this exposure could result in a slight increase in the risk for radiation-induced cancer fatality among the involved worker population. The annual number of workers so exposed could range from about 50 (under the no action alternative) to about 700 (under the use as metal alternative.) For management of DOE-generated cylinders, the increased exposure to radiation resulted in an estimated range of zero to one involved worker cancer fatality (under the no action alternative) to a range of one to two involved worker cancer fatalities (under the long-term storage as oxide, use as uranium oxide, use as metal, and disposal alternatives) over the assessment period.

Possible radiological exposures from the use of groundwater were also evaluated. For all alternatives except the disposal as oxide alternative, these exposures were estimated to be within applicable public health standards and regulations. During the operational phase of the disposal as oxide alternative, exposures were also estimated to remain within standards and regulations. Although design criteria are such that disposal facilities would not be expected to fail (that is, release material to the environment) until several hundred years after closure, for purposes of analysis, it was assumed that these facilities would fail 100 years after closure. For the disposal as oxide alternative, if the disposal facility was located in a "wet" environment (typical of the eastern United States), the estimated dose at 1,000 years after disposal facility failure from the use of groundwater would be about 100 mrem/yr, which would exceed the dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices would range up to 10, indicating the potential for chemically induced adverse effects. The groundwater analysis indicated that if disposal occurred in a dry environmental setting (typical of the western United States), no measurable groundwater contamination would have occurred at 1,000 years after failure of the disposal facility, because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.

Under all alternatives, consideration of the management of up to 15,000 USEC-generated cylinders would increase the total radiation exposure by about 30%, which would correspond to 0 to 1 additional LCF among involved workers. The total estimated number of health effects among involved workers would range from about 1 LCF under the no action alternative to up to 3 LCFs under the long-term storage as oxide and disposal alternatives. For noninvolved workers and the general public, the increased levels of exposure resulting from the management of USEC-generated cylinders would not be large enough to make a difference in the potential health impacts reported for DOE-generated cylinders only. In addition, although the estimated groundwater concentrations

of uranium at 1,000 years postclosure of a disposal facility would increase by about 20%, this increase would not change the assessment that the dose to a member of the public could exceed specified limits in a wet disposal environment.

2.4.2 Human Health and Safety — Facility Accidents

2.4.2.1 Physical Hazards

Under all alternatives, workers (including involved and noninvolved) could be injured or killed from on-the-job accidents unrelated to radiation or chemical exposure. For the management of DOE-generated cylinders and on the basis of statistics for similar industries, under the no action alternative, it was estimated that zero fatalities and about 140 injuries might occur over the period 1999 through 2039. Under all other alternatives, it was estimated that from zero to three fatalities and from 240 to 2,100 injuries might occur over the same period. Accidental injuries and deaths are not unusual in industries using heavy equipment to manipulate heavy objects and bulk materials. The differences among the alternatives reflect differences in the total number of work hours that would be required.

Management of up to 15,000 USEC-generated cylinders would increase the total number of estimated fatalities and injuries among workers. This increase would result in 1 additional estimated fatality for the long-term storage as UF_6 alternative and for the long-term storage as oxide alternative. (No additional fatalities were estimated for the other alternatives because of rounding effects and the fact that fatality estimates are presented as single whole numbers.) From about 40 to about 1,000 additional on-the-job injuries would be expected across all alternatives (see Table 2.2). Thus, total impacts (including both DOE- and USEC-generated cylinders) would range from 0 to 3 additional fatalities and from 180 to 2,700 injuries across all alternatives.

2.4.2.2 Facility Accidents Involving Releases of Radiation or Chemicals

Under all alternatives, accidents are possible that could release radiation or chemicals to the environment, potentially causing adverse health effects among workers and members of the public. Of all the accidents considered, those involving depleted UF_6 cylinders and those involving chemicals at a conversion facility were estimated to have the largest potential adverse effects.

Under all alternatives, accidents involving UF_6 cylinders could occur at the current storage sites because continued storage of cylinders is a component of all of the alternatives. In addition, cylinder accidents could occur at a consolidated long-term storage facility and at a conversion facility. Cylinder accidents could release UF_6 to the environment. If a release occurred, the UF_6 would combine with moisture in the air, forming gaseous HF and uranyl fluoride (UO_2F_2), a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind,

potentially exposing workers and members of the general public to radiation and chemical effects. The amount released would depend on the severity of the accident and the number of cylinders involved. The potential consequences of cylinder accidents are presented in Table 2.2 for (1) accidents that might happen at least once in 100 years ("likely" accidents; assumed frequency of once in 10 years for probability calculations) and (2) accidents that might happen much less frequently, from once in 10,000 to less than once in 1 million years (assumed frequency of once in 100,000 years for probablity calculations).

For releases involving UF_6 and other uranium compounds, both chemical and radiological adverse effects could occur if the material was ingested or inhaled. The chemical adverse effect of most concern associated with uranium exposure is kidney damage, and the radiological adverse effect is increased rate of cancer fatalities. Chemical effects (kidney damage) occur at lower exposure levels than radiological effects. Exposure to HF from accidental releases could result in a range of health effects, from eye and respiratory irritation to death, depending on the exposure level.

Chemical and radiological exposures for involved workers (those within 100 m of the release) under accident conditions would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

For accidents involving cylinders that might happen at least once in 100 years ("likely" accidents), the off-site concentrations of HF and uranium were estimated to be considerably below levels that would cause adverse chemical effects among members of the general public from exposure to these chemicals. However, up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that three noninvolved workers might experience potential irreversible adverse effects that are permanent in nature (such as lung damage or kidney damage), with no fatalities among these workers expected. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or members of the general public.

Cylinder accidents that are less likely to occur could have greater consequences and could affect off-site members of the general public. These types of accidents are considered extremely unlikely, expected to occur with a frequency of between once in 10,000 and once in 1 million per year of operations. Over the period 1999 through 2039, the probability of this type of accident would be about 1 chance in 2,500. Among all the accidents analyzed, the accident resulting in the largest number of people with adverse effects (including mild and temporary, as well as permanent effects) was a vehicle-induced fire involving three cylinders. If this accident occurred, it was estimated that

up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse chemical effects from HF and uranium exposure (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). More adverse effects are estimated among the general public than among noninvolved workers because of buoyancy effects of the fire on contaminant plume spread (that is, concentrations that occur are higher at points distant from the release than at closer locations).

The modeled accident resulting in the largest number of persons with irreversible adverse health effects was a corroded cylinder spill under wet conditions. If this accident occurred, it was estimated that 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage). No fatalities would be expected among the public; there would be a potential for three fatalities among noninvolved workers from chemical effects. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or the general public.

The number of persons actually experiencing adverse or irreversible adverse effects from cylinder accidents would likely be considerably fewer than those estimated for this analysis and would depend on the actual circumstances of the accident and the individual chemical sensitivities of the affected persons. For example, although exposures to releases from cylinder accidents could be life-threatening (especially with respect to immediate effects from HF inhalation), the guideline exposure level of 20 parts per million (ppm) for HF (American Industrial Hygiene Association [AIHA] 1996), which is used to estimate irreversible adverse effects from HF exposure, is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm (AIHA 1988), and generally, if death does not occur quickly after HF exposure, recovery is complete (McGuire 1991).

The guideline intake level of 30 mg used to estimate irreversible adverse effects of uranium in this PEIS is that suggested in NRC guidance (NRC 1994a). This level is somewhat conservative; that is, it is intended to overestimate rather than underestimate the potential number of irreversible adverse effects in the exposed population. In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing *solid* UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers. In previous accidental exposure incidents involving *liquid* UF_6 in gaseous diffusion plants, some worker fatalities occurred immediately following the accident as a result of inhalation of HF generated from the UF_6. However, no fatalities occurred as a result of the toxicity of the uranium exposure. A few workers were exposed to amounts of uranium estimated to be approximately three times the guideline level used for assessing irreversible adverse effects (30 mg), but none of these workers actually experienced such effects (McGuire 1991).

For all of the management strategies considered in the PEIS, low-probability accidents involving chemicals at a conversion facility were estimated to have the largest potential consequences to noninvolved workers and members of the public. Conversion would be required for

long-term storage as oxide, use as oxide, use as metal, and disposal. At a conversion site, accidents involving releases of chemicals, such as ammonia and HF, are possible. Ammonia is used for some conversion options, and HF can be produced in converting UF_6 to either uranium oxide or uranium metal. The primary impacts from conversion accidents are related to potential chemical exposures to the released material.

The conversion accidents estimated to have the largest potential consequences were accidents involving the rupture of tanks containing either anhydrous HF or ammonia. Such accidents could be caused by a large earthquake and are expected to occur with a frequency of less than once in 1 million per year of operations. The probability of these types of accidents occurring during the operation of a conversion facility would be about 1 chance in 50,000. If such accidents occurred, it was estimated that up to 41,000 members of the general public around the conversion facility and 1,100 noninvolved workers might experience adverse effects from chemical exposures (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). Of these, up to 1,700 members of the general public and 440 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage), with the potential for about 30 fatalities among the public and 4 fatalities among noninvolved workers. In addition, irreversible or fatal effects among involved workers are possible.

These high consequence accidents are expected to be extremely rare. The risk (defined as consequence multiplied by probability) for these accidents would be zero fatalities and irreversible adverse health effects expected for noninvolved workers and the members of the public combined, and one adverse health effect expected for the general public. Ammonia and anhydrous HF are commonly used chemicals for industrial applications in the United States. Industrial accident prevention and mitigative measures are well established for HF and ammonia storage tanks. These include storage tank siting principles, design recommendations, spill detection, and containment measures. These measures would be implemented, as appropriate, if conversion were required by the selected alternative.

Management of USEC-generated cylinders would not affect the accident consequences predicted for the DOE-generated cylinders (see Table 2.2), because, under all accident scenarios, only a limited amount of material would be at risk, regardless of the number of cylinders in storage. Frequencies for some facility accidents could increase. However, this increase would not be enough to change the overall expected frequency of specific accidents from the broad ranges used in the PEIS analysis.

2.4.3 Human Health and Safety — Transportation

A conservative estimate of transportation impacts was provided by assuming that continued cylinder storage, conversion, consolidated long-term storage, manufacture and use, and disposal facilities would be located at separate sites, requiring transportation of materials between these sites. Under the no action alternative, only small amounts of LLW and LLMW generated during cylinder

maintenance activities would require transportation, with only negligible impacts expected. The major materials assumed to require transportation for the other alternatives are summarized in Table 2.2. Most materials could be shipped by either truck or rail. For purposes of comparison, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. (Transportation impacts are evaluated for a range of shipment distances in Appendix J). Most shipments were assumed to occur over a 20-year period, from 2009 through 2028 (or through 2034 for management of USEC-generated cylinders). Impacts from transportation activities could be reduced if several facilities were located at the same site.

During normal transportation operations, radioactive material and chemicals would be contained within their transport packages. Potential health impacts to crew members (i.e., workers) and members of the general public along the route could occur if there were exposure to low-level external radiation in the vicinity of shipments of uranium materials. In addition, exposure to vehicle engine exhaust emissions could potentially cause adverse health effects from inhalation. Under all alternatives other than the no action and long-term storage as UF_6 alternatives, it was conservatively estimated that no more than one fatality would occur from these causes. Under all alternatives, members of the general public living along truck and rail transportation routes would receive extremely small doses of radiation from shipments, less than 0.1 mrem over 40 years. This would be true even if a single person were to be exposed to every shipment of radioactive material during the program.

Under all alternatives, traffic accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public either from the actual accident or from accidental releases of radioactive materials or chemicals.

Under each alternative, the total number of traffic fatalities (unrelated to the type of cargo) was estimated on the basis of national traffic statistics for shipments by both truck and rail modes. For DOE-generated cylinders, if shipments were predominantly by truck, it was estimated that from two to four traffic fatalities could occur over the duration of the program. If shipments were predominantly by rail, it was estimated that one to two traffic fatalities could possibly occur. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

Severe transportation accidents could also cause a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how *quickly* the released material dispersed and diluted to lower concentrations as it moved downwind.

All alternatives other than the no action alternative could involve the transportation of UF_6 cylinders between sites. For cylinder shipments, among the accidents analyzed, a severe rail accident involving four cylinders was estimated to have the highest potential consequences. The consequences of such an accident would be highest if the accident occurred in an urban area under stable weather conditions (such as at nighttime). The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 for shipping all cylinders by rail (the actual probability would depend on the route selected). In the unlikely event that such an accident were to occur, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung damage or kidney damage) from chemical exposure to HF and UO_2F_2 generated from released UF_6, with zero fatalities expected. Over the long term, radiation effects would be possible from exposure to the uranium released. It was estimated that approximately 60 cancer fatalities could occur in the urban population from such an accident in addition to the approximately 700,000 that would occur from all other causes (approximately 3 million persons were assumed to be exposed to low levels of uranium from the accident as the uranium dispersed in the air). The risk (consequence multiplied by probability) for this accident would be zero expected LCFs.

For all other materials assumed to be transported in the PEIS, the highest potential accident consequences would be caused by a rail accident involving anhydrous HF that might be produced during conversion. Conversion would be required for the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives. Anhydrous HF is commonly transported by industry as a liquid in trucks and rail tank cars. Anhydrous HF could be produced during conversion and could potentially be transported to a user. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site could potentially experience irreversible adverse effects from chemical exposure to HF. However, the probability of such an accident occurring if all the anhydrous HF produced was transported 620 miles (1,000 km) was estimated to be only about 1 chance in 30,000. Anhydrous HF is routinely shipped commercially in the United States for industrial applications. To provide perspective, since 1971, the period covered by DOT records, there have been no fatal or serious injuries to the public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars have been reported that had no associated evacuations or injuries. The only major release (estimated at 6,400 lb of anhydrous HF) occurred in 1985 and resulted in approximately 100 minor injuries. The last HF release during transportation was a minor release in 1990. The improved safety record of transporting anhydrous HF in the past 10 years can be attributed to several practices. Such practices include installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Nonetheless, if the unlikely rail accident described above (i.e., release of HF from a railcar in a densely populated urban area under stable weather conditions) were to occur, it was estimated

that up to 30,000 persons might experience irreversible adverse effects (such as lung damage), with the potential for about 300 fatalities. If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, including one expected fatality. The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF accident would be much less under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and lower downwind concentrations. Under unstable conditions, an area of about 1 mi^2 (2 km^2) could be affected by an accident. If such an accident occurred in an urban area, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, with the potential for about 30 fatalities. If the accident occurred in a rural area under unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with zero fatalities expected. When considering the probability of an HF accident occurring, one person would be expected to experience irreversible adverse effects, and no fatalities would be expected over the shipment period.

Management of up to 15,000 USEC-generated cylinders would increase the total estimated number of fatalities from truck and rail accidents by about 30%. This increase would result in 0 to 1 additional fatality under each alternative. The total number of traffic fatalities would range from 2 to 4 for truck shipments and from 1 to 3 for rail shipments. Although exposures would also increase, no increase in the number of fatalities from radiological exposures or vehicle emissions during routine operations would be expected. The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders, because the shipment sizes would be the same. The total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years. However, the risk (probability multiplied by consequence) results presented in Table 2.2 would stay the same.

2.4.4 Air Quality

For management of both DOE- and USEC-generated cylinders, air quality from construction and facility operations for all alternatives would be within existing regulatory standards and guidelines. All construction activities planned to support continued cylinder storage (e.g., constructing new storage yards) would be required within the first 10 years of continued storage when all cylinders would still be in storage under each alternative. Therefore, air quality impacts from construction activities at the current storage sites would be the same across the alternatives. Estimated concentrations of particulate matter (dust) that could be generated during construction activities are close to the regulatory standard levels; these temporary emissions could be controlled by good construction practices.

If it is assumed cylinder maintenance and painting activities would not reduce cylinder corrosion rates, it is possible that cylinder breaches could result in HF air concentrations greater than

the regulatory standard level at the K-25 storage site around the year 2020; HF concentrations at the Paducah and Portsmouth sites were estimated to remain within applicable standards or guidelines (Tschanz 1997b). However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, air concentrations of HF would be kept within regulatory standards at all storage sites (Tschanz 1997a).

2.4.5 Water and Soil

For operations under all alternatives, uranium concentrations in surface water, groundwater, and soil at the three current storage sites would remain below guidelines throughout the project duration (when the EPA proposed maximum contaminant level [MCL] of 20 µg/L for drinking water [EPA 1996] is used as a guideline for water and the EPA health-based residential soil guideline of 230 µg/g [EPA 1995a] is used as a guideline for soil). Under the no action alternative, if cylinder maintenance and painting would not reduce cylinder corrosion rates, it is possible that the uranium groundwater concentration could be greater than 20 µg/L at all three sites at some time in the future (earliest about the year 2100 at the Paducah site). However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, groundwater uranium concentrations would remain less than 20 µg/L. For all other alternatives, groundwater concentrations would remain less than 20 µg/L, even without continued cylinder maintenance and painting, because the cylinders would begin to be removed around the year 2009.

Under the disposal alternative, if a disposal facility in a dry environmental setting were to fail, groundwater impacts would be unlikely for at least 1,000 years. (No measurable groundwater contamination would have occurred because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.) For a disposal facility in a wet environmental setting, the uranium concentration in groundwater beneath the facility might be greater than 20 µg/L within 1,000 years after failure of the facility (with or without consideration of USEC-generated cylinders). It should be noted, however, that the disposal calculations are subject to a great deal of uncertainty, and results would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were part of the management strategy selected. If disposal was implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW.

Under all alternatives, construction activities have the potential to result in surface water, groundwater, or soil contamination through spills of construction chemicals. By following good engineering practices, concentrations in soil and wastewater (and therefore surface water and groundwater) could be kept well within applicable standards or guidelines.

Under the long-term storage as UF_6, long-term storage as oxide, and disposal as oxide alternatives, from 81,000 yd^3 to 2.6 million yd^3 (62,000 to 2 million m^3) of soil and rock could require excavation and surface disposal, depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was selected. The excavated material could result in changes to topography at the facilities; these changes could be mitigated, if necessary, through trucking the excavated material off-site and/or by contouring and reseeding the site. Mine storage and disposal would generally result in the largest excavation volumes. If mine storage or disposal were selected as a UF_6 management strategy, excavation volumes could also be reduced through use of a previously existing mine.

Management of up to 15,000 USEC-generated cylinders would not affect the maximum groundwater concentrations of uranium at the current storage sites estimated for the DOE-generated cylinders only. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent, but, on the basis of evaluations of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels under all alternatives.

For disposal, the estimated groundwater concentrations of uranium during the post-closure (long-term) time frame could increase by about 20% when the potential impacts from management of the additional USEC-generated cylinders are included. This increase would not change the overall impact assessment (i.e., guidelines could be exceeded in a wet environment before 1,000 years, but they would not be exceeded in a dry environment for more than 1,000 years).

Under alternatives involving long-term storage or disposal, soil excavation volumes would increase by about 35% for some options when USEC-generated cylinders are included. The range of excavation requirements would increase to 100,000 to 3.6 million yd^3 (76,000 to 2.8 million m^3), depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was the option selected.

2.4.6 Socioeconomics

The no action alternative would result in the smallest socioeconomic impacts of the alternatives considered, creating about 110 direct jobs and generating about $5.1 million in direct income per operational year. The storage as UF_6 alternative would have the second smallest socioeconomic impacts because conversion would not be required; this alternative would create about 570 to 1,200 direct jobs and generate about $33 to $66 million in direct income per year. The other alternatives (long-term storage as oxide, use as oxide, use as metal, and disposal as oxide) would have similar socioeconomic impacts, creating about 900 to 1,600, 1,200 to 1,600, 1,200 to 1,600, and 900 to 2,100 direct jobs per year, respectively, and generating about $53 to $85 million, $78 to $92 million, $78 to $92 million, and $55 to $120 million in direct income per year, respectively. Under the storage and disposal alternatives, the upper ends of the ranges of jobs created and income generated correspond to options requiring mine excavation.

Continued cylinder storage under all alternatives would result in negligible impacts on regional growth and housing. Such impacts would be site dependent, but would be minor for conversion and long-term storage based on the analysis for representative sites.

Management of up to 15,000 USEC-generated cylinders would increase the number of direct jobs and income at the Paducah and Portsmouth sites by about 30%. (Since no USEC-generated cylinders are located at the K-25 site, no change in socioeconomic impacts would occur at the K-25 site.) The annual impacts for conversion, manufacturing, and disposal facilities would be the same as those discussed for management of DOE-generated cylinders, but the period of operations would increase by about 6 years. For long-term storage and disposal facilities, the period of construction would also increase by about 6 years. Also, surveillance and maintenance impacts for long-term storage facilities would increase by about 30%.

2.4.7 Ecology

Habitat loss at the current storage sites for all alternatives would range from 0 to 7 acres (2.8 ha) for the no action alternative to 0 to 28 acres (11 ha) or less for all other alternatives, depending on whether cylinder transfer facilities at the three sites were selected as the cylinder preparation option. These habitat losses would constitute less than 1% of available land at the current sites and would have negligible impacts on biota.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 96 to 144 acres (39 to 58 ha) for long-term storage as depleted UF_6, 75 to 210 acres (30 to 85 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 30 to 470 acres (12 to 190 ha) for disposal when only DOE-generated cylinders are considered. When both DOE- and USEC-generated cylinders are considered, the land disturbed would increase to a range of 110 to 170 acres (44 to 68 ha) for long-term storage as UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, and 40 to 590 acres (16 to 240 ha) for disposal. The large ranges in estimated land requirements result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. The consequences of habitat loss would be site dependent in terms of adverse impacts to threatened and endangered species and wetlands, and they would be evaluated in subsequent site-specific NEPA reviews. As a general guideline, potential moderate adverse impacts to vegetation and wildlife from habitat loss were assumed if the required land area was greater than 10 acres, and potentially large adverse impacts were assumed if the required land area was greater than 100 acres.

If a disposal facility in a wet environmental setting were to fail, the uranium concentration in groundwater beneath the facility might exceed 20 µg/L within 1,000 years after failure. If the groundwater discharged to nearby surface waters, aquatic biota might be exposed to elevated concentrations of uranium, possibly resulting in adverse chemical effects; however, no adverse radiological effects would occur at the concentrations estimated. Concentrations would result in dose

rates to aquatic organisms of less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d specified in DOE Order 5400.5.

Consideration of up to 15,000 USEC-generated cylinders would not significantly affect ecological impacts. Concentrations of uranium in soil, groundwater, or surface water would remain below benchmark values for toxic and radiological effects under all alternatives except the disposal alternative (in a wet environment). The adverse impact from disposal would be present whether or not the USEC cylinders were considered. Under alternatives involving long-term storage or disposal, additional habitat loss would result from additional land use requirements. However, the overall impacts assessment (i.e., negligible, moderate, or large impacts to vegetation or wildlife) would not change under any of the alternatives.

2.4.8 Waste Management

During continued storage at the current sites under all alternatives, LLMW would be generated from cylinder scraping and painting activities. The amount of LLMW generated from these activities could result in moderate impacts to waste management at the Paducah site (annual volumes could be about 23% of the current site annual LLMW generation volume of 100 m^3/yr); however, the amount is less than 1% of the current estimated annual LLMW treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr) and would have a negligible to low impact on DOE's waste management system as a whole.

The alternatives requiring conversion to oxide are long-term storage as oxide, use as oxide, and disposal as oxide. Depending on the conversion option selected, anhydrous HF or CaF_2 could be produced. Historical industrial experience indicates that anhydrous HF, if produced, would contain only trace amounts of depleted uranium (less than 1 ppm). Because of the considerable market for HF (it is commonly used for many industrial applications, including the production of UF_6 from natural uranium ore), it was assumed that if anhydrous HF was produced, it would be sold for use, subject to review and approval by DOE or NRC, depending on the specific use.

If an option involving CaF_2 production was selected, it is currently unknown whether CaF_2 generated in the conversion to oxide processes could be sold, whether the low uranium content would allow disposal as nonhazardous solid waste, or whether disposal as LLW would be required. The low level of uranium contamination expected (i.e., less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste would be most likely. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use. Waste management for disposal as nonhazardous waste could be handled through appropriate planning and design of the facilities. If the CaF_2 was considered to be LLW, the largest CaF_2 generation volumes (about 426,000 m^3 over the 20-year period for the conversion to oxide with neutralization of HF option) would represent about 10% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e., 4.25 million m^3) and could result in moderate impacts on waste management (if the LLW was considered to be DOE waste).

Under alternatives requiring conversion to either oxide or metal, the empty cylinders would be treated to remove the heels material and crushed. It is assumed that the treated, crushed cylinders would become part of the DOE scrap metal inventory. If a decision on disposing of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume. This would constitute a low impact on DOE's waste management system as a whole.

Under the use as metal alternative, MgF_2 would also be produced during conversion. It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonhazardous solid waste. (It is estimated that the MgF_2 would contain uranium at a concentration of about 90 ppm.) If the MgF_2 was considered to be DOE LLW, the volume generated would represent about 6% of the projected DOE complexwide LLW disposal volume, a low to moderate impact for DOE's waste management system as a whole. Under the metal conversion option, if the HF was neutralized and the CaF_2 generated was considered to be DOE LLW, the CaF_2 would represent approximately an additional 3% of the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact on DOE's waste management system.

The LLW volumes requiring disposal under the disposal as oxide alternative represent an addition of from about 2 to 7% to the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact for DOE's waste management system. The waste management impacts for all alternatives requiring conversion of UF_6 would be similar, having the potential for a moderate impact on DOE's LLW management system.

Consideration of up to 15,000 USEC-generated cylinders would not significantly affect waste management impacts. Total waste generation would increase by about 30% as a result of the operation of facilities for 6 additional years. However, the general waste management impacts under each alternative would be the same as those estimated for the DOE cylinders only. For example, waste management impacts, when considered with regard to national and regional waste management capabilities, would still be low to moderate under alternatives involving conversion and/or disposal, because of the potential disposal of CaF_2, MgF_2, empty cylinders, and depleted uranium oxide as LLW.

2.4.9 Resource Requirements

Resource requirements include construction materials, fuel, electricity, process chemicals, and containers. In general, all of the alternatives would have a negligible effect on the local or national availability of these resources (when both DOE- and USEC-generated cylinders are considered). However, under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during construction (up to 1,100 MW-yr). The availability of this electricity would depend on site location. Also, the disposal alternative would result in permanent disposition of the depleted

uranium, a material that DOE considers to be a valuable national resource. Disposal would constitute an irreversible and irretrievable commitment of this resource to a nonproductive purpose.

2.4.10 Land Use

For current sites, continued storage and cylinder preparation could require up to 28 acres (11 ha) of land for new or reconstructed cylinder yards and transfer facilities, if built. This acreage constitutes less than 1% of available land at the three sites. Furthermore, it is likely that previously developed land could be used for these needs.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 96 to 144 acres (39 to 58 ha) for long-term storage as depleted UF_6, 75 to 210 acres (30 to 85 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 30 to 470 acres (12 to 190 ha) for disposal when only DOE-generated cylinders are considered. When both DOE- and USEC-generated cylinders are considered, the land disturbed would increase to a range of 110 to 170 acres (44 to 68 ha) for long-term storage as UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, and 40 to 590 acres (16 to 240 ha) for disposal. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres around the conversion facilities. The large ranges in the estimated land required result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. Potential land-use impacts would depend on where the facilities were sited. As a general guideline, potentially moderate land use impacts were assumed if the required land area was greater than 50 acres, and potentially large land use impacts were assumed if the required land area was greater than 200 acres.

2.4.11 Cultural Resources

Impacts to cultural resources at the current storage sites would be unlikely. Potential for impacts at new sites would depend entirely on their locations. Such impacts would be minimized through surveys conducted prior to construction activities and through consultation with state historic preservation officers.

2.4.12 Environmental Justice

No disproportionately high or adverse human health or environmental impacts would be expected to minority or low-income populations during normal facility operations for any of the alternatives (when both DOE and USEC-generated cylinders are considered). Although the consequences of facility accidents could be high if severe accidents occurred, the risk of irreversible adverse effects (including fatalities), among members of the general public from these accidents (taking into account the consequences and probability of the accidents) would be less than

one. Furthermore, transportation accidents with high and adverse impacts are unlikely, their locations have not been projected, and the types of persons who would be involved cannot be reliably predicted; therefore, there is no reason to expect that minority and low-income populations would be affected disproportionately by high and adverse impacts.

2.5 DOE'S PREFERRED ALTERNATIVE

2.5.1 Description

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors.

DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and metal products for use. Conversion to oxide or metal would also generate fluorine or fluorine compounds such as HF, which would also have beneficial uses. This preferred alternative provides the flexibility to respond to changing market conditions and to the continued development of new uses for the conversion products. During the time that the depleted UF_6 inventory is being converted for long-term storage and product applications, some depleted UF_6 would also be available for other uses that might develop.

Potential uses for fluorine products exist now in the aluminum, chemical, steel, and glass industries. Large-scale uses for the depleted uranium products are under development. These uses include radiation-shielding applications, in which uranium oxide is used as a substitute for the aggregate in concrete. Concrete made with depleted uranium would be a more effective shielding material than conventional concrete and would provide the same level of radiation shielding with less thickness than conventional concrete. Among other uses, this concrete could be fabricated into casks for storage of spent nuclear fuel or HLW.

In addition to the above potential large-scale uses of the depleted UF_6, small-scale use of some depleted UF_6 is being considered in industrial applications and by other DOE program decisions and NEPA analyses, such as that for the disposition of surplus plutonium (see Section 1.6). At this time, uses being considered by other DOE programs generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy in the Record of Decision to be issued following the publication of this PEIS.

DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999 (U.S. Department of Commerce 1999). Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

The locations for conversion and fabrication facilities, the start-up date for conversion, the rate of conversion, and the chemical form of depleted uranium and fluorine products would be subject to follow-on (tiered) NEPA analyses and availability of any necessary federal funding. Conversion of the depleted UF_6 to uranium oxide under the preferred alternative would begin as early as practicable. DOE expects that in the future, uses will be available for some portion of the converted material. The value of depleted uranium and HF or CaF_2 for use is based on their unique qualities, the size of the inventory, and the history of uses already implemented (e.g., industrial applications for fluorine compounds). DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted uranium inventory.

Current practices for managing the depleted UF_6 cylinder inventory include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, and surveillance and maintenance of the cylinders and cylinder yards. Under the preferred alternative, these practices would continue or be modified, as necessary, to meet any changing requirements for protection of worker and public health and safety and of the environment. Safe management of the cylinder inventory would continue through conversion of 100% of the inventory for use or storage. Aggressive cylinder management will ensure that continued storage of the depleted UF_6 cylinders prior to conversion will be consistent with DOE's policy of safe, effective material management.

2.5.2 Impacts of the Preferred Alternative

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. Most of the inventory would likely require interim storage as depleted uranium oxide pending use. The impacts of the 100% use as oxide alternative, 100% use as metal alternative, and 100% long-term storage as oxide alternative are described in detail in Sections 5.3, 5.4, and 5.5 for the DOE-generated cylinders. The impacts of adding the USEC cylinders under these alternatives are described in Sections 6.3.3, 6.3.4, and 6.3.5. The impacts of these three alternatives may be considered representative for the preferred alternative. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was also analyzed. The potential impacts of this combination strategy are discussed in detail in

Section 5.7 and Section 6.3.7. A tabular summary of the potential impacts of this combination strategy that is representative of the preferred alternative is shown in Table 2.4.

For the four alternative management strategies considered representative of the preferred alternative (100% use as oxide; 100% use as metal; 100% long-term storage as oxide; and combination 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide), potential environmental impacts for many technical areas are very similar (see Tables 2.2, 2.3, and 2.4). With respect to human health and safety impacts of normal facility operations, the strategies have similar impacts; that is, radiological and chemical exposures for the general public and workers would remain well within regulatory limits and public health standards under all four strategies. Also, the consequences of accidents would be similar under all four strategies. Impacts to air quality, water and soil quality, and waste management would also be similar for the four management strategies representative of the preferred alternative.

Potential differences in impacts arise for the 25% use as oxide, 25% use as metal, 50% long-term storage as oxide combination strategy because of increased requirements for workforce, acreage, and construction and operational materials associated with the potential need for two conversion facilities, two manufacturing facilities, two cylinder treatment facilities, and a long-term storage facility. The resources required for these facilities are nonlinear with throughput; that is, the resources required to build and operate a 25%-capacity or a 50%-capacity facility are more than one-quarter or one-half the resources required to build and operate one 100%-capacity facility. This situation results in some increased impacts for the combination strategy. For example, the estimated number of worker fatalities and injuries for construction and operation under the combination strategy (3 to 4 fatalities; 2,200 to 3,100 injuries for the DOE-cylinders only) is about 1.5 times that estimated for the 100% use as oxide and 100% use as metal strategies, separately. Similarly, required jobs and income produced under the combination strategy are greater than they are under the 100% use strategies. If the combination strategy resulted in construction of separate conversion, manufacturing, cylinder treatment, and long-term storage facilities, total land use requirements could almost double, also resulting in an increased potential for adverse ecological impacts.

For the purposes of analysis of the combination strategy, it was assumed that independent conversion, manufacturing, and storage facilities would be constructed. However, in practice, such facilities may be located together, which would reduce the resource needs of the combination strategy.

The impacts of an additional combination use strategy (i.e., 50% use as oxide, 50% use as metal) are presented in Appendix K, Table K.10.

2.6 SUMMARY OF ISSUES RELATED TO POTENTIAL LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the

TABLE 2.4 Summary of Potential Environmental Consequences of a Combination Management Strategy Representative of the Preferred Alternative for DOE-Generated Cylinders Only and for the Total Cylinder Inventory[a]

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Normal Facility Operations[b]	
Radiation Exposure	
Involved Workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	1 to 2 additional LCFs [2 to 3 additional LCFs]
Noninvolved Workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General Public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[c]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[b]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	3–4 fatalities; 2,200–3,100 injuries [4–5 fatalities; 2,900–4,100 injuries]
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[d]	
Accident[e]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	3 potential accidents [4 potential accidents]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[f]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[g]	
Accident[e]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse impacts)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – Noninvolved workers[f]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g]	
Chemical accident[e]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[f]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident[e]	Earthquake damage to storage building at conversion site
Release	Uranium (U_3O_8)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g] (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	270 mrem
Risk of LCF	1 in 10,000
Total dose to population	20 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[f]	
Dose to MEI	9,000 mrem
Risk of LCF	1 in 250
Total dose to workers	840 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[b]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	4 fatalities [5 fatalities]
Maximum use of rail	1 fatality [2 fatalities]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Transportation[b] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequency-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident Risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[h]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Water and Soil[i]	
Current Storage Sites Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[j]	No change
Other Facilities[h] Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[j]	Site-dependent; none to moderate impacts
Excavation of soil for long-term storage	Change in topography from 41,000 yd^3 to 1.1 million yd^3 of excavated material [51,000 yd^3 to 1.3 million yd^3]
Socioeconomics[k]	
Current Storage Sites Continued storage	**Jobs:** 30 peak year, construction; 120 per year over 20 years of operation [150 per year over 26 years of operation] **Income:** $1.4 million peak year, construction; $6 million per year over 20 years of operation [$7 million per year over 26 years of operation]
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years of operation [over 26 years of operation] **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 20 years of operation [over 26 years of operation]
Other Facilities[h] Conversion	**Jobs:** 670–960 peak year, construction; 510–720 per year over 20 years of operation [over 26 years of operation] **Income:** $28–41 million peak year, construction; $30–41 million per year over 20 years of operation [over 26 years of operation]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Socioeconomics*[k] *(Cont.)
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 20 years of operation [over 26 years of operation] **Income:** $13 million peak year, construction; $30 million per year over 20 years of operation [over 26 years of operation]
Long-term storage	**Jobs:** 60–210 peak year, construction; 30–35 per year over 30 years of operation [39–46 per year over 30 years of operation] **Income:** $3–10 million peak year, construction; $2–3 million per year over 30 years of operation [$3–4 million per year over 30 years of operation]
	Ecology
Current Storage Sites	
Habitat loss[l]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[h]	
Habitat loss[l]	**Conversion:** Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 79 acres at a single site; total of 160 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** About 49 acres; potential moderate impacts to vegetation and wildlife [About 61 acres]
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Waste Management	
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation [increase of about 30% in LLMW at Paducah site]
Other Facilities[h] Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
Long-term storage	Negligible impacts with respect to current regional or nationwide waste generation
Resource Requirements[m]	
All Sites	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation depend on site location
Land Use	
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[h] Conversion	Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts
Manufacturing	Up to 79 acres at a single site; total of 160 acres; potential moderate impacts
Long-term storage	About 49 acres; potential moderate impacts [About 61 acres]

TABLE 2.4 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Cultural Resources
Current Storage Sites	Impacts unlikely
Other Facilities[h]	Impacts depend on location; avoid and mitigate
	Environmental Justice
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely

[a] In general, the overall environmental consequences from managing the total cylinder inventory (total of USEC-generated and DOE-generated cylinders) are the same as those from managing the DOE-generated cylinders only. In this table, when the consequences for the total inventory differ from those for the DOE-generated cylinders only, the consequences for the total inventory are presented in brackets following the consequences for DOE cylinders only.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[d] Accidents with probabilities of occurrence greater than 0.01 per year.

[e] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[f] In addition to noninvolved worker impacts, involved worker injuries and fatalities are possible from chemical, radiological, and/or physical forces of accidents. Chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[g] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[h] Other facilities are facilities for conversion, manufacturing, and storage.

[i] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

[j] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

Footnotes continue on next page.

TABLE 2.4 (Cont.)

Footnotes (Cont.)

[k] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[l] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[m] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 μm or less; UF_6 = uranium hexafluoride.

PEIS. The potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready to be decided upon at this time. A discussion of issues related to the potential life-cycle impacts associated with depleted uranium management is provided in Section 5.9 and summarized here.

The management of depleted uranium beyond the year 2039 would depend on the management strategy in place at that time. If depleted uranium were in long-term storage in 2039, the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and then used or disposed of. Continued storage may require refurbishment or replacement of facilities and containers as their design lifetimes are exceeded.

Depleted uranium might also require management after use, depending on the type of product and nature of the use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or treated and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time. Disposal after use may also require further treatment or processing, such as conversion to a suitable chemical form. Some uses might also result indirectly in the permanent disposal of the material. For example, it is possible that casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or HLW in a geologic repository.

3 AFFECTED ENVIRONMENT

Depleted UF_6 is currently managed at three locations: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25 site on the Oak Ridge Reservation near Oak Ridge, Tennessee. In the context of this PEIS, a distinction is made between "site" (the entire DOE facility), a gaseous diffusion plant (a USEC-operated facility within the larger site), and the storage yards (the location of the depleted UF_6 cylinders within the site). This section describes the affected environment at these sites, as well as the environmental settings assumed for the long-term storage, conversion, and disposal options.

3.1 PADUCAH SITE

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River (Figure 3.1). The Paducah site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area (Martin Marietta Energy Systems [MMES] 1994b). According to a 1953 agreement granting the land to the Kentucky Department of Fish and Wildlife Resources, DOE can use any or all of this land whenever the need arises (MMES 1990). The city of Paducah is the largest urban area in the six counties surrounding the site. The six-county area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) occupies a 750-acre (303-ha) complex within the Paducah site and is surrounded by a security fence (Figure 3.1). The PGDP, previously operated by DOE and now operated by the USEC, includes 115 buildings with a combined floor space of approximately 8.2 million ft^2 (0.76 million m^2) (MMES 1990). The PGDP has operated since 1955.

In 1994, the Paducah site was placed on the EPA National Priorities List (NPL), a list of sites across the nation that have been designated by EPA as high priority for site remediation. The NPL designation was mainly due to groundwater contamination with trichloroethylene and technetium-99, first detected in 1988. Being placed on the NPL meant that the cleanup requirements of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) would be met in conducting remediation efforts at the Paducah site. Hazardous waste and mixed waste management at the Paducah site must comply with *Resource Conservation and Recovery Act* (RCRA) regulations, which are administered by the Commonwealth of Kentucky, Division of Waste Management. The RCRA regulations also address implementation of corrective (or remedial) actions for solid waste management units. Thus, both CERCLA and RCRA have requirements for remedial actions for contaminated environmental media. A Federal Facilities Agreement (FFA) has been developed to integrate CERCLA/RCRA requirements into a single remediation procedure for the

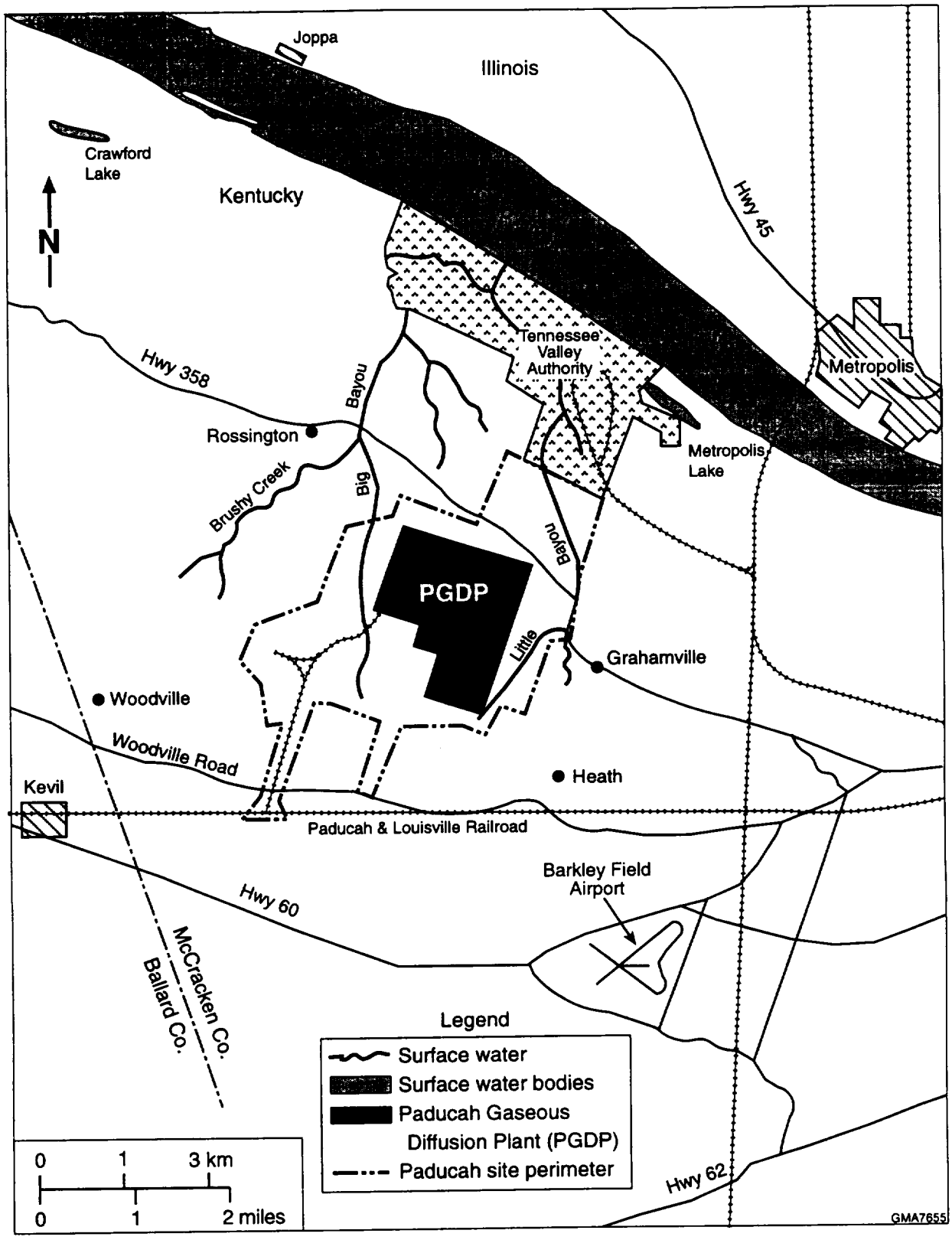

FIGURE 3.1 Regional Map of the Paducah Site Vicinity (Source: Adapted from LMES 1996a)

Paducah site. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF_6 cylinder storage areas into the context of sitewide conditions.

3.1.1 Cylinder Yards

The Paducah site has 13 yards used to store cylinders of DOE-generated depleted UF_6 (Table 3.1; Figure 3.2). The yards encompass approximately 13 acres (5.3 ha) and store 28,351 cylinders containing depleted UF_6. Nine of the Paducah storage yards have gravel bases. The C-745-F yard (F-yard) is located on a former building foundation. The C-745-S yard (S-yard), C-745-G yard (G-yard), and C-745-T yard (T-yard) are newly constructed with concrete bases.

TABLE 3.1 Locations of Cylinders of DOE-Generated Depleted UF_6 at the Paducah Site[a]

Yard	Area (ft^2)	Number of Cylinders
C-745-A[b]	199,899	1,802
C-745-B[b]	471,630	1,185
C-745-C	439,902	227
C-745-D	47,628	401
C-745-F	156,000	4,090
C-745-G	405,000	5,733
C-745-K	180,000	4,023
C-745-L	312,000	4,624
C-745-M	120,000	902
C-745-N	180,000	1,629
C-745-P	96,000	1,735
C-745-S	130,000	2,000
C-745-T	485,600	0
Total		28,351

[a] Locations of cylinders as of May 1996.

[b] USEC-leased yard with DOE cylinders in storage.

Source: Cash (1996).

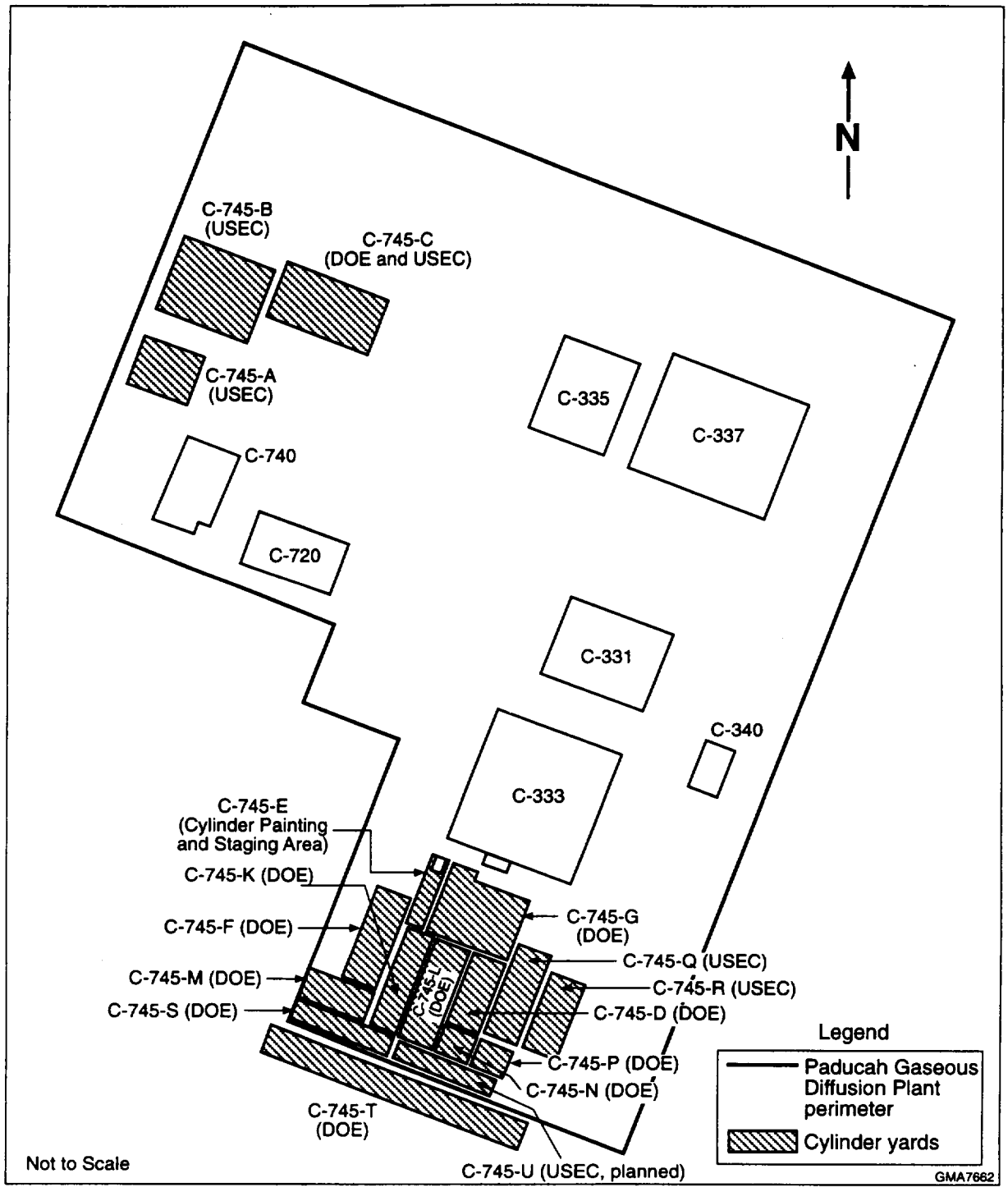

FIGURE 3.2 Locations of Cylinder Yards at the Paducah Site That Are Used to Store DOE Cylinders (Source: Adapted from DOE 1995c and Cash 1997)

The C-745-T (T-yard) was originally constructed outside the PGDP boundary but within the site perimeter. The PGDP boundary and fencing have been expanded to include the T-yard. The remaining cylinder yards will be rebuilt with concrete bases, starting with the C-745-K, C-745-L, C-745-M, C-745-N, and C-745-P yards (K-, L-, M-, N-, and P-yards). Cylinders are being restacked during relocation onto the newly constructed yards.

In addition to the DOE-generated cylinders, approximately 6,600 USEC-generated cylinders are stored in yards C-745-C, E, Q, and R (see Figure 3.2; DOE and USEC 1998a). Cylinder yard C-745-E is actually a cylinder staging area where cylinders are stored only temporarily; the USEC cylinders in this yard will be moved to C-745-Q or -R yards. The three yards C-745-C, Q, and R have gravel bases. Reconstruction of these yards with concrete bases is planned to follow the completion of reconstruction of the gravel yards currently storing DOE-generated cylinders (DOE and USEC 1998a). On the basis of a June 1998 Memorandum of Agreement, ownership and management of approximately 2,000 additional cylinders will be transferred from USEC to DOE between 1999 and 2004 (DOE and USEC 1998b). For purposes of analysis, this PEIS assumes that these cylinders will be located in yards C-745-C, Q, or R at the Paducah site.

One breached cylinder was identified in F-yard in November 1992. The small hole (about 1/16 in. × 2 in. [0.16 cm × 5 cm]) was attributed to handling damage, and a permanent patch was subsequently applied. In 1996, a steel engineered patch was welded onto another cylinder at the Paducah site. No material was thought to have been lost from either of these cylinders.

3.1.2 Site Infrastructure

The Paducah site is located in an area with an established transportation network. The area is served by two interstate highways, several U.S. and state highways, several rail lines, and a regional airport.

All water used by the site is obtained from the Ohio River through an intake at the steam plant near the Shawnee Power Plant north of the site. Before use, the water is treated on-site. Current water usage is approximately 15 million gal/d (57 million L/d). The maximum site capacity is 30 million gal/d (115 million L/d) (DOE 1996g).

Electric Energy, Inc., supplies electric power to the Paducah site. The current electrical need is 1,564 MW, with a maximum capacity of 3,040 MW. The coal system uses 82 tons (74 metric tons) per day, with a maximum capacity of 180 to 200 tons (160 to 180 metric tons) (DOE 1996g).

3.1.3 Ambient Air Quality and Airborne Emissions

The affected environment for air quality at the Paducah site is generally considered to be the Air Quality Control Region (AQCR) designated by the EPA: the Paducah (Kentucky) — Cairo (Illinois) Interstate AQCR in EPA Region 4. This AQCR includes McCracken County, Kentucky, in which the Paducah site is located. The EPA classifies McCracken County as an attainment area for all six National Ambient Air Quality Standards (NAAQS) criteria pollutants — carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM_{10}, particles with a mean diameter of 10 μm or less), ozone (O_3), nitrogen oxides (NO_x), and lead (Pb). An attainment area for a criteria pollutant is an area that has an ambient air concentration of the pollutant below the corresponding standard.

The Commonwealth of Kentucky has adopted ambient air quality standards that specify maximum permissible short-term and long-term concentrations of various contaminants (Table 3.2). These standards are generally the same as the national standards. In addition to standards for criteria pollutants, the Kentucky Department of Environmental Protection (KDEP) has adopted rules governing new or modified sources emitting toxic air pollutants ("General Standards of Performance," *Kentucky Administrative Regulations*, Title 401, Chapter 63, Regulation 022 [401 KAR 63:022]), as well as standards for the hazardous air pollutants regulated by the National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR Part 61).

DOE has responsibility for four air emission sources at the Paducah site, none of which involve the release of radiological effluents. The Paducah site is not required to conduct ambient air monitoring. DOE activities at the site in 1996 released quantities of criteria and hazardous air pollutants (HAPs) well below the amounts that would cause them to be classified by the *Clean Air Act* as a major source (LMES 1997c). An aggregate emission of 100 tons of any single criteria pollutant is required for the DOE operations to be classified as a major source. Emissions of criteria pollutants from cylinder refurbishment (grit blasting and painting) amounted to about 4.5 tons of particulate and 3.4 tons of volatile organic compounds (VOCs). Another 12 tons of VOCs may have been released from inactive closed landfills. In all, a total of as much as 16.6 tons of VOCs may have been emitted. The largest source of HAPs, a contaminated groundwater treatment facility, produced 1.4 tons of trichloroethylene, compared with the 10 tons of emissions of a single HAP necessary for major source designation.

3.1.4 Geology and Soil

3.1.4.1 Topography, Structure, and Seismic Risk

The topography of the Paducah site is relatively flat; within the boundaries of the PGDP security fence, the maximum difference in elevation is about 10 ft (3 m) (ERC/EDGe 1989). The site is underlain by bedrock of limestone and shale. Several zones of faulting occur in the vicinity of the site (Argonne National Laboratory [ANL] 1991a).

TABLE 3.2 Kentucky Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
Carbon monoxide (CO)		
1-hour average	35 ppm[a]	35 ppm
8-hour average	9 ppm[a]	9 ppm
Sulfur dioxide (SO_2)		
3-hour average	–	0.50 ppm[a]
24-hour average	0.14 ppm[a]	–
Annual average	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour average[b]	150 $\mu g/m^3$	150 $\mu g/m^3$
Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual average	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Hydrogen sulfide		
Maximum 1-hour average	–	14 $\mu g/m^3$ (0.01 ppm)[a]
Gaseous fluorides (as HF)		
Annual arithmetic mean, not to exceed	0.5 ppm	–
Maximum 1-month average	–	1.00 ppb[a]
Maximum 1-week average	–	2.00 ppb[a]
Maximum 24-hour average	1.0 ppm[a]	3.50 ppb[a]
Maximum 12-hour average	–	4.50 ppb[a]
Total fluorides[c]		
Average concentration of monthly samples over growing season (not to exceed 6 consecutive months)	–	40 ppm (w/w)
2-month average	–	60 ppm (w/w)
1-month average	–	80 ppm (w/w)
Odors	At any time when one volume unit of ambient air is mixed with seven volume units of odorless air, the mixture must have no detectable odor.	

[a] Average not to be exceeded more than once per year.

[b] Standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$, as determined in accordance with Appendix K of 40 CFR Part 50, is equal to or less than one.

[c] Concentrations not to be exceeded on a dry weight basis (as fluoride ion) in and on forage for consumption by grazing ruminants; w/w = weight for weight.

Source: DOE (1996g).

The largest recorded earthquake in the region occurred in 1812 and was centered in the New Madrid fault zone. This earthquake had a magnitude of 7.3, and the epicenter was 60 miles (96 km) southwest of the site (LMES 1997f). This earthquake completely destroyed the town of New Madrid, Missouri.

The seismic hazards at the Paducah site have been studied extensively. The safety analysis report (SAR) for this site, completed in March 1997, provided comprehensive analyses and discussions of seismic hazards at the site (see Sections 1.5 and 3.3 of the SAR; LMES 1997f). The analyses considered the possibility of large-magnitude earthquakes similar to the New Madrid earthquakes of 1811–1812. The analyses performed by DOE were independently reviewed by the U.S. Geological Survey (USGS). The independent review by the USGS indicated that the seismic sources, recurrence rates, maximum magnitudes, and the attenuation functions used in the SAR analyses were representative of a wide range of professional opinion and were suitable for obtaining probabilistically based seismic hazard estimates. Because of the proximity of the site to the New Madrid seismic zone, special deterministic analyses were also performed to estimate the ground motions at the site in the case of recurrence of an earthquake of the same magnitude as the 1811–1812 New Madrid earthquakes. The results of the deterministic analyses were similar to the probabilistic seismic hazard results for the probabilities associated with the recurrence of the New Madrid earthquake of 1811–1812. The results also indicated that continued storage of depleted UF_6 cylinders at the Paducah site is safe.

For the Paducah site, the evaluation basis earthquake (EBE) was designated by DOE to have a return period of 250 years. A detailed analysis indicated that the peak ground motion for the EBE was 0.15 times the acceleration of gravity (LMES 1997f). An earthquake of this size would have an equal probability of occurring any time during a 250-year period.

For this PEIS, the analyses of earthquake-initiated accidents at the Paducah site were based on the analyses and results provided in the SAR (LMES 1997f; see also Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.1.4.2 Soil

Substances in soil possibly associated with cylinder management activities would be uranium and fluoride compounds, which could be released if breached cylinders or faulty valves were present. For the evaluation of ongoing activities at the Paducah site, the purpose of soil sampling has been to identify the accumulation of any airborne pollutants; thus, annual soil samples have been collected from 10 off-site locations: four at the site boundary, four at distances of 5 miles

(8 km) beyond the boundary, and two at more remote locations to characterize background levels (LMES 1996a; MMES 1994b). In 1994, uranium concentrations for the 10 sampling locations ranged from 2.0 to 5.8 μg/g; plant boundary concentrations ranged from 2.3 to 4.9 μg/g (LMES 1996a).

Because of a transfer of responsibility for air point sources from DOE to USEC, concentrations of nonradiological parameters in soil at these sampling locations are no longer reported (LMES 1996a); however, analytical results for polychlorinated biphenyls (PCBs) and metals are available for previous years. In 1993, no detectable concentrations of PCBs were found in any of the samples, but elevated concentrations of bismuth, lead, manganese, thallium, and thorium were detected in several samples (MMES 1994b). Fluoride was not analyzed in soil samples, but it is naturally occurring in soils and of low toxicity.

As part of ongoing CERCLA/RCRA investigations of Paducah site operable units, several areas of soil have been identified as contaminated with radionuclides and chemicals such as PCBs and metals. However, this contamination is not associated with the depleted UF_6 cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

3.1.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples have indicated the presence of some contamination resulting from previous gaseous diffusion plant operations.

3.1.5.1 Surface Water

Big Bayou Creek is located on the west side of the Paducah site and Little Bayou Creek on the east side (Figure 3.1). These two streams join north of the site and discharge to the Ohio River. Flows in Big Bayou Creek and Little Bayou Creek fluctuate greatly as a result of precipitation. During most of the year, flows in both streams are derived primarily from plant effluents. All water used by the site is obtained from the Ohio River through an intake north of the site (ANL 1991a).

Most of the liquid effluents from the Paducah site consist of cooling water, although a variety of liquid wastes are produced by activities such as metal finishing, uranium recovery, and facility cleaning (Rogers et al. 1988a). In addition to these discharges, a large variety of conventional liquid wastes enter the surface water system, including treated domestic sewage, steam plant wastewater, and coal pile runoff.

All effluent discharges are under the Kentucky Pollutant Discharge Elimination System (KPDES). At the present time, there are a total of 15 outfalls. Ten outfalls are authorized to USEC

(KY0102083); five outfalls are authorized to DOE (KY000409). Of the DOE outfalls, three are to Big Bayou Creek and one is to an unnamed tributary of Little Bayou Creek. The average discharge of wastewater to Big Bayou Creek is approximately 4 million gal/d (15 million L/d). The average discharge to the Ohio River through Big Bayou and Little Bayou Creeks is about 4.1 million gal/d (16 million L/d). The average flow in the Ohio River is 1.7×10^{11} gal/d (6.5×10^{11} L/d).

Monitoring of surface water in 1995 and 1996 indicated that the maximum average concentration of uranium was 0.012 mg/L in the downstream portion of Little Bayou Creek (LMES 1997a; 1997c). The maximum average concentration of fluoride was < 0.224 mg/L in the north/south diversion ditch within the PGDP (MMES 1994e). Comparable fluoride data were not reported for 1994, 1995, or 1996 (LMES 1996a, 1997a,c).

The KPDES-permitted outfalls are monitored for inorganic substances and about 45 organic substances, including PCBs. The monitoring frequency for most substances is two to four times per year; several substances are monitored monthly or quarterly to comply with KPDES permit requirements. The maximum average uranium concentration in effluents from the DOE outfalls from 1994 through 1996 was 0.037 mg/L (LMES 1996a, 1997a,c). In both 1994 and 1995, two USEC-leased outfalls received a "Notice of Violation" for PCB exceedances.

Sediment samples are also collected annually from six locations and analyzed for uranium, PCBs, and metals. In 1993, concentrations of uranium and PCBs were detected at significantly higher levels than background in Little Bayou Creek (sampling location SS2). The uranium concentration of 200 mg/kg at the measuring location was two times higher than in 1992. The PCB concentration also increased from 0.9 mg/kg in 1992 to 2.0 mg/kg in 1993. However, levels decreased in 1994 (22 mg/kg maximum uranium concentration; 1.4 mg/kg maximum PCB concentration) (LMES 1996a) and again in 1995 (13 mg/kg maximum uranium concentration; < 0.1 mg/kg maximum PCB concentration) (LMES 1997a). In 1996, the uranium concentration in sediment at location SS2 was 44 mg/kg; the PCB concentration was 1.3 mg/kg. A new sampling location (SS29) was added on Little Bayou Creek closer to the PGDP. The uranium concentration at this location was 360 mg/kg; no PCB value was reported (LMES 1997c).

3.1.5.2 Groundwater

Two near-surface aquifers are of importance at the Paducah site. The upper aquifer is a shallow, perched-water aquifer composed of sands and sand and clay mixtures that are discontinuous (Rogers et al. 1988a). Water yields from this aquifer are very low, and the hydraulic gradient (change in water elevation with distance) is difficult to detect. Water movement is generally in a northeasterly direction at less than 0.1 ft/yr (0.3 m/yr).

The lower aquifer is a good-yielding gravel aquifer that has an upper surface at a depth of about 39 ft (12 m) and a thickness that ranges from about 20 to 59 ft (6 to 18 m). This aquifer appears to be continuous beneath the Paducah site. Hydraulic conductivity is estimated to be 0.0001

to 1 cm/s for the regional gravel aquifer and 0.00001 to 0.01 cm/s for the upper continental deposits (sands). Water movement is 2 to 5 ft/yr (0.6 to 1.5 m/yr) and variable in direction (Rogers et al. 1988a).

On-site and off-site groundwater sampling for the Paducah site is performed in about 200 monitoring wells, residential wells, and Tennessee Valley Authority wells. Off-site sampling is performed to monitor three separate trichloroethylene and technetium plumes first detected in 1988 (LMES 1996a) (Figure 3.3). The Paducah site has provided a municipal water supply to all residents whose wells are within the area of groundwater contamination from the site; resident wells that are no longer sampled are locked and capped.

Although the magnitude of groundwater contamination originating from the Paducah site is greatest for trichloroethylene and technetium, the primary drinking water standards or derived concentration guidelines for several other inorganic, volatile organic, and radionuclide substances were also exceeded in one or more of the monitoring wells on or near the Paducah site in monitoring occurring from 1993 through 1996 (MMES 1994b; LMES 1996a, 1997a,c). (The derived concentration guideline is equivalent to the MCL; it is the concentration of a radionuclide that under conditions of continuous exposure for 1 year would result in an effective dose equivalent of 4 mrem [EPA 1996; DOE Order 5400.5]). The uranium guideline of 20 ug/L was exceeded in four wells, and the fluoride guideline of 4 mg/L was exceeded in two wells. The wells with uranium and fluoride exceedances were not located near the cylinder yards.

3.1.6 Biotic Resources

3.1.6.1 Vegetation

The Paducah site includes the highly developed PGDP, which has few natural vegetation communities. The DOE property between the PGDP and the West Kentucky Wildlife Management Area consists primarily of open, frequently mowed grassy areas. The DOE property also includes several small upland areas of mature forest, old field, and transitional habitats. The banks of Big Bayou Creek and Little Bayou Creek support mature riparian forest with river birch, black willow, and cottonwood (ANL 1991a). The West Kentucky Wildlife Management Area contains wooded areas from early and mid-successional stages to mature forest communities. Nonforested areas are managed by controlled burns, mowing, and planting.

3.1.6.2 Wildlife

The habitats at the Paducah site support a relatively high diversity of wildlife species. Ground-nesting species include the white-footed mouse, bobwhite, and eastern box turtle. Big Bayou Creek, upstream of the Paducah site, supports aquatic fauna indicative of oxygen-rich, clean water,

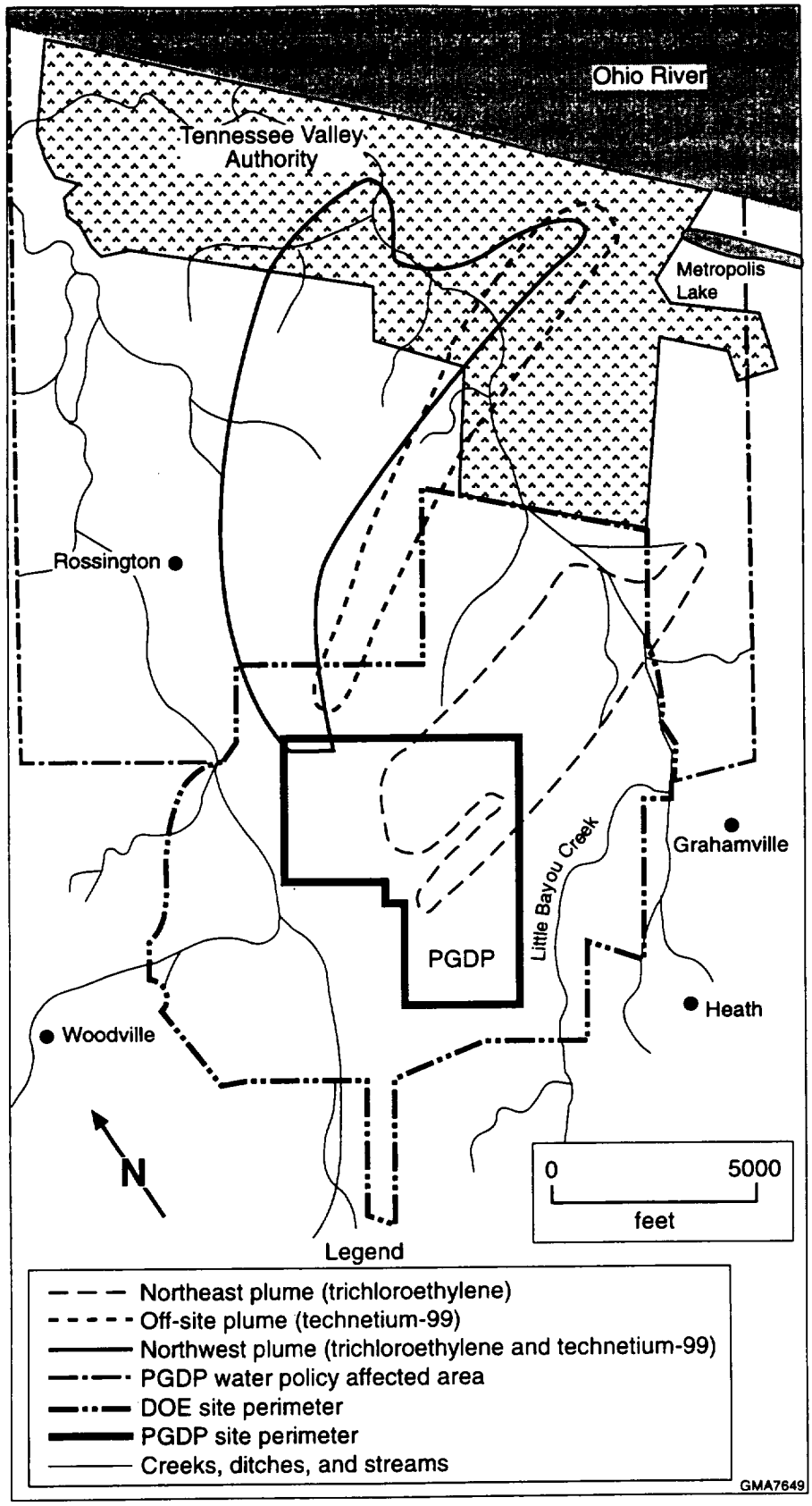

FIGURE 3.3 Locations of Contaminated Groundwater Plumes at the Paducah Site (Source: Adapted from MMES 1994b)

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including 14 fish species. Aquatic species just downstream of the Paducah site discharge points include 11 fish species (LMES 1997c). The density and diversity of aquatic organisms are generally lower near the outfalls than upstream areas for both Little Bayou Creek and Big Bayou Creek (DOE 1994b).

3.1.6.3 Wetlands

Although no wetlands are identified on the PGDP by the National Wetlands Inventory, approximately 5 acres of jurisdictional wetlands have been identified in drainage ditches scattered throughout the PGDP (ANL 1991a; CDM Federal Programs Corporation 1994; Sadri 1995). Outside the PGDP, a large number of wetlands are scattered throughout the Paducah site. These include forested wetlands, ponds, wet meadows, vernal pools, and wetlands converted to agriculture (U.S. Department of the Army 1994c). Palustrine forested wetlands occur extensively along the banks of Big Bayou Creek and Little Bayou Creek. The National Wetlands Inventory identifies many wetlands on the Paducah site, primarily ponds and forested wetlands. A forested wetland dominated by tupelo trees in the West Kentucky Wildlife Management Area has been designated by the Kentucky Nature Preserves Commission and Kentucky Department of Fish and Wildlife as an area of ecological concern (DOE 1996g).

3.1.6.4 Threatened and Endangered Species

No federal-listed plant or animal species are known to occur on the Paducah site. However, the Indiana bat (federal- and state-listed as endangered) has been found near the confluence of Bayou Creek and the Ohio River 3 miles north of the PGDP. Potential habitat occurs on the Paducah site outside the PGDP (U.S. Department of the Army 1994b) and in adjacent wooded areas. State-listed species known to occur on the Paducah site include the compass plant, which is listed by the Kentucky State Nature Preserve Commission as threatened. The lake chubsucker, listed by the Nature Preserve Commission as threatened, is known from early, but not recent, surveys of Big Bayou Creek and Little Bayou Creek. State-listed species of special concern that occur on or near the Paducah site include Bell's vireo, cream wild indigo, and Northern crawfish frog. The presence of state-listed species and requirements for consultation with the Kentucky State Nature Preserve Commission would be determined in site-specific environmental analyses.

3.1.7 Public and Occupational Health and Safety

3.1.7.1 Radiation Environment

Operations at the Paducah site result in radiation exposures of both on-site workers and off-site members of the general public (Table 3.3). Exposures of on-site workers generally are

TABLE 3.3 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the Paducah Gaseous Diffusion Plant

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides	0.0023[b]
	Waterborne radionuclides	0.67[c]
	Direct gamma radiation	1[d]
	Ingestion of drinking water	0[e]
	Ingestion of wildlife	0.0023[f]
Cylinder yard worker	External radiation	16 – 56[g]
Member of public or worker	Natural background radiation and medical sources	360[h]
DOE worker limit		2,000[i]

[a] The maximally exposed individual (MEI) was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were calculated by using an air dispersion model and considered exposure from external radiation, inhalation, and ingestion of foodstuffs. The MEI is located approximately 1,170 m (3,836 ft) north-northeast of the plant site (LMES 1997c).

[c] Radiation doses could result from incidental ingestion of contaminated sediment and inhalation of contaminated particles from fishing, hunting, and other recreational activities in Little Bayou Creek (LMES 1997c).

[d] Radiation doses could result from hunting activities on the banks of Little Bayou Creek (LMES 1997c).

[e] According to the results of a 1990 survey, there was no reported use of surface water. Also, contaminated well water is not used because all residents in that area receive city water (LMES 1996a).

[f] Radiation doses could result from ingestion of the edible portion of two average-weight deer containing the maximum detected concentrations of radionuclides (LMES 1997c).

[g] Range of annual average doses from years 1990 through 1995 (Hodges 1996).

[h] Average dose to a member of the U.S. population as estimated in Report No. 93 of the National Council on Radiation Protection and Measurements (NCRP 1987b).

[i] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

associated with handling of radioactive materials used in the on-site facilities and with inhalation of radionuclides released from processes conducted on-site. Members of the off-site general public are exposed to radionuclides discharged from on-site facilities through airborne and/or waterborne emissions.

The total radiation dose to the maximally exposed individual (MEI) of the general public is estimated to be 1.7 mrem/yr, which is much lower than the maximum radiation dose limit set for the general public of 100 mrem/yr from operation of a DOE facility (DOE Order 5400.5). The average external radiation dose for cylinder yard workers has ranged from 16 to 56 mrem/yr (Hodges 1996) in the past few years and has been well below the maximum dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835). All of these exposures are a very small fraction of the 360 mrem/yr dose received by the general public and workers from natural background and medical sources (Table 3.3).

3.1.7.2 Chemical Environment

Estimated hazard quotients for members of the general public under existing environmental conditions near the Paducah site are presented in Table 3.4. The hazard quotient represents a comparison of estimated human intake levels with intake levels below which adverse effects are very unlikely to occur (see Chapter 4). The estimated hazard quotients indicate that exposures near the Paducah site are generally a small fraction of those that might be associated with adverse health effects. An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, because this groundwater is not a drinking water source, there is no exposure. The residents near the PGDP whose wells have been contaminated have been provided with alternate water sources.

The Occupational Safety and Health Administration (OSHA) has proposed permissible exposure limits (PELs) for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998), as follows: 0.05 mg/m^3 for soluble uranium compounds; 2.5 mg/m^3 for HF. Paducah worker exposures are kept below these limits.

3.1.8 Socioeconomics

The socioeconomic environment of the Paducah site was assessed in terms of regional economic activity, population and housing, and local public finances. The region of influence (ROI) consists of Ballard, Carlisle, Graves, Marshall, and McCracken Counties in Kentucky, and Massac County in Illinois; 93.1% of employees at the site currently reside in those counties, with 59.1% residing in McCracken County (DOE 1997a). Allison and Folga (1997) provide a listing of the counties, cities, and school districts within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

TABLE 3.4 Estimated Hazard Quotients for Members of the General Public near the Paducah Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d,e]	Uranium	0.0078 $\mu g/m^3$	2.2×10^{-6}	0.0003	0.0074
	HF	0.096 $\mu g/m^3$	2.7×10^{-5}	0.02	0.0014
Soil[f]	Uranium	5.8 µg/g	7.7×10^{-5}	0.003	0.026
Surface water[e]	Uranium	16 µg/L	8.7×10^{-6}	0.003	0.003
	Fluoride	< 224 µg/L	1.2×10^{-4}	0.06	0.002
Sediments[e]	Uranium	360 µg/g	6.2×10^{-6}	0.003	0.033
	Aroclor 1254	1.4 µg/g	3.8×10^{-7}	0.00002	0.019
	Aroclor 1254[g]	1.4 µg/g	5.5×10^{-8}	2.0 (slope factor)	1.1×10^{-7} (cancer risk)
Groundwater[h]	Uranium	20 µg/L	5.7×10^{-4}	0.003	≥ 0.19
	Fluoride	4,000 µg/L	1.1×10^{-1}	0.06	≥1.9

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C. For carcinogens, the slope factor is also given; slope factors in units of $(mg/kg\text{-}d)^{-1}$ are multiplied by lifetime average intake to estimate excess cancer risk.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference level. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake × slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

[d] Gross alpha was used as a surrogate measure of uranium concentration.

[e] Exposure concentrations are the maximum annual averages for all monitoring locations (MMES 1994b; LMES 1996a; 1997a, 1997c).

[f] Maximum uranium concentration from 10 plant boundary and off-site soil monitoring locations (LMES 1996a).

[g] Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

[h] Data are for monitoring and residential wells located on or near DOE property at the Paducah site (the residential wells are not currently used for drinking water). Several additional substances exceeded reference levels between 1993 and 1996 (Section 3.1.5.2); listed here are only substances of particular interest for this PEIS. Well-specific concentrations were not available; the exposure concentrations given are actually drinking water standards or guidelines. Hazard indices based on well-specific concentrations could exceed those presented.

3.1.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 72,300 to 78,900, an increase of 9.1%. Within the ROI, the largest percent employment increase occurred in McCracken County (13.8%), which had 51% of total ROI employment in 1995. The U.S. Bureau of Economic Analysis (BEA) projects a 1.9% increase in employment in the ROI over the period 1995 to 2020 (1,500 jobs), with the largest increase expected in McCracken County (3.5%, 1,400 jobs) (BEA 1996a). Unemployment in the ROI in 1996 was 5.4% (Allison 1996). Employment at the Paducah site in 1995 was 1,700 (DOE 1997a), amounting to approximately 2.2% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from $1.6 billion to $1.8 billion, an increase of 13%. The largest percent increase occurred in McCracken County (20%), which had 46% of total ROI personal income in 1995. The BEA projects a 31.9% increase in ROI personal income from 1995 to 2020 ($0.6 billion), with the largest increase in McCracken County (33%, $0.3 billion) (BEA 1996a).

3.1.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 150,271 to 153,000, an increase of 1.8%. The 1995 ROI population was concentrated in McCracken County (41.7%). The BEA projects the ROI population as a whole to increase by 9,600 (6.3%) from 1995 to 2020, with the largest increase in McCracken County (7.7%, 4,900 people) (BEA 1996a).

3.1.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased by 9.6%, from 61,000 to 66,900. McCracken County had 41% of the total housing units. Based on BEA (1996a) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the total number of vacant owner-occupied units in the ROI is expected to increase from 4,460 to 4,880 and the total number of vacant rental units from 1,520 to 1,620.

3.1.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.5. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

TABLE 3.5 Summary of Financial Characteristics for the Paducah Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	8.8	6.5	Local sources	23.8
Fines, fees, permits, etc.	1.3	14.5	State sources	67.2
Intergovernmental	1.3	6.1	Federal sources	4.1
Other	0.8	2.6	Other	16.5
Total	12.3	29.7	Total	111.6
Expenditures			**Expenditures**	
General government	6.3	4.7	Administration	2.2
Safety, health, community services	6.0	16.1	Instruction	67.1
Debt service	0.0	0.1	Services	8.5
Other financing sources	1.4	-5.6	Physical plant	9.8
Total	14.0	15.3	Other	24.4
			Total	112.1
Revenues less Expenditures	-1.7	14.4	**Revenues less Expenditures**	-0.4

[a] Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

3.1.9 Waste Management

The affected environment with respect to waste management is considered to be wastewater and solid waste generated at the Paducah site. Disposal of this waste is currently managed by USEC, including any waste generated from ongoing management of the DOE-generated depleted UF_6 cylinders currently in storage. The cylinder storage yards at Paducah currently generate only a very small amount of waste compared with the volume of waste generated from ongoing plant operations. Cylinder yard waste consists of small amounts of metal, scrapings from cylinder maintenance operations, potentially contaminated soil, and miscellaneous items.

The Paducah site generates wastewater, solid LLW, solid and liquid LLMW, nonradioactive hazardous waste, and nonradioactive nonhazardous solid waste. The site has an active program to minimize the generation of solid LLW, hazardous waste, and LLMW. Waste minimization efforts for radioactive waste include prevention of packaging material from entering radiological areas and replacement of wood pallets used in radiological areas. Hazardous waste and LLMW minimization actions include use of less chlorinated solvents, recycling of paint wastes, and compaction of PCB

wastes. Solid waste minimization actions include recycling of paper and cardboard and off-site recycling of fluorescent bulbs and used batteries.

3.1.9.1 Wastewater

Wastewater at the Paducah site consists of nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, and radioactive process-related liquid effluents. Wastewater is processed at on-site treatment facilities and is discharged to Big Bayou Creek or Little Bayou Creek through eight outfalls identified under the site KPDES permit #KY0004049. In 1993, the wastewater treatment system processed approximately 0.4 million gal/d (1.5 million L/d) of wastewater. The total capacity of the site wastewater control facilities is approximately 1.75 million gal/d (6.6 million L/d). About 23% of the capacity of wastewater treatment facilities is currently used.

In 1992, the wastewater discharge at the Paducah site was in compliance with KPDES permit requirements 99.5% of the time. A few exceedances occurred for total residual chlorine, trichloroethylene, pH, and total suspended solids (MMES 1994b). In 1994, the PCB effluent limits were exceeded 18 times in site wastewater discharges. These exceedances were addressed through existing site agreements with the state (LMES 1996a).

3.1.9.2 Solid Nonhazardous, Nonradioactive Waste

Solid waste — including sanitary refuse, cafeteria waste, industrial waste, and construction and demolition waste — is collected and disposed of at the on-site landfill, which consists of three cells. The first cell is closed and capped, the second is near capacity, and the third cell awaits final authorization from the Kentucky Division of Waste Management. The total capacity of the landfill is 26,000 yd^3 (20,000 m^3). The site solid waste generation rate for 1993 was 2,740 yd^3/yr (2,100 m^3/yr) (DOE 1996g).

3.1.9.3 Nonradioactive Hazardous and Toxic Waste

Nonradioactive waste that is considered hazardous waste according to RCRA or contains PCBs as defined under the TSCA requires special handling, storage, and disposal. The Paducah site generates hazardous waste — including spent solvents and heavy-metal-contaminated waste — and PCB-contaminated toxic waste. The site has a Kentucky Division of Waste Management RCRA Part B permit (#KY8890008982), which expires in 2001. The permit authorizes the Paducah site to treat and store hazardous waste in 10 treatment units, 16 tanks, and 4 container storage areas at the site. There are several additional 90-day storage areas for temporary storage of hazardous waste.

Approximately 99 yd^3 (76 m^3), or 209 tons (190 metric tons), of solid hazardous waste was generated in 1992. Certain hazardous/toxic wastes are sent to permitted off-site contractors for final treatment and/or disposal. Much of the hazardous/toxic waste load consists of PCB-contaminated waste. More than 370 yd^3 (280 m^3) of PCBs is used in electrical equipment at the Paducah site (MMES 1994b). Some liquid hazardous and/or mixed waste streams are shipped to the K-25 site for incineration in a TSCA incinerator, which has a capacity of 1,800 yd^3/yr (1,400 m^3/yr).

3.1.9.4 Low-Level Waste

LLW generated at the Paducah site is stored on-site pending shipment to a commercial facility in Tennessee for volume reduction. Solid LLW generated at the Paducah site includes refuse, sludge, and debris contaminated with radionuclides, primarily uranium and technetium. The site generated 2,450 yd^3 (1,870 m^3) of solid LLW in 1991 and 650 yd^3 (500 m^3) in 1992. As of 1995, the site had 4,380 yd^3 (3,350 m^3) of LLW in storage (DOE 1996g). Site wastewater treatment facilities can process up to 1,480 yd^3 (1,140 m^3) per year of aqueous LLW.

3.1.9.5 Low-Level Mixed Waste

LLW that contains PCBs or RCRA hazardous components is considered to be low-level mixed waste (LLMW). As of 1995, 243 yd^3 (186 m^3) of LLMW was in storage at the Paducah site. Of this total, 63 yd^3 (48 m^3) represents waste subject to land disposal restrictions. Solid LLMW generation in 1992 was 1,080 yd^3 (824 m^3). In 1992, approximately 560,000 lb (256,000 kg) of organic liquid was sent to the TSCA incinerator on the K-25 site. On-site capacity for storing LLMW containers at the Paducah site is 3,600 yd^3 (2,800 m^3). The site can treat up to 204 ft^3/yr (156 m^3/yr) of aqueous LLMW (DOE 1996g).

3.1.10 Cultural Resources

Thirty-two cultural resource sites are currently recorded within and immediately surrounding the PGDP. Twenty-two were recorded during surveys conducted in the 1970s and early 1980s, and 10 more were recently recorded during a cultural resources study consisting of a 20% stratified random sample survey for prehistoric and historic archaeological sites. Results of a sensitivity analysis, also conducted as part of the study, indicate that much of the area surrounding the fenced complex has a low or very low index of sensitivity, meaning there is a low probability of finding prehistoric sites near the developed area. However, scattered areas of high sensitivity are located along Little Bayou Creek and Big Bayou Creek; at least three prehistoric sites and one historic site are potentially eligible for the *National Register of Historic Places* (U.S. Department of the Army 1994a-b).

An inventory of historic buildings is planned but has not been conducted at the Paducah site. It is likely that buildings related to uranium enrichment and the gaseous diffusion process that

supported atomic weapon manufacture or to activities at the Kentucky Ordnance Works could be eligible for the *National Register*. No cemeteries are located on the Paducah site.

No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified at the Paducah site to date.

3.1.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the Paducah site consists of 9.2% minorities and 19.0% persons with low income (see Appendix C, Section C.8.1).

3.2 PORTSMOUTH SITE

The Portsmouth site is located in Pike County, Ohio, approximately 22 miles (35 km) north of the Ohio River and 3 miles (5 km) southeast of the town of Piketon (Figure 3.4). The two largest cities in the vicinity are Chillicothe, located 26 miles (42 km) north of the site, and Portsmouth, 22 miles (35 km) south.

The Portsmouth site includes the Portsmouth Uranium Enrichment Complex (PUEC), a gaseous diffusion plant previously operated by DOE and currently operated by the USEC. The Portsmouth site occupies 3,708 acres (1,500 ha) of land, with an 800-acre (320-ha) fenced core area that contains the PUEC production facilities. The 2,908 acres (1,180 ha) outside of the core area consist of restricted buffers, waste management areas, plant management and administrative facilities, gaseous diffusion plant support facilities, and vacant land (MMES 1992b). The PUEC has operated since 1995.

Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly over 1 mile (1.6 km) from the site boundaries. Forests account for over 60% of the land in Pike County and over 70% in Scioto County. Neither county has residential land uses exceeding 2% or industrial/commercial land uses exceeding 1%.

No land-use maps or comprehensive or master plans have been developed for either Pike County or Scioto County, although the city of Portsmouth is in the process of developing one. The Portsmouth facility has a master plan, which indicates that future land-use patterns on the site are expected to remain essentially the same as current conditions (MMES 1992b).

The Portsmouth site is not on the NPL; environmental remediation activities at the site are overseen under the provisions of RCRA. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some

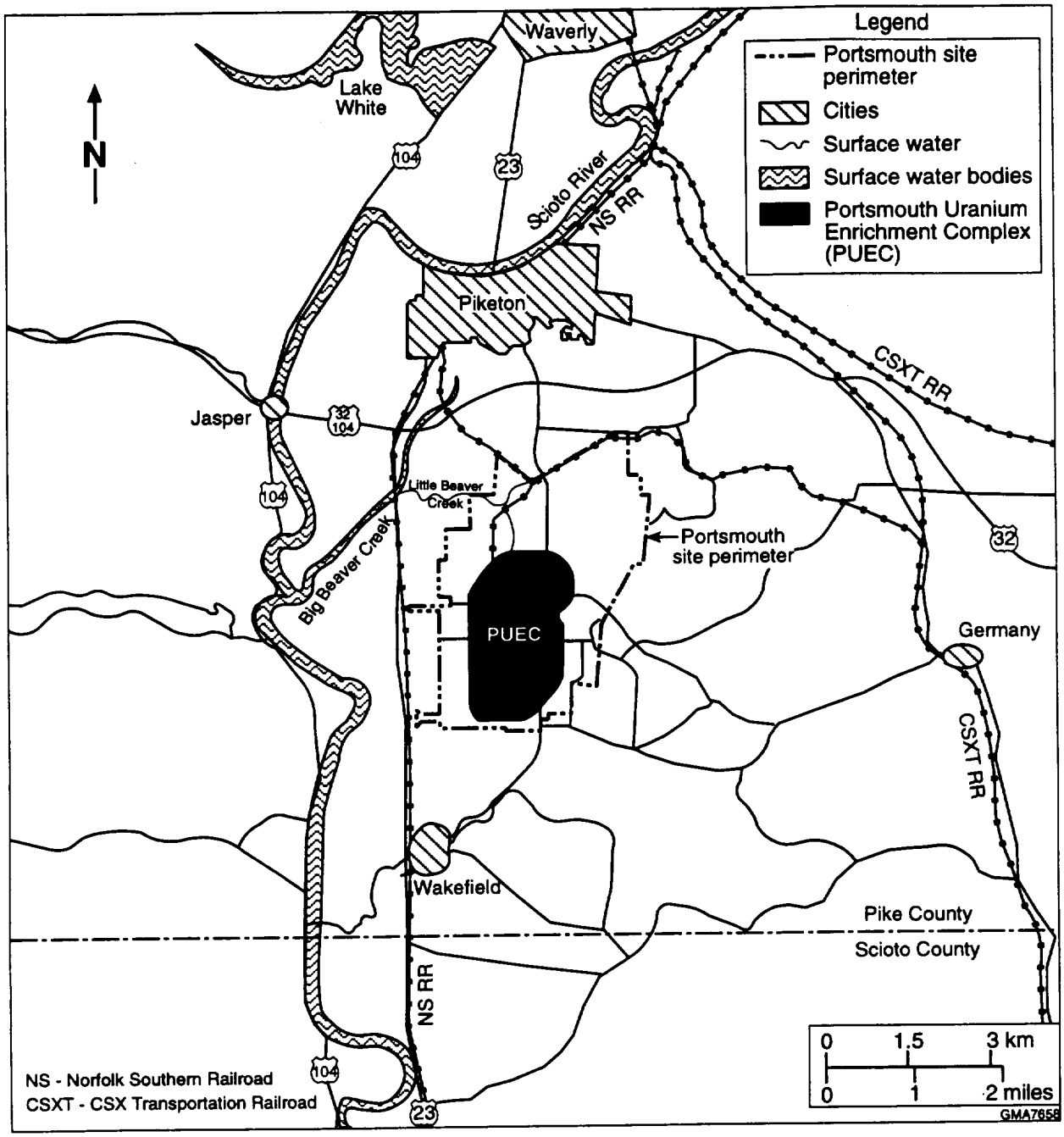

FIGURE 3.4 Regional Map of the Portsmouth Site Vicinity (Source: Adapted from LMES 1996b)

sitewide information from ongoing RCRA investigations is also included to put environmental conditions in the current cylinder storage areas into the context of sitewide conditions.

TABLE 3.6 Locations of DOE Depleted UF_6 Cylinders at the Portsmouth Site[a]

Yard	Area (ft^2)	Number of Cylinders
X-745-C	550,000	8,988
X-745-E	215,000	4,400

[a] Locations of cylinders as of May 1996.

Source: Cash (1996).

3.2.1 Cylinder Yards

The DOE-managed cylinders containing depleted UF_6 at the Portsmouth site are stored in two cylinder yards, X-745-C (C-yard) and X-745-E (E-yard) (Table 3.6; Figure 3.5). These storage yards have concrete bases. The cylinders are stacked two high to conserve yard storage space, with the cylinder-to-cylinder contact typically occurring in the areas of the stiffening rings. All 10- and 14-ton (9- and 12-metric ton) cylinders stored in these yards have been or are being inspected and repositioned. They are being placed on new concrete saddles with sufficient room between cylinders and cylinder rows to permit adequate visual inspection.

In addition to the DOE-generated cylinders, approximately 2,800 USEC-generated cylinders are stored in X-745-G yard (see Figure 3.5; DOE and USEC 1998a). These cylinders do not meet the 4-ft aisle spacing requirements; therefore, restacking of the cylinders is planned.

Two breached cylinders were identified in C-yard in June 1990; both breaches were attributed to handling damage and subsequent corrosion at the damaged point. One of the breached cylinders had a hole diameter of about 2 in. (5.1 cm); the estimated maximum material loss from this cylinder was 4 lb (1.8 kg). The cylinder contents were subsequently emptied into a new cylinder. The other cylinder had a much larger hole of approximately 9 in. × 18 in. (23 cm × 46 cm), with an estimated maximum material loss of about 109 lb (49 kg) (Barber et al. 1994). This cylinder was patched, and the contents were subsequently transferred to a new cylinder.

In March 1978, a cylinder containing liquid depleted UF_6 was accidentally dropped in the south-southwest portion of yard X-745-B (currently a USEC storage yard located north of Building X-330). Much of the material was carried into the storm sewer by melting snow. Cleanup efforts were conducted to collect as much of the lost material as possible; environmental sampling was also conducted to monitor uranium levels subsequent to the release (see Section 3.2.4).

3.2.2 Site Infrastructure

The Portsmouth site has direct access to major highway and rail systems, a nearby regional airport, and barge terminals on the Ohio River. Use of the Ohio River barge terminals requires transportation by public road from the Portsmouth site.

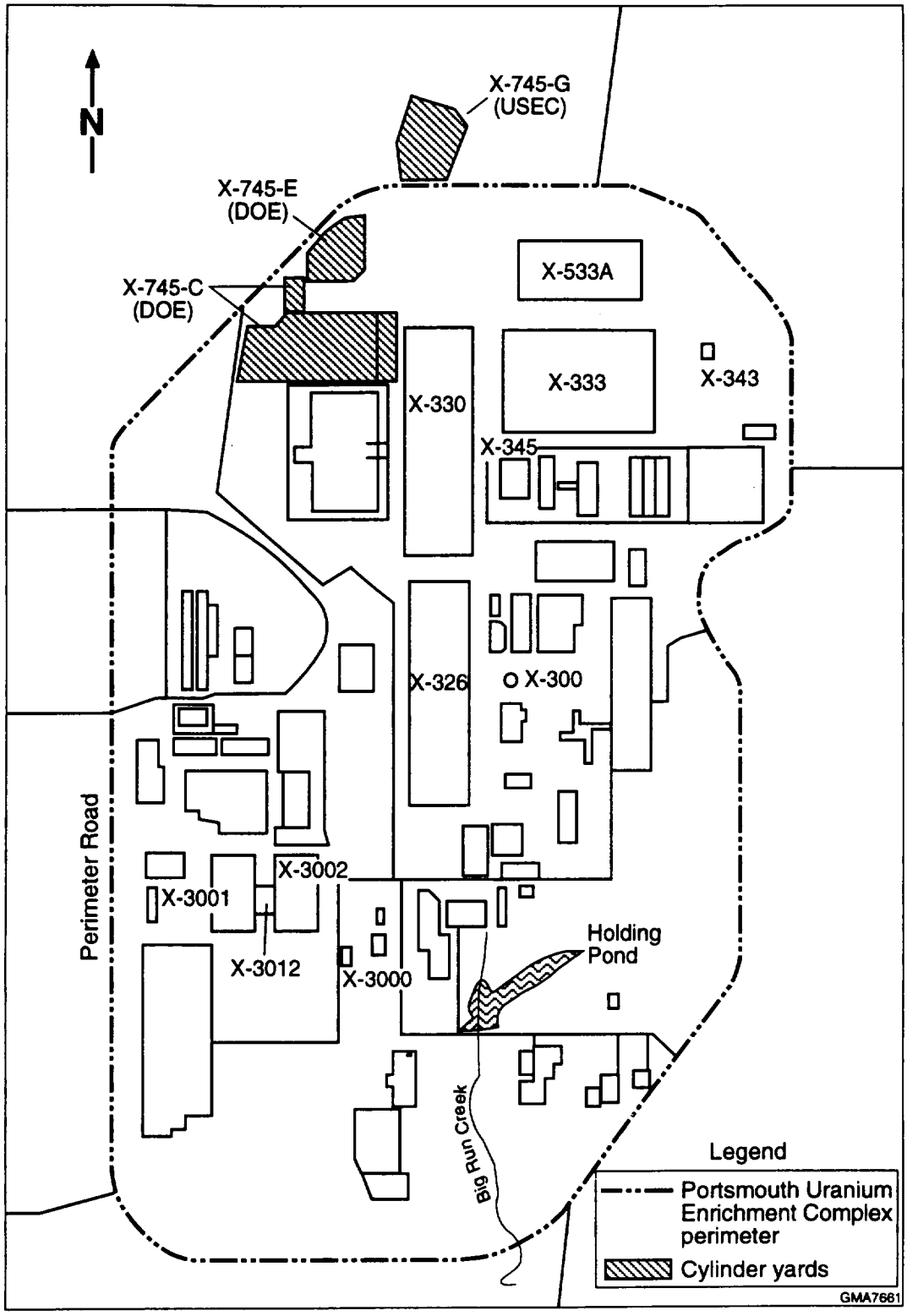

FIGURE 3.5 Locations of Cylinder Yards at the Portsmouth Site That Are Used to Store DOE-Managed Cylinders (Source: Adapted from DOE 1996g and MMES 1992a)

The Portsmouth site draws its water supply from an on-site facility consisting of four wells and from 31 off-site supply wells. Current water usage is about 14 million gal/d (53 million L/d). The maximum site capacity is 38 million gal/d (140 million L/d).

The Ohio Valley Electric Corporation supplies the site with electrical power. The current electrical consumption is 1,537 MW, with additional power supplied by a coal system using 4,500 tons per month. The maximum electrical design capacity is 2,260 MW, but a power supply of only 1,940 MW is guaranteed by the local power utility (MMES 1992b).

3.2.3 Ambient Air Quality and Airborne Emissions

The affected environment for air quality at the Portsmouth site is generally considered to be the EPA-defined AQCR. The EPA has designated the Portsmouth site as being in the Wilmington-Chillicothe-Logan AQCR in EPA Region 5. The EPA classifies Pike County, in which the Portsmouth site is located, as an attainment area for all six NAAQS criteria pollutants.

The State of Ohio has adopted ambient air quality standards for six criteria pollutants that specify maximum permissible short-term and long-term concentrations of these contaminants. These standards are listed in Table 3.7 and are generally the same as the national standards. In addition to standards for criteria pollutants, the Ohio Environmental Protection Agency has adopted emissions limits, guidelines, and acceptable ambient concentration levels for the 189 hazardous air pollutants specified in Section 112(b) of the *Clean Air Act Amendments* (CAAA). Regulations for these hazardous air pollutants are established in the NESHAPS (40 CFR Part 61).

Gaseous radiological emissions were monitored at one active source during 1996. The total discharge of uranium to the air from DOE sources at Portsmouth in 1996 was less than 0.01 Ci, a reduction of more than 90% compared with the 1994 total. The active source has been transferred to USEC responsibility, leaving DOE responsible for a single radiological source that is currently inactive (LMES 1997e).

Nonradiological emissions consisted mainly of fugitive dust. Other small sources of pollutants emitted chlorine, HF, methanol, assorted solvents, and coolants. The emission of the HAP trichloroethylene (TCE), several hundred gallons of which were collected in groundwater treatment facilities, was prevented by activated carbon filtration of the treatment facility air stripper off-gases (LMES 1997e).

TABLE 3.7 Ohio Ambient Air Quality Standards

Pollutant	Ohio Standard[a] Primary	Ohio Standard[a] Secondary
Carbon monoxide (CO)		
1-hour average	35 ppm	35 ppm
8-hour average	9 ppm	9 ppm
Sulfur dioxide (SO_2)		
3-hour average	–[b]	0.50 ppm
24-hour average	0.14 ppm	–
Annual average	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour average	150 $\mu g/m^3$	150 $\mu g/m^3$
Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual average	0.053 ppm	0.053 ppm
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Gaseous fluorides (as HF)	NS[c]	NS[c]

[a] Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless noted.

[b] A hyphen (–) indicates no standard available for this averaging period.

[c] Ohio has no standard for gaseous fluorides.

Source: DOE (1996g).

3.2.4 Geology and Soil

3.2.4.1 Topography, Structure, and Seismic Risk

The topography of the Portsmouth site area consists of steep hills and narrow valleys, except where major rivers have formed broad floodplains. The site is underlain by bedrock of shale and sandstone.

The Portsmouth site is within 60 miles (96 km) of the Bryant Station-Hickman Creek Fault (ANL 1991b). No correlation has been made between this fault and historical seismicity. Seismic Source Zone 60 is a north-northeast-trending zone in central and eastern Ohio and includes the Portsmouth facility. For this site, the EBE was designated by DOE to have a return period of 250 years. A detailed analysis indicated that the peak ground motion for the EBE was approximately 0.06 times the acceleration of gravity (LMES 1997g). An earthquake of this size would have an equal probability of occurring any time during a 250-year period.

The seismic hazards at the Portsmouth site have been analyzed and documented in a SAR completed in March 1997 (see Sections 1.5 and 3.3 in LMES 1997g). The results presented in the SAR indicate that continued storage of depleted UF_6 cylinders at the Portsmouth site is safe. The results of the SAR analyses were used for the accident analyses in this PEIS (see Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.2.4.2 Soil

The substances in soil that might be associated with cylinder management activities at the Portsmouth site are uranium and fluoride compounds, which could be released if breached cylinders or faulty valves were present. In 1993, soil was sampled for radioactive parameters and chromium at 23 on-site, 32 off-site, and 4 background locations; soil sample analyses indicated no major environmental contamination (MMES 1994c). Analytical results for all off-site and most on-site sampling locations were similar to background values (MMES 1994d). One on-site sampling point (RIS-19, adjacent to the X-705 decontamination building) was contaminated with technetium-99 (143 pCi/g) and low levels of uranium (45 µg/g). This area is known to be contaminated from historical small spills; the source of uranium was not considered to be cylinder storage yards. Chromium concentrations were elevated at two locations immediately adjacent to and downwind of the X-633 cooling towers. Fluoride has not been analyzed in soil samples, but it is naturally occurring in soils and of low toxicity. Soils data have not been reported in more recent annual environmental reports (LMES 1996b, 1997e).

After the March 1978 cylinder handling accident (see Section 3.2.1), soil samples were collected to determine whether the X-745-C and X-745-B yards were contaminated (Geraghty & Miller 1994a-b). Total uranium concentrations in the X-745-C yard did not appear to be elevated, ranging from 2.2 to 4.4 mg/kg. Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCBs were detected in shallow soil samples at maximum levels up to about 3 mg/kg (for polycyclic aromatic hydrocarbons [PAHs]). Although a few VOCs were detected at low concentrations in groundwater from one well, the source is unlikely to be the X-745-C yard (Geraghty & Miller 1994a).

Total uranium concentrations in the X-745-B yard were elevated in some soil samples, ranging from 2.7 to 352 mg/kg. The source of the uranium contamination might have been the 1978 spill. Some VOCs, SVOCs, and PCBs were also detected in shallow soil samples at maximum levels up to 31 mg/kg (for the PAH phenanthrene). However, no uranium, VOCs, SVOCs, or PCBs were detected in groundwater associated with the X-745-B yard. The contamination was confined to shallow soils and limited to the immediate proximity of the unit (Geraghty & Miller 1994b).

3.2.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples has indicated the presence of some contamination resulting from previous gaseous diffusion plant operations. Although several contaminants are present in the water, only small amounts of uranium and fluoride compounds are related to releases from the cylinders.

3.2.5.1 Surface Water

The Portsmouth site is drained by several small tributaries of the Scioto River (see Figure 3.4). The largest stream on the plant property is Little Beaver Creek, which drains the northern and northeastern portions of the site before discharging into Big Beaver Creek. Upstream of the plant, Little Beaver Creek flows intermittently during the year. On-site, it receives treated process wastewater from a holding pond (via the east drainage ditch) and storm-water runoff from the northwestern and northern sections of the plant via several storm sewers, watercourses, and the north holding pond. The average release to Little Beaver Creek for 1993 was 940 gpm (3,600 L/min).

All plant liquid effluents are regulated by an NPDES permit and are either discharged to Little Beaver Creek or piped directly to the Scioto River (Rogers et al. 1988b). The Portsmouth site has 21 NPDES-permitted outfalls, of which 9 required routine monitoring in 1993. The maximum annual average uranium concentration (0.024 mg/L) for 1993 was measured at NPDES outfall 003 on the west side of the site (MMES 1994c). Responsibility for all but two of these outfalls has been transferred to the USEC. The maximum uranium concentration in these two outfalls in 1996 sampling was 0.002 mg/L (LMES 1997d).

In addition to NPDES outfall monitoring, surface water bodies were monitored for radioactive and nonradioactive contamination at one on-site and nine off-site locations, which include upstream and downstream locations on the Scioto River. The surface water monitoring results for 1993 indicated that the measured radioactive contamination was consistently less than the applicable drinking water standards (MMES 1994d). In 1996, TCE was detected in one sampling round for Little Beaver Creek. The TCE levels returned to below detection limits by the fourth quarter of 1996, after an interceptor trench and pump were repaired (LMES 1997e).

In addition to surface water sampling, sediment sampling was performed twice in 1993 to monitor for potential radioactive contamination. The fall-quarter sediment sampling results indicated minor radioactive contamination in Little Beaver Creek sediments downstream of the east drainage ditch (MMES 1994d). Uranium was elevated only slightly at about 7 to 11 μg/g (MMES 1994c). Technetium-99 was present at an activity level of about 130 to 160 pCi/L in Little Beaver Creek below the site. No uranium contamination was detected in Big Beaver Creek downstream of the confluence with Little Beaver Creek; however, technetium-99 was measured at 23 pCi/g in the spring and 55 pCi/g in the fall. No radioactive contamination was detected in sediments from Big Run Creek or the Scioto River. Sediment data were not reported in more recent annual environmental reports (LMES 1996b, 1997e).

Results for 1993 for nonradioactive constituents indicated the presence of iron and zinc contamination in the streams (MMES 1994d). Fluoride and phosphate concentrations have also been monitored at upstream and downstream locations on the Scioto River. Results of this monitoring indicate no major difference between upstream and downstream concentrations of either chemical.

In addition, unusually high concentrations of thallium (up to about 400 mg/kg) were detected in Scioto River sediments in 1993 and 1994 (MMES 1994c; Manual 1998). These high measurements may have been due to an analytical laboratory problem (MMES 1994c). Levels at the same locations in 1995, 1996, and 1997 have been much lower, ranging from less than 3 to 19 mg/kg (Manual 1998).

3.2.5.2 Groundwater

Five hydrologic units at the Portsmouth site are important for groundwater flow and contaminant migration. These units are, in descending order, the Minford Clay, Gallia Sand, Sunbury Shale, Berea Sandstone, and Bedford Shale. The upper two units form an aquifer in unconsolidated deposits; the lower three units form a bedrock aquifer. At the site, the hydraulic conductivity (rate at which water moves) of all units is very low (Geraghty & Miller 1989a). The most conductive unit is the Gallia Sand, which has a mean hydraulic conductivity of 3.4 ft/d (0.0012 cm/s) and a range of 0.11 to 150 ft/d (0.000039 to 0.05 cm/s). This unit acts as the principal conduit for contaminant transport.

The direction of groundwater flow beneath the Portsmouth site is controlled by a complex interaction between the Gallia and Berea units (Geraghty & Miller 1989a). The flow patterns are also affected by the presence of storm sewers and the reduction in recharge caused by the presence of buildings and paved areas. Three main discharge areas exist for the groundwater system beneath the site: Little Beaver Creek to the north and east; Big Run Creek to the south; and two unnamed drainages to the west (Geraghty & Miller 1989a).

Although the Portsmouth site could use Scioto River water, all on-site water is currently supplied by wells. Four wells have the capacity to supply between 23.5 and 26 million gal/d (89 and 98 million L/d). Currently, about 14 million gal/d (53 million L/d) of groundwater is used for sanitary and production needs (ANL 1991b). Recharge of the aquifers is from river and stream flow, as well as from precipitation.

On-site groundwater at the Portsmouth site is monitored for radioactive and nonradioactive constituents at more than 245 wells. Additional off-site wells are used to monitor groundwater quality away from the site. On-site, three areas of groundwater contamination have been identified (Figure 3.6) that contain contaminants, including TCE, Freon-113, uranium, and technetium. In 1996, the maximum detected concentration of uranium was 26 µg/L for an on-site well in the X-701B holding pond area adjacent to Building X-333 (see Figure 3.6) (LMES 1997d).

3.2.6 Biotic Resources

3.2.6.1 Vegetation

The Portsmouth site within the perimeter road consists primarily of open grassy areas, including frequently mowed lawns, pasture, and old-field. Small areas of pine plantation, upland mixed hardwood forest, oak-hickory forest, bottomland mixed hardwood forest, and shrub thicket also occur on the site (DOE 1995c).

3.2.6.2 Wildlife

Habitats on the Portsmouth site support a relatively high diversity of terrestrial and aquatic wildlife species. Ground-nesting species include bobwhite and eastern box turtle. Various species of reptiles and amphibians are associated with streams and other surface water on the site. Migrating waterfowl use site retention ponds (ANL 1991b). Additional information on wildlife resources is available from MMES (1993) and ANL (1991b).

Little Beaver Creek, upstream of the site outfall, supports a high diversity of aquatic species. However, diversity is considerably lower downstream in Little Beaver Creek and in an unnamed stream (ANL 1991b).

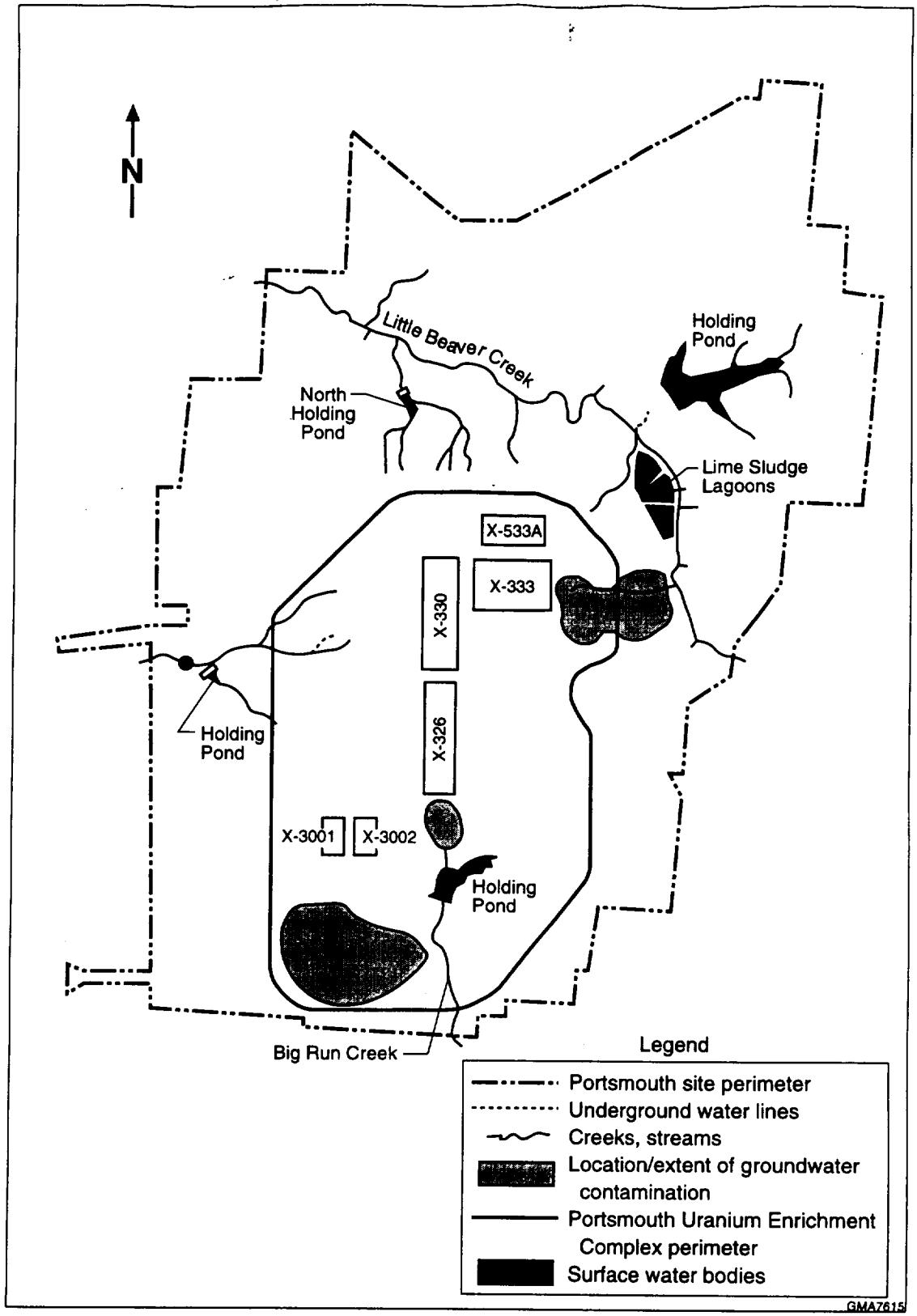

FIGURE 3.6 Locations of Contaminated Groundwater at the Portsmouth Site (Source: LMES 1996b)

3.2.6.3 Wetlands

A wetland survey of the Portsmouth site was conducted in 1995. Approximately 34 acres (13.8 ha) of wetlands occur on the site, excluding retention ponds. Forty-one wetlands meet the criteria for jurisdictional wetlands, while four wetlands are nonjurisdictional (Bechtel Jacobs Company LLC 1998). Wetlands on the site primarily support emergent vegetation that includes cattail, great bulrush, and rush. Palustrine forested wetlands occur on the site along Little Beaver Creek (ANL 1991b). The Ohio State Division of Natural Areas and Preserves has listed two wetland areas near the site as significant wetland communities: (1) a palustrine forested wetland, about 5 miles (8 km) east of the site, and (2) Givens Marsh, a palustrine wetland with persistent emergent vegetation, about 2.5 miles (4 km) northeast of the site.

3.2.6.4 Threatened and Endangered Species

No federal-listed plant or animal species are known to occur on the Portsmouth site. The Indiana bat, federal- and state-listed as endangered, has been reported in the site area and may occur on the site during spring or summer in breeding colonies. Roosting and nursery sites may include forested areas with loose barked trees (such as shagbark hickory) and standing dead trees (DOE 1995c).

The sharp-shinned hawk, listed by the State of Ohio as endangered, has been sighted occasionally at the Portsmouth site and has been observed foraging on the site (ANL 1991b). A population of long-beaked arrowhead, a wetland plant listed by the state as threatened, occurs just north of the site.

3.2.7 Public and Occupational Health and Safety

3.2.7.1 Radiation Environment

Operations at the Portsmouth site result in radiation exposures of on-site workers and members of the general public (Table 3.8). The total radiation dose to an off-site member of the public as a result of gaseous diffusion plant operations is estimated to be 0.07 mrem/yr, which is less than 0.02% of the average dose of 360 mrem/yr that an individual in the United States receives each year from natural background and medical sources of radiation.

Radiation exposures of the cylinder yard workers include exposures from activities performed outside the cylinder yards. The average dose ranged from 55 to 196 mrem/yr between 1990 and 1995 (Hodges 1996), considerably below the maximum dose limit of 5,000 mrem/yr set for workers (10 CFR Part 835).

TABLE 3.8 Estimated Radiation Doses to Members of the General Public and to Uranium Material Handlers at the Portsmouth Gaseous Diffusion Plant

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides	0.016[b]
	Waterborne radionuclides	0.006[c]
	Direct gamma radiation	~0[d]
	Ingestion of foodstuffs	~0.044[e]
Uranium material handler[f]	External radiation	55 – 196[g]
Member of public or worker	Natural background radiation and medical sources	360[h]
DOE worker limit		2,000[i]

[a] The MEI was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were estimated using air concentrations calculated by an air dispersion model (LMES 1996b).

[c] The MEI was assumed to use the Scioto River as a source of drinking water and for fishing and recreation (LMES 1996b).

[d] Radiation levels around the site could result in doses about the same as those from off-site radiation levels (LMES 1996b).

[e] Radiation doses could result from consumption of locally produced foodstuffs (including fish caught in the Scioto River). Estimated doses were obtained by subtracting doses from airborne and waterborne radionuclides from the total dose (0.07 mrem/yr) received by the MEI (LMES 1996b).

[f] Uranium material handlers at the Portsmouth plant perform feed and withdrawal operations, cylinder movements, inspections, and radiation surveys (Hodges 1996).

[g] Range of annual average doses from years 1990 through 1995 (Hodges 1996).

[h] Average dose to a member of the U.S. population as estimated in Report No. 93 of the NCRP (1987b).

[i] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

3.2.7.2 Chemical Environment

The estimated hazard quotients for MEIs under existing environmental conditions near the Portsmouth site are listed in Table 3.9. These hazard quotients indicate that exposures to uranium, fluoride, and chromium for members of the general public near the Portsmouth site are much lower than those that might be associated with deleterious health effects. Portsmouth worker exposures are kept below the proposed OSHA permissible exposure limits (PELs) for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998) (see Section 3.1.7.2).

3.2.8 Socioeconomics

The socioeconomic environment of the Portsmouth site was assessed in terms of regional economic activity, population and housing, and local public finances. The ROI consists of Jackson, Pike, Ross, and Scioto Counties in Ohio; 92.4% of employees at the site currently reside in these counties, with 46% residing in Scioto County (DOE 1996b). Allison and Folga (1997) provide a listing of the cities and school districts in each county within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

3.2.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 75,600 to 81,000, an increase of 7.1%. Within the ROI, the largest percent employment increase occurred in Pike County (19.1%). Employment in the ROI is concentrated in Ross and Scioto Counties, which together had 71.1% of the ROI total in 1995. The BEA projects no overall increase in employment in the ROI over the period 1995 to 2020. However, Pike County (2.0%, 200 jobs) and Scioto County (0.4%, 100 jobs) are expected to gain in ROI employment, with losses expected elsewhere (BEA 1996b). Unemployment in the ROI in 1996 was 9.3% (Allison 1996). Employment at the Portsmouth site in 1995 was 2,400 (DOE 1997a), amounting to approximately 3.0% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from $1.8 billion to $2.0 billion, an increase of 11%. The largest percent increase occurred in Pike County (41.7%). Personal income is concentrated in Ross and Scioto Counties, which together had 75.1% of total ROI personal income in 1995. The BEA projects a 26.8% increase in ROI personal income from 1995 to 2020 ($0.5 billion), with the largest increase in Pike County (38.2%, $0.09 billion) (BEA 1996b).

TABLE 3.9 Estimated Hazard Quotients for Members of the General Public near the Portsmouth Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d]	Uranium	$< 0.01\ \mu g/m^3$	$< 4.3 \times 10^{-6}$	0.0003	0.0095
	HF	$< 0.11\ \mu g/m^3$	$< 3.1 \times 10^{-5}$	0.02	0.0016
Soil[e]	Uranium	5.3 mg/kg	7.0×10^{-5}	0.003	0.024
	Chromium	23 mg/kg	3.0×10^{-4}	0.005	0.060
Surface water[f]	Uranium	24 µg/L	1.3×10^{-5}	0.003	0.0044
	Fluoride	600 µg/L	3.3×10^{-4}	0.06	0.0055
Sediments[f]	Uranium	11 mg/kg	3.0×10^{-6}	0.003	0.0010
Groundwater[g]	Uranium	26 µg/L	6.9×10^{-5}	0.003	0.25

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference level. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely.

[d] Property-line sampling locations were used for assessment of general public exposures. Gross alpha was reported, which was used as a surrogate for uranium. Air exposure concentrations are the maximum annual average reported for all property-line and off-site monitoring locations (LMES 1996b).

[e] Soil exposure concentrations are the maximum values from 32 property-line and off-site sampling locations (MMES 1994c).

[f] Surface water and sediment exposure concentrations are the maximum annual averages reported for all NPDES outfall locations and other monitoring locations (MMES 1994c-d).

[g] Groundwater exposure concentration is the maximum concentration reported for on-site monitoring wells (LMES 1997d). These wells are not used for drinking water. Several additional substances exceeded drinking water standards or guidelines in 1996 (see Section 3.2.5.2); listed here are only substances of particular interest for this PEIS. Groundwater fluoride concentrations were not available.

3.2.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 202,900 to 205,200, an increase of 1.1%. The 1995 ROI population was concentrated in Ross and Scioto Counties (73.3%). The BEA projects the ROI population to increase by 9,800 (4.8%) from 1995 to 2020, with the largest increase in Pike County (7.7%, 1,900 people) (BEA 1996b).

3.2.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased 6.5%, from 75,800 to 80,800. Scioto and Ross Counties had 73.1% of the total housing units. Based on BEA (1996b) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the number of vacant owner-occupied units in the ROI is expected to increase from 4,630 to 4,850 and the number of vacant rental units from 1,940 to 2,030.

3.2.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.10. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

3.2.9 Waste Management

The Portsmouth site generates several categories of waste, including wastewater, solid LLW, solid and liquid LLMW, nonradioactive hazardous waste, and nonradioactive nonhazardous solid waste. The site has an active program to minimize the generation of solid LLW, hazardous waste, and LLMW. Radioactive waste minimization efforts include segregating radioactive waste from nonradioactive waste; reduction of radiologically controlled areas, thereby reducing the use of disposable personal protective equipment; and improved segregation and handling of laboratory waste. Hazardous and mixed waste minimization actions include the sorting of burnable waste from radioactively contaminated materials, reduction of absorbent cloth use in PCB spill cleanup, reduction in floor sweeping waste, and substitution of materials containing nonhazardous components. Solid waste minimization actions include the recycling of corrugated cardboard and aluminum.

3.2.9.1 Wastewater

Wastewater at Portsmouth consists of nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, radioactive process-related liquid effluent, discharges

TABLE 3.10 Summary of Financial Characteristics for the Portsmouth Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	18.1	13.1	Local sources	22.8
Fines, fees, permits, etc.	3.3	3.2	State sources	33.6
Intergovernmental	3.7	4.1	Federal sources	4.6
Other	3.0	3.4	Other	0.2
Total	28.1	23.8	Total	61.2
Expenditures			**Expenditures**	
General government	12.1	6.7	Administration	0.0
Safety, health, community services	8.6	14.3	Instruction	36.9
			Services	23.4
Debt service	0.0	0.0	Physical plant	0.4
Other financing sources	7.6	2.5	Other	2.0
Total	28.3	23.6	Total	62.8
Revenues less Expenditures	-0.2	0.2	**Revenues less Expenditures**	-1.6

[a] Data for fiscal year ending December 31, 1994.

Sources: see Allison and Folga (1997).

from groundwater treatment systems, and storm-water runoff from plant areas, including runoff from the coal pile. Wastewater is processed at several on-site treatment facilities and is discharged to either the Scioto River or its immediate tributaries, including Little Beaver Creek, through 21 outfalls identified under the site NPDES permit. Treatment facilities include an activated sludge sewage treatment plant; several facilities that employ waste-specific pretreatment technologies (e.g., pH adjustment, activated carbon adsorption, metals removal, denitrification, and ion absorption); and numerous settling basins designed to facilitate solids settling, oil collection, and chlorine dissipation. In 1993, about 4.3 million gal/d (16 million L/d) of wastewater was discharged through the permitted outfalls. The site wastewater facilities are used at about 80% of a total capacity of approximately 5.3 million gal/d (20 million L/d) (DOE 1996g).

3.2.9.2 Solid Nonhazardous, Nonradioactive Waste

Solid waste — including sanitary refuse, cafeteria waste, industrial waste, disinfected medical waste (excluding drugs), and construction and demolition wastes — is collected and disposed of on-site at the X-735 sanitary landfill. Disposal is in shallow trenches covered with earthen fill. The site operates the landfill under an annual permit issued by Pike County, Ohio. No RCRA hazardous waste, PCB waste, or radioactive materials are allowed in the landfill. Asbestos waste is disposed of in specially designated areas of the sanitary landfill. In 1993, the landfill load was 236,000 yd^3 (180,000 m^3), which represented 86% of the landfill capacity of 273,000 yd^3 (209,000 m^3) (DOE 1996g).

Materials, such as certain construction and demolition debris, that are not regulated as solid waste by the state of Ohio are disposed of at the Portsmouth X-736 construction spoils area, located immediately west of the sanitary landfill.

3.2.9.3 Nonradioactive Hazardous and Toxic Waste

Nonradioactive waste that is considered hazardous waste according to RCRA or contains PCBs as defined under TSCA requires special handling, storage, and disposal. The Portsmouth site generates hazardous waste, including spent solvents and heavy-metal-contaminated waste, and PCB-contaminated toxic waste. As of 1994, Portsmouth had a RCRA Part B permit application pending before the Ohio Environmental Protection Agency. Portsmouth provides long-term on-site storage for hazardous waste at the X-7725 and X-326L RCRA container storage units. Several additional 90-day satellite storage areas are available for temporary storage of hazardous waste. In 1993, the site had 7,200 yd^3 (5,500 m^3) of hazardous waste in storage; site storage capacity is 9,700 yd^3 (7,400 m^3) (DOE 1996g).

Hazardous waste is sent to permitted off-site contractors for final treatment and/or disposal. Annual generation of solid hazardous waste ranged from 130 to 160 yd^3/yr (100 to 120 m^3/yr) in 1991 and 1992, respectively. Much of the hazardous waste load consists of PCB-contaminated waste. The site has over 2×10^6 lb (900,000 kg) of PCBs in various site electrical equipment in both active and inventory equipment (1993 data). In 1992, about 325 yd^3 (250 m^3) of hazardous organic liquid waste streams was sent to the K-25 site TSCA-approved incinerator. The capacity of the incinerator is 1,800 yd^3/yr (1,400 m^3/yr) (DOE 1996g).

3.2.9.4 Low-Level Waste

LLW generated at the Portsmouth site is stored on-site pending shipment to off-site treatment/disposal facilities. Portsmouth has initiated shipment of some LLW to the Hanford site (Washington) for disposal. Solid LLW generated at the site includes refuse, sludge, and debris contaminated with radionuclides, primarily uranium and technetium. As of 1995, 38,600 yd^3

(29,500 m^3) of LLW was in storage at the Portsmouth site (DOE 1996g). The annual generation of LLW ranged from 2,920 yd^3 (2,230 m^3) in 1991 to 2,160 yd^3 (1,650 m^3) in 1992.

3.2.9.5 Low-Level Mixed Waste

LLW that contains PCBs or RCRA hazardous components is considered to be LLMW. All of the LLMW inventory at Portsmouth is subject to RCRA land disposal restrictions; LLMW is currently stored at the site. Treatment technologies exist for all of the LLMW streams in the Portsmouth inventory. As of 1995, 7,290 yd^3 (5,570 m^3) of mixed waste was in storage at the site. Of this, approximately 18% was derived from operations, and the rest was packaged solvent and/or metals-contaminated soil from environmental restoration activities. Mixed waste generation in 1992 was 510 yd^3 (390 m^3) liquid and 460 yd^3 (350 m^3) solid. In 1992, approximately 558,000 lb (254,000 kg) of organic liquid LLMW was sent to the TSCA incinerator or the K-25 site (DOE 1996g). In 1995 and 1996, approximately 1,300 yd^3 (1,000 m^3) of contaminated soil (LLMW) was shipped to a commercial facility in Utah for disposal.

3.2.10 Cultural Resources

An archaeological survey has been initiated at the Portsmouth site but has not been completed at this time. A survey conducted in 1952 recorded no sites. However, because of the archaeological site density in the surrounding area (over 200 sites have been recorded for Pike County alone), there is potential for discovering sites at Portsmouth using modern archaeological methods.

An inventory of historic buildings has been planned but has not been conducted at the Portsmouth site. It is likely that buildings related to uranium enrichment and atomic weapons manufacture would be eligible for the *National Register of Historic Places*. Two cemeteries, Holt Cemetery and Mount Gilead Cemetery, are located within the boundary of the facility.

No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified at the Portsmouth site to date.

3.2.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the Portsmouth site consists of 3.2% minorities and 20.7% persons with low income (see Appendix C, Section C.8.1).

3.3 K-25 SITE AT OAK RIDGE

The K-25 site is part of the Oak Ridge Reservation, which is located in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville (Figure 3.7). The reservation consists of three major facilities — the K-25 site, Oak Ridge National Laboratory, and Y-12 plant (Figure 3.8) — and surrounding property. The 1,700-acre (688-ha) K-25 site contains the Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities (MMES 1994f).

Anderson County and the City of Oak Ridge have developed planning documents to control land use. Anderson County's comprehensive plan was created in 1982, and the City of Oak Ridge updated its comprehensive plan in 1988. Roane County has not formally developed or adopted a comprehensive or master plan.

The K-25 site includes more than 300 buildings with a combined floor space of 13 million ft^2 (1.2 million m^2) (MMES 1994f). Site management, in conjunction with DOE's land management policy, is currently pursuing an option to lease a 957-acre (387-ha) parcel of site land to the Community Reuse Organization of East Tennessee. The K-25 parcel, which is located

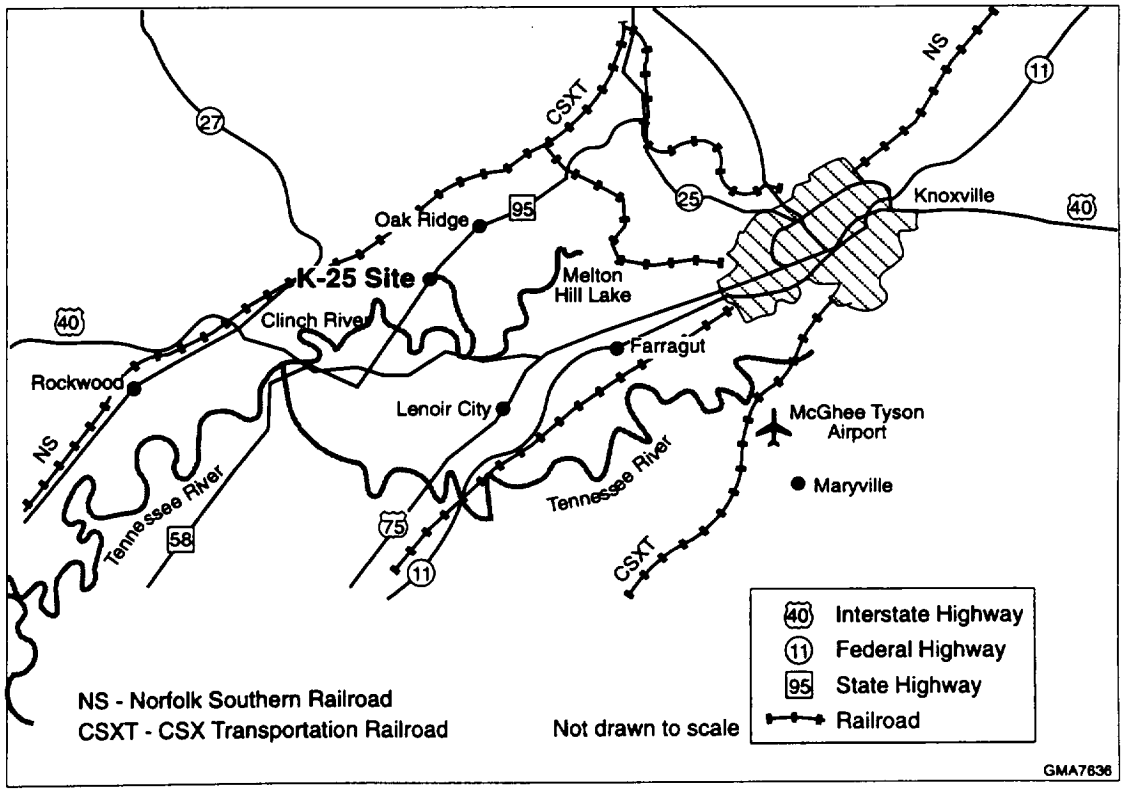

FIGURE 3.7 Regional Map of the K-25 Site Vicinity (Source: Adapted from ANL 1991c)

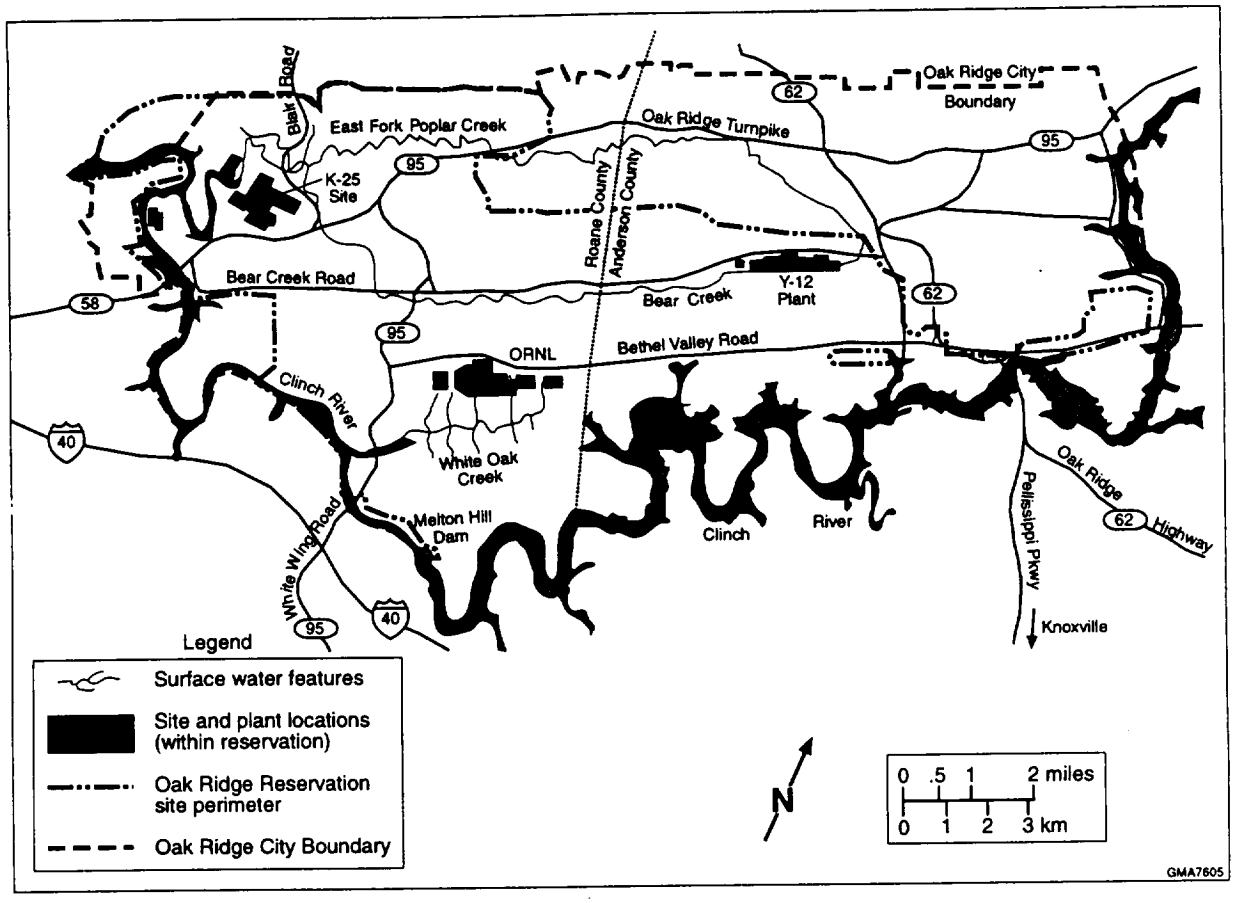

FIGURE 3.8 Map of the Oak Ridge Reservation (Source: MMES 1994f)

northeast of the core area, would be used as an industrial park, a use that is compatible with current site development plans. The Oak Ridge Reservation has a master plan that is updated every 5 years.

In 1989, the Oak Ridge Reservation was placed on the NPL, meaning that CERCLA cleanup requirements would be met in conducting remediation efforts. Several operable units (groups of similar potentially contaminated units) have been identified at the Y-12 plant, 20 waste area groupings (similar to operable units) have been identified at Oak Ridge National Laboratory, and 15 operable units have been identified at the K-25 site. Hazardous waste and mixed waste management at the Oak Ridge Reservation must also comply with RCRA regulations. The Oak Ridge Reservation FFA was developed to integrate CERCLA/RCRA requirements into a single remediation procedure. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some K-25 sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF_6 cylinder storage areas into the context of sitewide conditions.

3.3.1 Cylinder Yards

There are 4,683 depleted UF_6 storage cylinders located in three K-25 site cylinder yards (Table 3.11; Figure 3.9). Cylinders are stacked two high to conserve storage yard space. The K-1066-K yard (K-yard) currently contains the most cylinders (2,945); it is constructed of concrete and crushed stone. Due to historical poor drainage conditions in K-yard, all cylinders in the K-yard are currently inspected annually. Most of the remaining K-25 site cylinders (1,716) are stored in the K-1066-E yard (E-yard), which is constructed of concrete; the K-1066-L yard (L-yard) contains only 22 cylinders. The E-yard and L-yard cylinders are inspected once every 4 years.

Four breached cylinders were discovered at the K-25 site in early 1992; two were located in K-yard and two in E-yard. The cause of the K-yard breaches seemed to be external corrosion from poor storage conditions, whereas the cause of the E-yard breaches could be attributed to handling damage and subsequent corrosion at the damaged points. The hole diameters for three of the breached cylinders ranged from 2 to 10 in. (5 to 25 cm); the dimensions of the fourth breach, the largest (an E-yard breached cylinder), were approximately 17 in. × 12 in. (43 cm × 30 cm). The four breached cylinders have been patched to restore their integrity, segregated from the other cylinders in K- and E-yards, and placed under temporary awnings. Because equipment to weigh the cylinders was not available at the K-25 site, the extent of material loss from these cylinders could not be determined.

One additional cylinder breach occurred in 1998 during the course of cylinder maintenance operations (i.e., surface preparation and painting). The breach was patched to prevent material loss from the cylinder.

3.3.2 Site Infrastructure

The K-25 site is located in an area with a well-established transportation network. The site is near two interstate highways, several U.S. and state highways, two major rail lines, and a regional airport (Figure 3.7).

Water is supplied to the K-25 site through a pumping station on the Clinch River. The water is treated and stored in two storage tanks. This system, with a capacity of 4 million gal/d (15 million L/d), also provides water to the Transportation Safeguards Facility and the K-25 site. Average water consumption for these three facilities in 1994 was 2 million gal/d (8 million L/d) (DOE 1995a).

Electric power is supplied by the Tennessee Valley Authority. The distribution of power is managed through the K-25 Power Operations Department. The average demand for electricity by all of the Oak Ridge DOE facilities, including the K-25 site, is approximately 100 MVa. The maximum capacity of the system is 920 MVa (DOE 1995a). Natural gas is supplied by the East Tennessee Natural Gas Company; the current daily capacity of 7,600 decatherms is capable of being increased, if necessary. The average daily usage in 1994 was 3,600 decatherms (DOE 1995a).

TABLE 3.11 Locations of DOE Depleted UF_6 Cylinders at the K-25 Site[a]

Yard	Area (ft^2)	Number of Cylinders
K-1066-K	134,825	2,945
K-1066-E	157,376	1,716
K-1066-L	43,824	22

[a] Locations of cylinders as of May 1996.

Source: Cash (1996).

3.3.3 Ambient Air Quality and Airborne Emissions

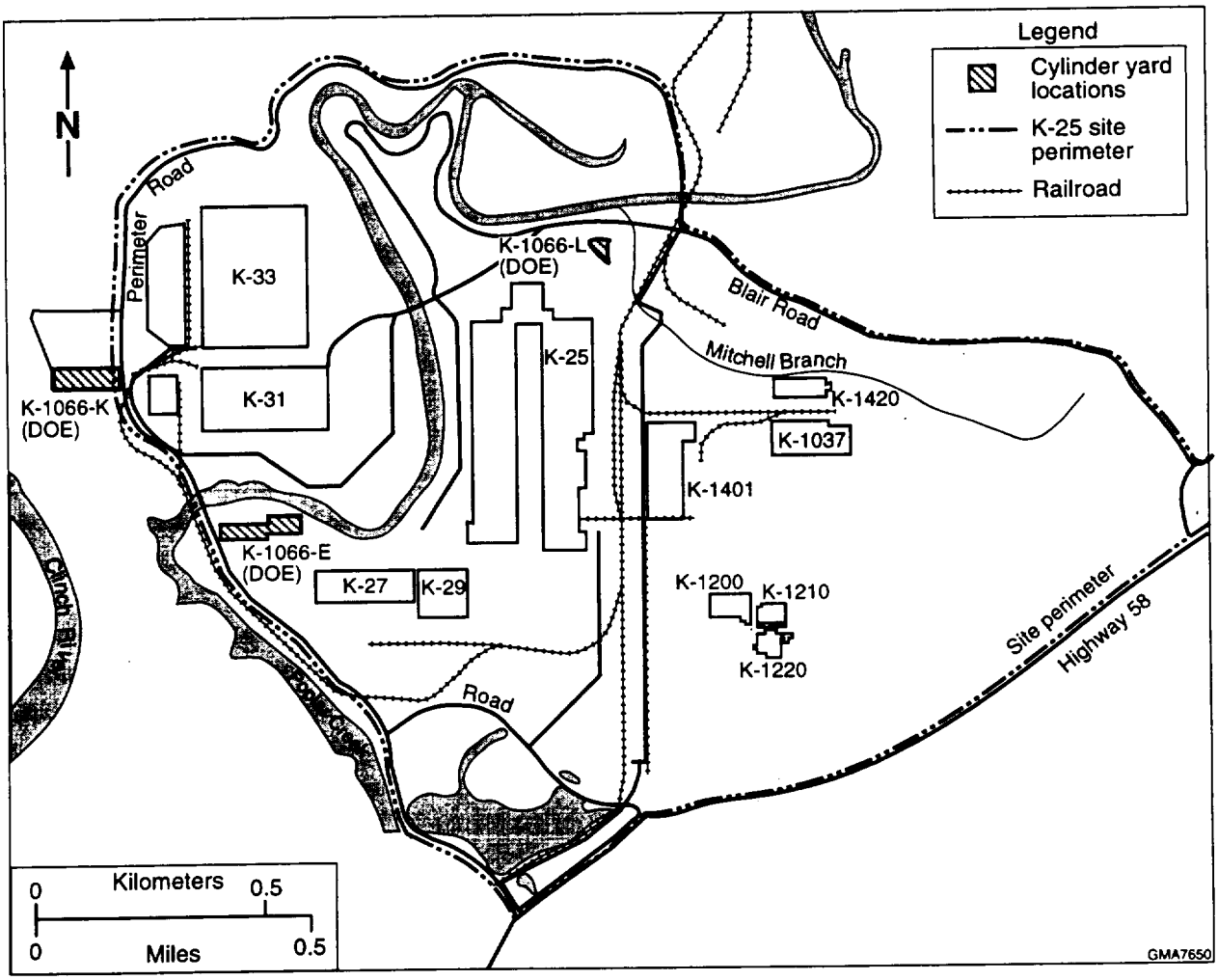

FIGURE 3.9 Locations of Cylinder Yards at the K-25 Site That Are Used to Store DOE Cylinders (Source: Adapted from MMES 1994a and LMES 1996c)

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The affected environment for air quality at the K-25 site was generally considered to be the EPA-defined AQCR. The EPA has designated the K-25 site as being in the Eastern Tennessee-Southwestern Virginia Interstate AQCR in EPA Region 4. The EPA classifies this AQCR as an attainment area for all six NAAQS criteria pollutants.

The State of Tennessee has adopted NAAQS, which are presented in Table 3.12. In addition to the standards for criteria pollutants, the Tennessee Department of Environment and Conservation (TDEC) has adopted regulations to provide guidance for evaluating HAPs and air toxics that specify permissible short-term and long-term concentrations of various contaminants ("Hazardous Air Contaminants," *Air Pollution Control Regulations*, Chapter 11). The TDEC list is the same as the 189 HAPs listed in Section 112(b) of the *Clean Air Act Amendments* (42 USC Parts 7401–7626). Emission standards for these HAPs are established in NESHAPS (40 CFR Part 61).

Ambient air quality is monitored in Anderson and Roane Counties by the Tennessee Division of Air Pollution Control. During 1992, no violations were recorded at the ozone monitor on the Oak Ridge Reservation or in nearby Nancy's Grove.

Although uranium enrichment activities at K-25 were discontinued in 1987, ambient air monitoring for uranium, PM_{10}, and several metals has continued at six on-site and off-site locations, with samples collected weekly; fluoride monitoring has been discontinued. As of 1996, monitoring was discontinued at four of the locations after review and concurrence by DOE and the Tennessee Department of Environmental Conservation (LMES 1997b).

For the period 1994 through 1996, the maximum annual average concentration of uranium for the six monitoring locations was 0.00039 $\mu g/m^3$ at Station K2 (LMES 1995a, 1996d, 1997b). The maximum annual average PM_{10} concentration for the same time period was 24.3 $\mu g/m^3$ (40% of the Tennessee and national primary and secondary standards); the maximum quarterly lead concentration was 0.0076 $\mu g/m^3$ (0.5% of the Tennessee and national primary and secondary standards) (LMES 1995a, 1996d, 1997b).

Steam plant emissions have accounted for most of the criteria pollutant emissions at the K-25 site (LMES 1995a). In 1994, all estimated emissions were less than the allowable ones. The K-25 site also contains a TSCA incinerator. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Estimated emissions from the incinerator are significantly less than the permitted allowable emissions.

TABLE 3.12 Tennessee Ambient Air Quality Standards

Pollutant	Tennessee Standard[a] Primary	Tennessee Standard[a] Secondary
Carbon monoxide (CO)		
1-hour average	35.0 ppm	35.0 ppm
8-hour average	9.0 ppm	9.0 ppm
Sulfur dioxide (SO_2)		
3-hour average	–[b]	0.50 ppm
24-hour average	0.14 ppm	–
Annual arithmetic mean	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour	150 $\mu g/m^3$	150 $\mu g/m^3$
Annual geometric mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual arithmetic mean	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Gaseous fluorides (as HF)		
12-hour average	4.5 ppb	4.5 ppb
24-hour average	3.5 ppb	3.5 ppb
7-day average	2.0 ppb	2.0 ppb
30-day average	1.5 ppb	1.5 ppb

[a] Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless noted.

[b] A hyphen (–) indicates no standard available for this averaging period.

Source: DOE (1996g).

3.3.4 Geology and Soil

3.3.4.1 Topography, Structure, and Seismic Risk

The topography of the K-25 site is varied; the maximum change in elevation across the site is about 420 ft (130 m). The site is underlain by sedimentary rocks composed of limestone and dolomite. Sinkholes, large springs, and other karst features can occur in the limestone formations adjacent to the site (DOE 1995a).

The most important structural feature near the site is a system of three faults: the Whiteoak Mountain Fault, which runs through the southeastern corner of K-25; the Kingston Fault, a parallel fault that occurs north of Poplar Creek; and the Copper Creek Fault, located in Melton Valley. A branch of the Whiteoak Mountain Fault originates just south of the site and runs due north through its center. None of these faults appear to have any topographic expression, and it is assumed that displacement took place prior to the development of the current surface of erosion (DOE 1979). Because no surface movement has occurred along these faults for more than 35,000 years and there has been no movement of a recurring nature within the past 500,000 years, the faults are not considered to be capable. Therefore, the evaluation-basis earthquake for this site was designated by DOE to have a return period of 1,000 years. For K-25, an earthquake that has a 1,000-year return period would have a horizontal top-of-soil acceleration of 0.2 times the acceleration of gravity. Such an earthquake could occur with equal probability any time during the 1,000-year period. For these conditions, slope stability and soil liquefaction (loss of shear strength) would not be problems, and rocking and rolling-out of cylinders would not occur for single or multiple-stacked cylinders (LMES 1997h).

The seismic hazards at the K-25 site have been analyzed and documented in a SAR completed in March 1997 (see Sections 1.5 and 3.4 in LMES 1997h). The results presented in the SAR indicate that continued storage of depleted UF_6 cylinders at the K-25 site is safe. The results of the SAR analyses were used for the accident analyses in this PEIS (see Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.3.4.2 Soil

Soil and groundwater data have been collected to determine whether contamination is associated with the K-25 cylinder yards (DOE 1994a). Substances in soil possibly associated with cylinder management activities are uranium and fluoride compounds, which could be released to soil if breached cylinders or faulty valves were present. In 1991, 122 systematic soil samples were collected at the K-yard; these samples had maximum concentrations of 0.14 mg/kg uranium-235 and

13 mg/kg uranium-238. Soil samples collected in March 1992 at the K-yard had a maximum uranium concentration of 36 ± 2 mg/kg.

In 1994, 200 systematic and 28 biased soil samples were collected in areas surrounding the cylinder yards; the maximum concentrations detected in these samples were 0.83 mg/kg uranium-235 at K-1066-F yard (F-yard) and 75 mg/kg uranium-238 at E-yard. Groundwater concentrations of total uranium (measured as gross alpha and gross beta) for upgradient and downgradient wells have indicated that although some elevated levels of uranium have been detected in cylinder yard soil, no migration to groundwater has occurred (DOE 1994a). The cause of the isolated elevated uranium-238 level in soil was not identified.

Soil samples collected as part of general site monitoring at K-25 and the immediate surrounding area in 1994 had the following maximum concentrations: uranium, 6.7 mg/kg; Aroclor 1254 (a PCB), 0.16 mg/kg; cadmium, 0.34 mg/kg; mercury, 0.15 mg/kg; and nickel, 33 mg/kg (LMES 1996c). Fluoride was not analyzed in the soil samples, but it is naturally occurring and of low toxicity. Concentrations of uranium in 1995 and 1996 soil monitoring were lower (LMES 1996d, 1997b).

As part of ongoing CERCLA/RCRA investigations for the K-25 site, several areas of soil have been identified as contaminated with radionuclides and/or chemicals. However, this contamination is not associated with the depleted UF_6 cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

3.3.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples has indicated the presence of some contamination resulting from previous gaseous diffusion plant operations. Although several contaminants are present in the water, only small amounts of uranium and fluoride compounds are related to releases from the cylinders.

3.3.5.1 Surface Water

The K-25 site is located near the confluence of the Clinch River (a tributary of the Tennessee River) and Poplar Creek (Figure 3.10). There are effluent discharge points on both Poplar Creek and the Clinch River and two water withdrawal points on the Clinch River (DOE 1979).

Because of the presence of the Melton Hill and Watts Bar Dams, the hydrology of the Clinch River-Poplar Creek system near K-25 is very complex. In the vicinity of K-25, most of the facilities are free of flood hazards for both the 100-year and 500-year maximum probable floods in Poplar Creek (Rothschild et al. 1984).

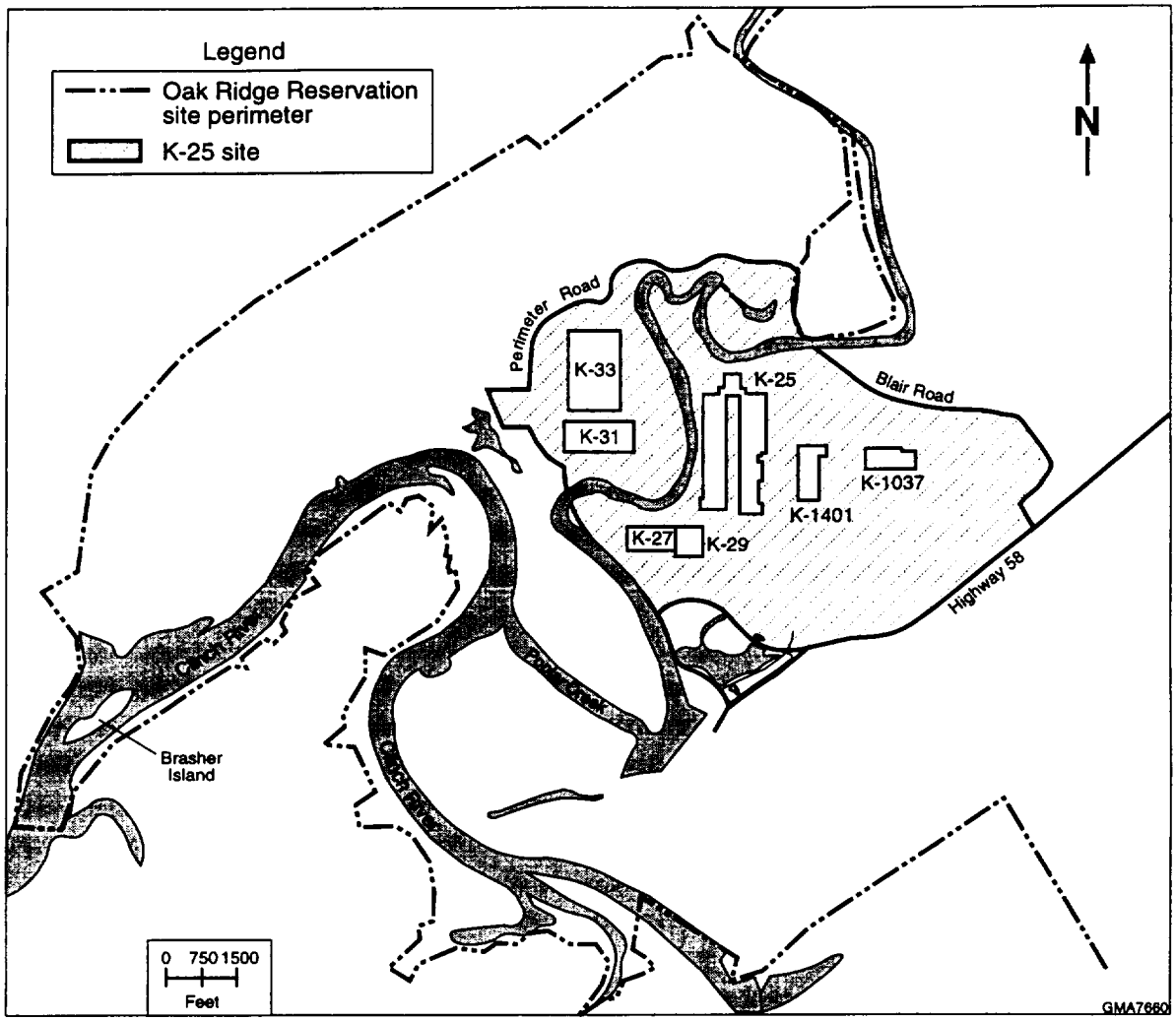

FIGURE 3.10 Locations of Surface Water Bodies near the K-25 Site

As of 1996, surface water monitoring at K-25 has been conducted at five locations (LMES 1997b). The K-1710 sampling location provides information on surface water conditions upstream of K-25. Station K-716 is downstream of most of the K-25 operations and provides information on the cumulative effects of K-25 operations. The remaining sampling locations are at points where drainage in the major surface water basins converge before discharging to Poplar Creek.

Samples from the K-25 site are analyzed monthly for radionuclides; quarterly samples are collected and analyzed for general water quality parameters, selected metals, and organic compounds (LMES 1997b). Uranium levels have been considerably below permitted levels based on radiological standards. In most instances, results for nonradiological parameters are considerably below their applicable Tennessee water quality standards. In 1994, zinc, which occurs naturally in the soils of the area, was detected just above the limit in one sample from the K-1700 sampling location (LMES

1995a). Lead, nickel, and mercury were occasionally detected but always at low concentrations. In general, analytical results for samples collected upstream of K-25 are chemically similar to those collected downstream of the site.

Sediment sampling has also been performed at points that coincide with the K-25 water sampling locations. These samples were analyzed for uranium and other parameters. For 1994, the following maximum concentrations were measured: uranium, 43 µg/g; mercury, 6 µg/g; nickel, 89 µg/g; and Aroclor 1254, 10 µg/g (LMES 1996c).

3.3.5.2 Groundwater

Groundwater in the vicinity of the K-25 site occurs in a surficial aquifer and in bedrock aquifers. The surficial aquifer is made up of man-made fill, alluvium, and the residuum of weathered bedrock (Geraghty & Miller 1989b). The depth to unweathered bedrock varies from less than 10 ft (3 m) to more than 50 ft (15 m), depending on the characteristics of the underlying rocks. Bedrock aquifers in the area are composed of sandstones, siltstones, shales, dolostones, and limestones. The uppermost bedrock aquifer occurs in the Chickamauga Group. Shale beds restrict groundwater flow in the aquifer, resulting in concentrated flow along the limestone-shale contact, with resultant solution cavities. The next lower aquifer occurs in the Knox Group, which is composed of dolostone with interbeds of limestone. Solution features such as sinkholes and caverns are common and are an important route for groundwater flow. This unit is the principal aquifer on the K-25 site (Rothschild et al. 1984).

In 1994 and 1995, groundwater samples were collected from a network of between 200 and 225 monitoring wells at the K-25 site (LMES 1995a, 1996d). The number of wells monitored was greatly decreased in 1996, based on reorganization of the site into six watersheds and reduced monitoring requirements (LMES 1997b). In the 1994 and 1995 sampling conducted for the larger network of monitoring wells, the following substances were detected at levels exceeding their associated primary drinking water standards: antimony, arsenic, barium, cadmium, chromium (up to 0.741 mg/L), fluoride (only at 2 wells), lead, nickel (up to 0.626 mg/L), thallium (up to 0.021 mg/L), benzene (up to 6 µg/L), carbon tetrachloride, 1,1-dichloroethene (greater than 1,000 µg/L), chloroform, 1,2 dichloroethene (greater than 1,000 µg/L), methylene chloride, toluene (greater than 1,000 µg/L), 1,1,2-trichloro-1,2,2-trifluoroethane (greater than 1,000 µg/L), trichloroethylene (up to 11,000 µg/L), 1,1,1-trichloroethane (up to 140,000 µg/L), 1,1,2-trichlororethane, tetrachloroethene (up to 17 µg/L), vinyl chloride, gross alpha activity (up to 43 pCi/L), and gross beta activity (up to 6,770 pCi/L) (LMES 1995a, 1996d). Aluminum, iron, and manganese also consistently exceeded secondary, non-health-based standards because of the natural geochemical nature of the groundwater underlying the site (LMES 1996d).

Exit-pathway groundwater surveillance monitoring was also conducted in 1994 and 1995 at convergence points where shallow groundwater flows from relatively large areas of the K-25 site and converges before discharging to surface water locations (LMES 1995a, 1996d). The exit

pathway monitoring data are representative of maximum groundwater contamination levels associated with the K-25 site to which the general public might possibly have access in the future. For 1994, monitoring indicated that thallium, bis(2-ethylhexyl)phthalate, and trichloroethylene were present in at least one exit pathway well sample at concentrations exceeding primary drinking water standards (LMES 1996c). The following average concentrations of these constituents were measured: thallium, 0.007 mg/L; bis(2-ethylhexyl)phthalate, 0.169 mg/L; and trichloroethylene, 0.008 mg/L. Alpha activity and fluoride levels were also measured but did not exceed reference levels (average concentration was 4.4 pCi/L for alpha activity and 0.4 mg/L for fluoride). For 1995, monitoring indicated that no inorganic or organic substances exceeded primary drinking water standards, but alpha activity exceeded the reference level in one well during the spring sampling event only (level of 17 pCi/L) (LMES 1996d).

3.3.6 Biotic Resources

3.3.6.1 Vegetation

About 65% of the land within a 5-mile (8-km) radius of the K-25 site is forested, although most of the K-25 site consists of mowed grasses. Oak-hickory forest is the predominant community on ridges and dry slopes. Mixed pine forests or pine plantations, many of which are managed, have replaced former agricultural fields. Selective logging occurred over much of the site prior to 1986. Cedar barrens are small communities, primarily on shallow limestone soils, which support drought-tolerant species such as little bluestem, dropseed, eastern red cedar, and stunted oak. A cedar barrens across the Clinch River from the K-25 site may be the best example of this habitat in the state and has been designated a State Natural Area.

3.3.6.2 Wildlife

The high diversity of habitats in the area supports a large number of wildlife species. Ground-nesting species commonly occurring on the K-25 site include the red fox, ruffed grouse, and eastern box turtle. Canada geese are also common in the K-25 area, and most are probably residents (ANL 1991c). Waterfowl, wading birds, and shorebirds are numerous along the Clinch River in its backwaters and in ponds. Two great blue heron rookeries are located north of the K-25 site on Poplar Creek (ANL 1991c). Species commonly associated with streams and ponds include the muskrat, beaver, and several species of turtles and frogs.

The aquatic communities within the Clinch River and Poplar Creek support a high diversity of fish species and other aquatic fauna. Mitchell Branch supports fewer fish species, although the diversity of fish species increased considerably downstream of most K-25 discharges between 1989 and 1995 (LMES 1995a).

3.3.6.3 Wetlands

Numerous wetlands occur in the vicinity of K-25, including three small wetlands along Mitchell Branch (ANL 1991c). Extensive forested wetlands occur along Poplar Creek, East Fork Poplar Creek, Bear Creek, and their tributaries. Shallow water embayments of Melton Hill Reservoir and Watts Bar Reservoir support large areas of palustrine emergent wetlands with persistent vegetation. Forested wetlands occur along these marshy areas and extend into tributaries (DOE 1995a).

3.3.6.4 Threatened and Endangered Species

No federal listed threatened or endangered species are known to occur on the K-25 site. Bachman's sparrow, state-listed as endangered, nests on the Oak Ridge Reservation. Suitable habitat on the reservation includes open pine woods with shrubs and dense ground cover (ANL 1991c). Sharp-shinned hawk and Cooper's hawk, both listed by the state as endangered, forage on the Oak Ridge Reservation. The purple fringeless orchid, state-listed as threatened, occurs in a wetland near the south boundary of the K-25 site and in several areas along Bear Creek and its tributaries southeast of K-25.

3.3.7 Public and Occupational Health and Safety

3.3.7.1 Radiation Environment

Radiation doses to the K-25 cylinder yard workers and to off-site members of the general public are summarized in Table 3.13. Airborne emissions from operations of the K-25 site constitute a small fraction of the emissions from the entire Oak Ridge Reservation and result in approximately 10 times less exposure of the off-site general public than do emissions from the entire reservation. The total radiation dose to the off-site MEI of the general public is estimated to be about 4.5 mrem/yr (LMES 1997b). This dose is much less than the maximum dose limit of 100 mrem/yr set for the general public (DOE Order 5400.5) and a small fraction of the dose from natural background and medical sources of radiation.

Between 1991 and 1995, the average annual dose to cylinder yard workers ranged from 32 to 92 mrem/yr, which is less than 2% of the maximum radiation dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835).

TABLE 3.13 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the K-25 Site

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides[b]	
	K-25 site only	0.056
	Entire Oak Ridge Reservation	0.45
	Waterborne radionuclides[c]	1.52
	Direct gamma radiation	1[d]
	Ingestion of wildlife	1.58[e]
Cylinder yard worker	External radiation	32 – 92[f]
Member of public or worker	Natural background radiation and medical sources	360[g]
DOE worker limit		2,000[h]

[a] The MEI was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were estimated using an air dispersion model and considered exposures from external radiation, inhalation, and ingestion of foodstuffs. Doses were estimated on the basis of the emission rate from the K-25 site only and from the entire Oak Ridge Reservation (LMES 1997b).

[c] Radiation doses would result from drinking 730 L of water per year provided by the Kingston Municipal Water Plant (0.32 mrem/yr) and ingesting 21 kg of the maximally contaminated fish caught from lower Poplar Creek per year (1.2 mrem/yr) (LMES 1997b).

[d] Radiation doses would result from 250 hours of shoreline activity per year along the banks of Poplar Creek or Clinch River (LMES 1997b).

[e] Radiation doses would result from ingestion of two deer containing the field-derived concentration of cesium-137 (1.5 mrem/yr) and ingestion of eight Canada geese per year with an average cesium-137 concentration of 0.12 pCi/g (0.08 mrem/yr) (LMES 1997b).

[f] Range of annual average doses from years 1991 through 1995 (Hodges 1996).

[g] Average dose to a member of the U.S. population as estimated in Report No. 93 of the NCRP (1987b).

[h] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

3.3.7.2 Chemical Environment

The estimated hazard quotients for members of the general public under existing environmental conditions near the K-25 site are listed in Table 3.14. The estimated hazard quotients indicate that exposures to uranium compounds, fluoride compounds, and other contaminants near the K-25 site are generally lower than those that might be associated with deleterious health effects (hazard quotient less than 1). An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, it is highly unlikely that this groundwater will be used as a drinking water source.

Oak Ridge worker exposures are kept below the proposed OSHA PELs for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998) (see Section 3.1.7.2).

3.3.8 Socioeconomics

The socioeconomic environment of the Oak Ridge K-25 site was assessed in terms of regional economic activity, population and housing, and local public finances. The ROI consists of Anderson, Knox, Loudon, and Roane Counties in Tennessee; 91.3% of employees at the site currently reside in these counties, with 36% residing in Knox County and 33.3% in Anderson County (DOE 1997a). Allison and Folga (1997) provide a list of the cities and school districts in each county within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

3.3.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 242,600 to 311,700, an increase of 28.5%. Within the ROI, the largest percent employment increase occurred in Knox County (31.9%), which had 74.6% of total ROI employment in 1995. The BEA projects a 9.4% increase in employment in the ROI over the period 1995 to 2020 (29,400 jobs), with the largest increase expected to occur in Knox County (10.2%, 23,700 jobs) (BEA 1996c). Unemployment in the ROI in 1996 was 3.7% (Allison 1996). Employment at the site in 1995 was 21,500 (DOE 1996e), amounting to approximately 4.3% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from $4.7 billion to $6.7 billion, an increase of 43%. The largest percent increase occurred in Knox County (48.7%), which had 72.3% of total ROI personal income in 1995. The BEA projects a 40.7% increase in ROI personal income from 1995 to 2020 ($2.7 billion), with the largest increase in Knox County (41.8%, $2.0 billion) (BEA 1996c).

TABLE 3.14 Estimated Hazard Quotients for Members of the General Public near the K-25 Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d,e]	Uranium	0.0004 $\mu g/m^3$	1.1×10^{-7}	0.0003	0.0004
Soil[d]	Uranium	6.7 µg/g	8.9×10^{-5}	0.003	0.03
	Cadmium	0.34 µg/g	4.5×10^{-6}	0.001	0.0045
	Mercury	0.15 µg/g	2.0×10^{-6}	0.0003	0.0067
	Nickel	33 µg/g	4.4×10^{-4}	0.02	0.022
	Aroclor 1254	0.16 µg/g	2.1×10^{-6}	0.00002	0.11
	Aroclor 1254[f]	0.16 µg/g	9.1×10^{-7}	2.0 (slope factor)	1.8×10^{-6} (cancer risk)
Surface water[d]	Uranium	13 µg/L	7.1×10^{-6}	0.003	0.0024
	Fluoride	180 µg/L	9.9×10^{-5}	0.06	0.0016
Sediments[d]	Uranium	43 µg/g	1.2×10^{-5}	0.003	0.0039
	Cadmium	0.38 µg/g	1.0×10^{-7}	0.001	0.0001
	Mercury	6 µg/g	1.6×10^{-6}	0.0003	0.0055
	Nickel	89 µg/g	2.4×10^{-5}	0.02	0.0012
	Aroclor 1254	10 µg/g	2.7×10^{-6}	0.00002	0.14
	Aroclor 1254[f]	10 µg/g	3.9×10^{-7}	2.0 (slope factor)	7.8×10^{-7} (cancer risk)
Groundwater[g]	Uranium	25 µg/L	1.8×10^{-4}	0.003	0.24
	Fluoride	4,000 µg/L	1.1×10^{-2}	0.06	1.9

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C. For carcinogens, the slope factor is also given; slope factors in units of $(mg/kg\text{-}d)^{-1}$ are multiplied by lifetime average intake to estimate excess cancer risk.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference does. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake × slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

[d] Exposure concentrations are the maximum annual averages for all monitoring locations (LMES 1995a, 1996c).

[e] HF was not measured.

[f] Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

[g] Concentration for uranium is the maximum annual average for all exit pathway monitoring locations because these are the locations where the general public could most likely be exposed in the future. Alpha activity was used as a surrogate measure of uranium concentration. The well-specific concentration for fluoride was not available; the exposure concentration given is actually the drinking water standard. The hazard index for fluoride could therefore exceed that presented. Several additional substances exceeded drinking water standards or guidelines in 1994 and 1995 monitoring; listed here are only substances of particular interest for this PEIS. Data are from LMES (1996c,d).

3.3.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 464,000 to 506,600, an increase of 9.2%. The 1995 ROI population was concentrated in Knox County (69.8%). The BEA projects the ROI population as a whole to increase by 77,200 (15.2%) from 1995 to 2020, with the largest increase in Knox County (15.9%, 56,300 people) (BEA 1996c).

3.3.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased 13.8%, from 181,300 to 206,200. Knox County had 69.6% of the total housing units. Based on BEA (1996c) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the number of vacant owner-occupied units in the ROI is expected to increase from 10,190 to 11,750 and the number of vacant rental units from 5,030 to 5,800.

3.3.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.15. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

3.3.9 Waste Management

The K-25 site generates industrial and sanitary waste, including wastewater, solid non-hazardous waste, solid and liquid hazardous waste, and radioactive waste. Much of the waste generated at K-25 is by-products of the ongoing environmental remediation efforts at the site. The K-25 site has the capability to treat wastewater and certain radioactive and hazardous waste; other waste treatment facilities that can process and/or dispose of K-25 waste are located at the Y-12 Plant and Oak Ridge National Laboratory. The K-25 waste facilities also store and process waste generated at K-25, as well as waste from Y-12 and Oak Ridge National Laboratory and from other DOE installations at Paducah, Portsmouth, and Fernald. Most radioactive waste at K-25 is contaminated with uranium and uranium decay products, with small amounts of fission products.

The K-25 site is active in the program for waste minimization and recycling at the Oak Ridge Reservation. In 1994, the Oak Ridge Reservation recycled about 700 tons (640 metric tons) of paper, 350 tons (320 metric tons) of cardboard, and 30 to 50 tons (27 to 45 metric tons) of aluminum (LMES 1995a).

TABLE 3.15 Summary of Financial Characteristics for the K-25 Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	66.7	118.6	Local sources	143.6
Fines, fees, permits, etc.	9.1	2.7	State sources	145.7
Intergovernmental	8.9	26.5	Federal sources	3.2
Other	5.4	9.5	Other	1.1
Total	90.1	157.2	Total	323.2
Expenditures			**Expenditures**	
General government	31.5	14.1	Administration	30.2
Safety, health, community services	50.7	91.6	Instruction	189.7
			Services	16.3
Debt service	0.0	2.3	Physical plant	17.2
Other financing sources	1.3	48.6	Other	16.3
Total	83.4	156.6	Total	298.7
Revenues less Expenditures	6.7	0.6	**Revenues less Expenditures**	24.5

[a] Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

3.3.9.1 Wastewater

Treated wastewater at the K-25 site is discharged under NPDES permit TN0002950. In 1994, the discharge was in compliance more than 99% of the time. Sanitary wastewater is processed at the K-1203 sewage treatment plant, which has a capacity of 0.92 million gal/d (3.5 million L/d). In 1994, the average loading to the facility was 0.64 million gal/d (70% of capacity). Currently, there is a project to reline sewer lines to reduce rainfall infiltration (DOE 1996g).

3.3.9.2 Solid Nonhazardous, Nonradioactive Waste

The Oak Ridge Reservation, including the K-25 site, generates about 35,000 yd^3/yr (27,000 m^3/yr) of solid nonhazardous waste. The waste is disposed of at the Y-12 landfill, which has a capacity of 405,000 yd^3 (310,000 m^3) (DOE 1996g). An additional 1.8 million yd^3 (1.4 million m^3) of capacity will be developed at the landfill. Given current and/or future projected waste loading, the

landfill will have approximately 50% of capacity, or 920,000 yd^3 (700,000 m^3), available in the year 2020.

3.3.9.3 Nonradioactive Hazardous and Toxic Waste

The K-25 site generates both RCRA-hazardous and TSCA-hazardous waste. The site operates several RCRA Part B hazardous waste treatment/storage facilities. The majority of the hazardous waste consists of PCB-containing solids and liquids regulated according to TSCA guidelines. In 1992, the site generated 1,124 tons (1,020 metric tons) of PCB waste. The site operates a permitted TSCA incinerator to treat hazardous and LLMW liquids contaminated with PCBs. The incinerator also processes PCB waste from other facilities at the Oak Ridge Reservation and from off-site DOE installations. Total capacity of the TSCA incinerator is 1,800 yd^3/yr (1,400 m^3/yr). The K-25 waste input of 1,300 yd^3/yr (1,000 m^3/yr) (DOE 1996g) represents 70% of incinerator capacity. In 1991, the hazardous waste generation for the Oak Ridge Reservation was 154 yd^3 (118 m^3). On-site storage capacity for hazardous waste is 16,100 yd^3 (12,300 m^3).

3.3.9.4 Low-Level Waste

The K-25 site generated approximately 1,400 yd^3 (1,100 m^3) of solid LLW in 1992. The Oak Ridge Reservation has a compaction/shredding facility with the capacity to treat approximately 1,800 yd^3/yr (1,400 m^3/yr) of LLW. The Oak Ridge Reservation disposed of approximately 1,100 yd^3 (840 m^3) of LLW in 1994. Low-level waste that is not treated or disposed of on-site at the Oak Ridge Reservation is placed in storage, pending either treatment or disposal, or both, at off-site facilities. In 1993, approximately 57,900 yd^3 (44,300 m^3) of LLW was in storage at the K-25 site (DOE 1996g).

3.3.9.5 Low-Level Mixed Waste

The majority of radioactive waste generated at the K-25 site is LLMW. The site LLMW consists of two major categories: (1) aqueous RCRA-hazardous radioactive waste contaminated with corrosives or metals and (2) organic liquids contaminated with PCBs. About 4,000 yd^3 (3,000 m^3) of contaminated soil (LLMW) is stored at the Oak Ridge Reservation.

In 1992, the K-25 site generated 100,000 yd^3 (76,000 m^3) of liquid LLMW. Aqueous LLMW is treated at the K-1407H central neutralization facility, which processes aqueous waste by pH adjustment of corrosives and chemical precipitation of metals. Treated wastewaters are discharged to the NPDES-permitted discharges, which have a capacity of 450,000 yd^3/yr (340,000 m^3/yr). The K-25 TSCA incinerator, with a capacity of 1,800 yd^3/yr (1,400 m^3/yr), is used to treat organic LLMW liquids contaminated with PCBs. Total K-25 input to the TSCA incinerator

(both PCB-contaminated radioactive and nonradioactive waste) is approximately 1,300 yd^3/yr (1,000 m^3/yr).

The K-25 site has the capability to treat approximately 6,500 yd^3/yr (5,000 m^3/yr) of liquid LLMW via grout stabilization. The site currently stores 38,000 yd^3 (29,000 m^3) of grouted LLMW (DOE 1996g), with a capacity for 88,600 yd^3 (67,800 m^3) of LLMW container storage. The current inventory of LLMW stored at the Oak Ridge Reservation (and the K-25 site) is proposed to be treated in Oak Ridge Reservation facilities. The planned waste treatment will require more than 20 years to complete (LMES 1995b).

3.3.10 Cultural Resources

An archaeological survey was completed at the K-25 site during 1994. This survey confirmed findings of previous surveys of the Oak Ridge Reservation, which had identified 45 prehistoric sites, 10 of which are potentially eligible for the *National Register of Historic Places*. Twelve of the sites are located near the K-25 site (Fielder 1974). More than 240 historic resources have also been recorded at the Oak Ridge Reservation; six are listed on the *National Register*, and 20 or more may be eligible.

The K-25 site was associated with the Manhattan Project and played a significant role in the production of highly enriched uranium for weapons manufacture between 1944 and 1964. Buildings at the K-25 site were evaluated in 1994. One historic district, the Main Plant Historic District, is eligible for the *National Register*. The district consists of 157 buildings, of which 120 buildings contribute to the district and 37 do not. Eleven additional buildings not adjacent to the district are also considered eligible based on their supporting roles in the uranium-235 enrichment process. The George Jones Memorial Baptist Church and Cemetery (established 1901) is also located on the K-25 site and is included in the *National Register*.

On May 6, 1994, a programmatic agreement concerning management of historic properties on the Oak Ridge Reservation was signed by the DOE Oak Ridge Operations Office, the Advisory Council on Historic Preservation, and the Tennessee State Historic Preservation Officer. This agreement concerned management of significant cultural resources that meet eligibility criteria for listing in the *National Register*. DOE committed to developing a draft cultural resources management plan within 2 years of the signing of the agreement. The draft plan was completed in May 1996 and is currently being reviewed. Once final, this plan will supersede the programmatic agreement.

The Overhill Cherokee occupied part of eastern Tennessee from the 1700s until their relocation to Oklahoma in 1838. However, no religious or sacred sites, burial sites, or resources significant to the Overhill Cherokee have been identified at the K-25 site to date.

3.3.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the K-25 site consists of 6.1% minorities and 16.2% persons with low income (see Appendix C, Section C.8.1).

3.4 ENVIRONMENTAL SETTINGS FOR CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL

The locations of potential conversion, long-term storage, disposal, or manufacturing/use facilities will not be evaluated or selected on the basis of the analysis conducted for this PEIS; site selection will be evaluated at a later time during the second tier of NEPA program activities. Because the evaluation of environmental impacts generally depends to a large degree on site characteristics — such as the population distribution around a site, local air quality and weather, local ecology, and proximity of surface water and subsurface water (groundwater) — representative or generic environmental settings were defined for each of the PEIS categories of options. These environmental settings were defined to provide a reasonable, generalized range of environmental conditions for the purposes of impact assessment in this PEIS. Assumptions for the environmental settings are described further in Chapter 4.

3.4.1 Conversion

For the evaluation of conversion options, the potential environmental setting was assumed to be similar to the settings of the three current cylinder storage sites. Environmental data from the three current sites were used to provide a reasonable range of environmental conditions. The impacts of conversion are presented as ranges based on the differences in conditions represented by data used to define the environmental settings.

3.4.2 Long-Term Storage

Similar to the conversion options, the potential environmental settings for storage in yards, buildings, and vaults were selected on the basis of environmental conditions at the three current cylinder storage sites. The impacts of long-term storage are presented as ranges based on the differences in conditions represented by differences in data used to define the environmental settings. For assessment of mine storage, a generic environmental setting for a dry location was assumed (storage in a wet mine environment was not considered reasonable due to potential corrosion of containers). The environmental conditions of a generic dry setting are discussed in Section 3.4.4.1.

3.4.3 Manufacture and Use

The environmental settings for the manufacture and use options were developed for a manufacturing facility located in a generic dry setting and a generic wet setting. The dry setting would be typical of conditions in the arid western United States, and the wet setting would be typical of conditions in the eastern United States. The conditions assumed for the generic wet and dry settings were the same as those used for the assessment of disposal impacts, described in detail in Sections 3.4.4.1 and 3.4.4.2. For both dry and wet settings, manufacturing impacts were calculated for a rural area with a population density corresponding to 15 persons/mi^2 (6 persons/km^2), 120,000 people within a 50-mile (80-km) radius; and an urban area with a population density of 700 persons/mi^2 (275 persons/km^2), 5,500,000 people within a 50-mile (80-km) radius, respectively.

3.4.4 Disposal

The potential environmental settings for the disposal options were based on data representing a dry setting and a wet setting — as described in Sections 3.4.4.1 and 3.4.4.2. Both the dry and wet settings were assumed to be in a rural environment with an average population density of 15 persons/mi^2 (6 persons/km^2).

3.4.4.1 Generic Setting for a Dry Location

For the representative dry setting, a disposal facility was assumed to be located in an arid to semiarid climate. Under these conditions, annual precipitation typically would be about 10 in./yr (25 cm/yr). Approximately 1% of the annual rainfall (Rice et al. 1989), or about 0.1 in./yr (0.25 cm/yr), would be expected to infiltrate the ground, recharging the groundwater. The remainder of the precipitation would be lost to runoff or evapotranspiration (evaporation plus plant transpiration). No ponded waters would be expected to occur nearby, although it was assumed for assessment purposes that a nearby river could be used to supply raw water and to receive liquid waste discharges. The area would be well drained and free of flooding or frequent ponding.

The dry setting was assumed to be in a relatively flat area, overlying approximately 500 ft (150 m) of unconsolidated soil. This soil material was assumed to consist of sandy gravel and gravelly sand interbedded with lenses of clay, silt, and sand that have a variable thickness from about 1 ft (0.3 m) to more than 30 ft (9.1 m). Caliche (layers cemented together by calcium carbonate and other salts), commonly formed on exposed surfaces, would further limit infiltration. The presence of clay layers would impede vertical contaminant transport to the underlying water table. Because of the arid climate, water content of the soil would generally be less than 10% by volume. The unconsolidated material was assumed to have a limited number of small, discontinuous fractures and no significant voids or flow channels.

The groundwater aquifer was assumed to be located at a depth of about 500 ft (150 m) below the surface. This aquifer was assumed to consist of 100 ft (30 m) of semiconsolidated sands, gravels, silts, and clays.

The assessment of air dispersion following potential releases to the atmosphere was based on historical meteorological conditions for five actual "dry" locations in the southwestern United States to provide a range for impact calculations.

3.4.4.2 Generic Setting for a Wet Location

For the generic wet setting, a disposal facility was assumed to be in a modified continental climate. Under these conditions, annual precipitation would be about 40 in./yr (100 cm/yr). About 50% of the rainfall would be expected to be lost to runoff and evapotranspiration, with the remainder, 20 in./yr (51 cm/yr), infiltrating the ground and recharging the underlying groundwater aquifer (Rice et al. 1989). Because of moderate climatic conditions, nearby surface water features would likely be present; however, the setting would be above the elevation of any 100-year floodplain. It was assumed that a nearby river would be available to supply raw water and to receive liquid waste discharges. The area was assumed to be well drained and free of areas of flooding or frequent ponding.

The wet setting was assumed to be in a relatively flat area, overlying approximately 30 ft (9 m) of unconsolidated soil. This material would consist of layers of sand, gravel, and clay. The presence of clay layers would impede vertical contaminant transport to the underlying water table. Because of frequent rainfall events, the water content of the soil would be high. The unconsolidated material was assumed to have a limited number of small, discontinuous fractures and no significant voids or flow channels. Frost penetration of the uppermost layer of soil would be less than 3 ft (0.9 m).

The groundwater aquifer was assumed to be located at a depth of about 30 ft (9 m) below the surface. This aquifer was assumed to consist of 20 ft (6.1 m) of semiconsolidated sands, gravels, silts, and clays.

The assessment of air dispersion following potential releases to the atmosphere was based on historical meteorological conditions for five actual "wet" locations in the central and southeastern United States to provide a range for impact calculations.

3.4.5 Transportation

Transport of depleted UF_6 cylinders, uranium products, and waste materials would be generally over established highways, interstates, and rail lines in accordance with the applicable routing regulations and guidelines of the DOT and the Federal Railway Administration. For PEIS

assessment purposes, representative truck and rail route characteristics were defined on the basis of national averages.

4 ENVIRONMENTAL IMPACT ASSESSMENT APPROACH, ASSUMPTIONS, AND METHODOLOGY

This PEIS evaluates potential impacts on human health and the natural environment from implementing proposed alternative strategies for management of depleted UF_6. These impacts might be positive in the sense that they would improve conditions in the human or natural environment or negative in the sense that they would cause a decline in those conditions. This chapter provides an overview of the methods used to estimate the potential impacts associated with the PEIS alternatives and summarizes the major assumptions that formed the basis of the evaluation. Some background information describing human health impacts from exposure to radiation and chemicals is also provided, and the approach used to account for uncertainties in the estimation of potential environmental impacts is discussed. Additional detailed information on the methodology and assumptions for each area of analysis, including discussions of the analytical models used, is provided in Appendix C.

4.1 GENERAL ASSESSMENT APPROACH

Potential environmental impacts were generally assessed by examining all of the activities required to implement each alternative from 1999 through 2039 (i.e., 41 years) — including the construction of any new facilities required, the operation of new or existing facilities, and the transportation of materials between sites. In addition, for the continued storage component of all alternatives and for the disposal alternative, long-term impacts from potential groundwater contamination were estimated. For continued cylinder storage, potential long-term impacts from cylinder breaches occurring at the sites through the analyzed storage periods were estimated by calculating the maximum groundwater contamination levels possible in the future from those breaches. For the disposal alternative, impacts were estimated for a period up to 1,000 years after the assumed failure of the facility. The impacts of an alternative might occur at one or several sites, as well as along the transportation routes between the sites. For each alternative, potential impacts to workers, members of the general public, and the environment were estimated for both normal operations and for potential accidents.

The PEIS analysis considered all potential areas of impact but emphasized those areas that might have a significant impact on human health or the environment, would differentiate among alternatives, were appropriate for the Phase I programmatic level of analysis, or were of special interest to the public (such as potential radiation effects). For activities that would occur at known locations, the potential impacts were evaluated for the actual sites; for activities at locations that will be determined in the future in Phase II of the Depleted Uranium Hexafluoride Management Program, potential impacts were evaluated for representative or generic settings. Thus, continued storage of cylinders and preparation of cylinders for shipment, if required, would take place at the three current storage sites for all alternatives. However, the locations of potential long-term storage, conversion, manufacture and use, and disposal sites are not yet known, so the analysis considered representative or generic environmental settings for assessment purposes. The environmental characteristics of the

three current storage sites are described in Sections 3.1 through 3.3; representative and generic environmental settings are summarized in Section 3.4.

The estimation of potential environmental impacts was based primarily on information provided in the engineering analysis report (LLNL 1997a), which contains preliminary facility design data for cylinder preparation, conversion, long-term storage (except for long-term storage of cylinders in yards), manufacture and use, and disposal options. For these options, the engineering analysis report includes descriptions of facility layouts, resource requirements, and construction requirements; estimates of effluents, wastes, and emissions during operations; and descriptions and estimated frequencies for a range of potential accident scenarios. (The summary of the engineering analysis report is provided in Appendix O.) Calculation of potential environmental impacts from continued cylinder storage at the current sites and from long-term storage of UF_6 cylinders in yards was based on current management practices (Parks 1997), using assumptions consistent with the engineering analysis report (LLNL 1997a). These facility design data, as well as environmental setting information, were used as input to the calculational models or "tools" for estimating potential environmental impacts that could result under each alternative. The methods for estimating impacts and determining their importance are described for each assessment area in Section 4.3.

The facility descriptions and preliminary designs presented in the engineering analysis report (LLNL 1997a) were based on processing the DOE-generated depleted UF_6 cylinder inventory of 46,422 cylinders over a 20-year period. After the publication of the engineering analysis report and the draft PEIS, responsibility for approximately 11,400 additional depleted UF_6 cylinders (approximately 137,000 metric tons) was transferred from USEC to DOE by the signing of two memoranda of agreement (see Section 1.5.2). Consequently, the analysis in the PEIS was expanded to consider management of up to 15,000 USEC-generated cylinders (approximately 180,000 metric tons). To account for this increase in inventory, the PEIS assessment in Chapter 6 assumes that the facility operational periods would be extended from 20 years to approximately 26 years to process the additional USEC cylinders.

4.2 MAJOR ASSESSMENT ASSUMPTIONS AND PARAMETERS

4.2.1 General Assumptions and Parameters

Several general assumptions and parameters formed the basis of the evaluation of alternatives in this PEIS, as follows:

- ***Cylinder Inventory:*** This PEIS considers the depleted UF_6 inventory stored at the Paducah site, the Portsmouth site, and the K-25 site on the Oak Ridge Reservation for which DOE has management responsibility. This inventory includes depleted UF_6 generated by DOE prior to the formation of USEC in July 1993 and depleted UF_6 generated by USEC that has been or will be

transferred to DOE. Specifically, the PEIS analyzes alternatives for the management of 46,422 cylinders generated by DOE and up to 15,000 cylinders generated by USEC. The depleted UF_6 inventory generated by DOE before July 1993 consists of 46,422 cylinders that contain approximately 560,000 metric tons of UF_6; of these, 28,351 are located at Paducah (342,000 metric tons); 13,388 are at Portsmouth (161,000 metric tons); and 4,683 are at K-25 (56,000 metric tons). The PEIS also considers management of up to 15,000 USEC-generated cylinders (approximately 180,000 metric tons). For the purposes of analysis, it was assumed that 12,000 of the USEC-generated cylinders would be managed at Paducah, and 3,000 would be managed at Portsmouth.

DOE is also responsible for managing a total of approximately 200 cylinders at the three sites that contain small amounts of material. (Termed "heels" cylinders, they contain a total of about 2,300 lb of depleted UF_6, less than 0.0002% of the inventory.) A cylinder heel is defined as the residual amount of nonvolatile material remaining in a cylinder after removal of the depleted UF_6. For this PEIS, it has been assumed that the heels cylinders will continue to be safely stored under the cylinder management program. If a management strategy that involves conversion is selected, these existing heels cylinders will be treated in the same way as the heels cylinders that would be generated from the conversion process. Details on the treatment of heels cylinders are given in Appendix F, Section F.2. Any impacts associated with the management of the heels would be very small because of the very small numbers of cylinders and amount of depleted UF_6 handled. The impacts in all technical areas from a cylinder treatment facility that would process all the UF_6 cylinders would generally be low (see Appendix F, Sections F.3.1-F.3.9); therefore, the impacts from the small number of additional heels cylinders would be negligible.

- ***Assessment Period:*** Potential impacts from depleted UF_6 management activities were considered for the period from 1999 through 2039: generally 10 years for siting, design, and construction of required facilities; 20 to 26 years for operations; and, when appropriate, about 4 to 10 years for monitoring.[1] Activities beyond 2039 would be subject to appropriate NEPA reviews and decisions in the future. In addition, for the disposal alternative, impacts were estimated for a period of up to 1,000 years beyond the assumed failure of the facility.

[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

- ***Timing — No Action Alternative:*** Under the no action alternative, the depleted UF_6 cylinder inventory was assumed to be stored indefinitely at the three current storage sites.

- ***Timing — Alternatives Other Than No Action:*** For the alternatives other than no action, the analysis assumed that operation of any required conversion, disposal, manufacturing, or long-term storage facilities would begin by the year 2009. The time between signing of the Record of Decision and facility start-up was assumed to be needed for activities such as technology selection, facility design, site selection and preparation, facility construction, procurement, and appropriate NEPA reviews. Operation of the facilities to process the entire inventory was assumed to continue for up to 26 years (as noted in footnote 1, the timeframe estimates were meant solely to provide a consistent analytical basis and do not represent a definitive schedule). Processing was assumed to occur at a constant rate over the 26 years, at a throughput rate of about 28,000 metric tons per year (as depleted UF_6). Following processing, either monitoring and maintenance of long-term storage or disposal facilities or use as casks would take place through 2039.

4.2.2 Cylinder Assumptions and Parameters

Analysis of the continued management of cylinders at the three current storage sites and the future condition of cylinders was based on the following assumptions and parameters:

- ***Cylinder Monitoring and Maintenance Activities:*** While in storage at the three current storage sites, cylinders were assumed to be inspected and maintained in safe storage consistent with current management practices and plans (LMES 1997i; Parks 1997). These activities include routine cylinder inspections, cylinder painting to control corrosion, and cylinder yard upgrades to improve storage conditions. Maintenance also includes cylinder valve replacement and cylinder repair and replacement, as necessary. These activities are described in detail in Appendix D.

- ***Cylinder Corrosion/Breach Estimates:*** Cylinder maintenance and painting will be employed at the three sites to control cylinder corrosion. Based on information provided in the document "Technical Basis for Cylinder Painting Schedule" (Pawel 1997), the analysis in the PEIS assumed that cylinder maintenance and painting activities would halt further corrosion of the cylinders. However, because of uncertainties associated with the effectiveness of cylinder painting in stopping corrosion and uncertainties in the painting schedule, an analysis was also conducted assuming that the cylinders would continue to corrode at rates estimated from historical data prior to initiation

of storage condition improvements and cylinder painting. A detailed description of the assumptions used to estimate the incidence of cylinder breaches is provided in Appendix B; the impacts of continued cylinder storage are described in Appendix D for each of the three current storage sites.

- ***Preparation of Cylinders for Shipment:*** A portion of the cylinder inventory might not be suitable for off-site transportation without some type of preparation (see Appendix E). It is currently uncertain how many cylinders might not meet transportation requirements in the future. Thus, impacts were evaluated for the preparation of a range of cylinders (about 30 to 100% of the DOE-generated inventory) at each site, as follows: 9,600 to 28,351 cylinders at Paducah, 2,600 to 13,388 cylinders at Portsmouth, and 2,342 to 4,683 cylinders at K-25.

4.2.3 Environmental Setting Assumptions and Parameters

The assessment of environmental impacts considered three types of environmental settings for evaluating different management activities. These settings are summarized in Table 4.1 and as follows:

- ***Existing Settings (Current Storage Sites):*** Activities necessary to maintain the continued safe storage of cylinders at the current storage sites and activities necessary to remove the cylinders from these sites were assessed using data specific to those sites.

- ***Representative Environmental Settings:*** The environmental impacts of potential conversion and long-term storage facilities (yards, buildings, and vaults) were evaluated using a range of representative site conditions. For purposes of analysis, the range of environmental conditions present at the current storage sites was used as the representative range for the potential conversion or long-term storage facilities. Because of the large quantities of material to be shipped and consequent costs, these facilities might be located at relatively short distances from the current storage sites. However, sites outside of the region of the current storage sites, including any private facilities that now exist or might be built in the future, would be included among the reasonable range of alternatives that would be evaluated in the site-selection process. The current storage sites have a well documented and comparable set of environmental data on both the natural environment and on operations of facilities handling depleted UF_6. Use of such data allows for a comprehensive assessment of impacts associated with potential conversion and long-term storage facilities.

- ***Generic Environmental Settings***: The environmental impacts of potential facilities for manufacturing, long-term storage in a mine, and disposal were assessed using generic environmental settings. These settings were selected from locations in either a dry environment (representative of the western United States) or a wet environment (representative of the eastern United States) (Table 4.1).

4.3 IMPACT ASSESSMENT METHODOLOGIES

In general, the activities assessed in this PEIS could affect workers, members of the general public, and the environment during construction of new facilities, during routine operations of existing or new facilities, during transportation, and during facility or transportation accidents. Activities could have adverse effects (e.g., human health impairment) or positive effects (e.g., regional socioeconomic benefits, such as the creation of jobs). Some impacts would result primarily from the unique characteristics of uranium and other chemical compounds handled or generated under the alternatives. Other impacts would occur regardless of the types of materials involved, such as impacts on air or water quality from construction activities or vehicle-related impacts resulting from transportation.

The areas of potential environmental impacts evaluated in the PEIS are shown in Figure 4.1 (the order of presentation does not imply relative importance). For each area, different analytical methods were used to estimate the potential impacts from construction, operations, and accidents for each of the PEIS alternatives. The assessment methodologies are summarized in Sections 4.3.1 through 4.3.13; additional detailed information, such as descriptions of computer models used, are presented in Appendix C.

Throughout the PEIS, the results of the impact analyses are summarized for each area of impact using the criteria defined in Table 4.2. The criteria are defined differently for each area because of differences in the nature of the impacts. For example, impacts to human health are summarized quantitatively in the PEIS by presenting the estimated number of health effects among workers and members of the general public. Impacts to water and air quality are summarized by indicating whether or not the estimated pollutant concentrations would be above or below applicable guidelines or standards. Other areas of impact, primarily those for which guidelines or standards are not specifically defined, are summarized qualitatively in the PEIS using the terms negligible to low, moderate, and large (as defined in Table 4.2).

4.3.1 Human Health — Normal Facility Operations

Human health impacts were estimated for three types of potential exposures: exposure to radiation, exposure to chemicals, and exposure to physical hazards (e.g., on-the-job injuries or fatalities from falls, lifting, or equipment malfunctions). These potential human exposures could occur in and around facilities or during transportation of materials among the facilities. Exposures

TABLE 4.1 Summary of Environmental Setting Assumptions

Management Activity	Environmental Setting[a]	Assumptions and Approach
Continued cylinder storage	Site-specific	Impacts were calculated specifically for the Paducah, Portsmouth, and K-25 (Oak Ridge Reservation) sites.
Cylinder preparation	Site-specific	Impacts were calculated specifically for the Paducah, Portsmouth, and K-25 sites.
Conversion	Representative	The environmental settings of the three current storage sites were used to create a representative range of environmental conditions.
Long-term storage	Representative	*Yards, Buildings, Vaults* — The environmental setting and analysis of impacts are similar to those for the conversion category of options.
	Generic	*Mine* — A new mine, located in a generic "dry" environment, was assumed. The mine would be located 400 ft below the ground surface (100 ft above the water table) in an area having 10 in. precipitation per year.
Manufacture and use	Generic	A range of meteorological conditions, based on five eastern and five western U.S. locations, was used to determine air dispersion. Impacts were calculated for both generic rural (6 persons/km^2) and urban (275 persons/km^2) locations.
Disposal	Generic	Two generic settings with low population densities (6 persons/km^2) were considered: *Wet setting* — Disposal facility located 30 ft above the water table in an area having 40 in. precipitation per year; five example eastern locations were used to determine a range of meteorological conditions for air dispersion. *Dry setting* — Disposal facility located either 500 ft (shallow earthen structure and vault) or 100 ft (mine) above the water table in an area having 10 in. precipitation per year; five example western locations were used to determine a range of meteorological conditions for air dispersion.

[a] Because actual sites for the conversion, long-term storage, manufacture and use, and disposal alternatives will be identified in Phase II studies and NEPA reviews, representative or generic environmental settings were used to analyze potential impacts.

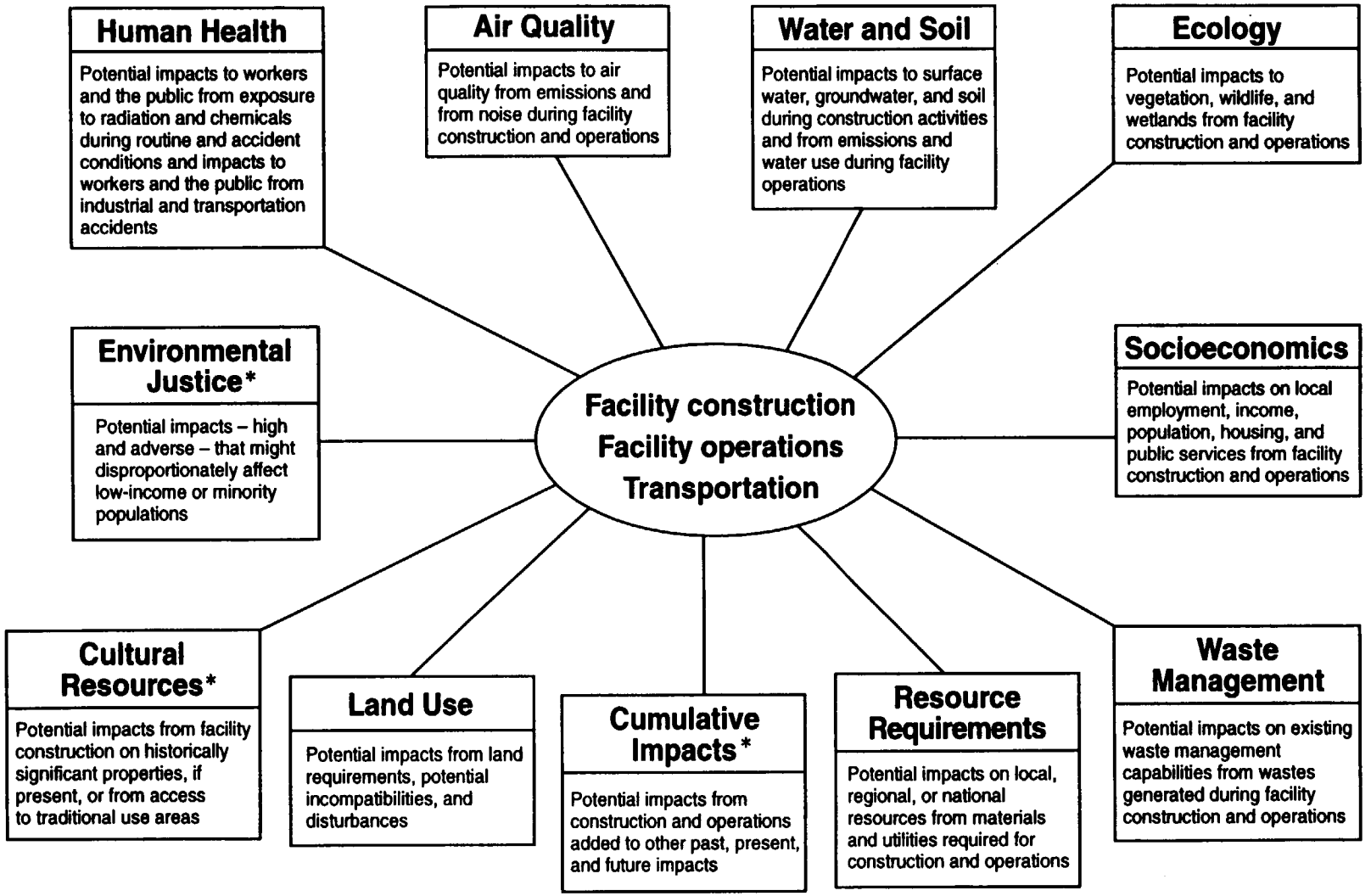

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FIGURE 4.1 Areas of Potential Impact Evaluated in the PEIS for Each Alternative

TABLE 4.2 General Criteria Used to Summarize and Describe the Magnitude of Environmental Impacts in the PEIS

	General Criteria Used to Define Descriptor Term		
Area of Impact	Negligible to Low	Moderate	Large
Human health and safety (construction, operations, transportation)	Human health and safety impacts are provided in terms of the number or degree of health effects (impacts are not described in terms of negligible to low, moderate, or large).		
Air quality	Air quality impacts are compared with applicable air standards or guidelines (impacts are not described in terms of negligible to low, moderate, or large).		
Surface water			
Runoff	No observable increase in runoff.	Increased runoff, but manageable through existing drainage patterns.	Existing drainage patterns possibly inadequate to handle increased runoff.
Floodplains	No observable change in existing floodplains.	Change in existing floodplain area of between 1% and 10%.	Change in existing floodplain area of more than 10%.
Water quality	Water quality impacts are compared with applicable water quality standards or guidelines (impacts are not described in terms of negligible to low, moderate, or large).		
Groundwater			
Recharge	No observable change in recharge.	Observable change in volumetric flow of water reaching the groundwater aquifer, but less than a 50% change in the existing rate.	Change in volumetric flow of water reaching the groundwater aquifer of more than 50%.
Depth to groundwater	No observable change.	Change of less than 10% from the current value.	Change of more than 10% from the current value.
Water quality	Water quality impacts are compared with water quality standards or guidelines (impacts are not described in terms of negligible to low, moderate, or large).		

TABLE 4.2 (Cont.)

Area of Impact	General Criteria Used to Define Descriptor Term		
	Negligible to Low	Moderate	Large
Soil			
Topography	No observable change in elevations.	Changes in elevation of less than 5 ft over the area impacted.	Changes in elevation of more than 5 ft over the area impacted.
Permeability	No observable change in infiltration.	Changes of less than 50% in infiltration.	Changes of more than 50% in infiltration.
Erosion potential	No observable change in soil loss.	Changes in soil loss of less than 50% of existing rate.	Changes in soil loss of more than 50% of the existing rate.
Soil quality	Soil quality impacts are compared with EPA guidelines (impacts are not described in terms of negligible to low, moderate, or large).		
Socioeconomics			
Economic activity	Less than 0.1 percentage point increase in annual employment growth rate in the region of influence.	Between 0.1 and 1.0 percentage point increase in annual employment growth rate in the region of influence.	More than 1.0 percentage point increase in annual employment growth rate in the region of influence.
Population	Less than 0.1 percentage point increase in annual population growth rate in the region of influence.	Between 0.1 and 1.0 percentage point increase in annual population growth rate in the region of influence.	More than 1.0 percentage point increase in annual population growth rate in the region of influence.
Housing	Less than 20% of vacant housing units required in the region of influence.	Between 20% and 50% of vacant housing units required in the region of influence.	More than 50% of vacant housing units required in the region of influence.
Public finance	Less than 1% increase in local jurisdictional revenues and expenditures.	Between 1% and 5% increase in local jurisdictional revenues and expenditures.	More than 5% increase in local jurisdictional revenues and expenditures.
Ecology	No mortality of individual organisms; no measurable effects on population or community parameters; general guideline of less than 10 acres of habitat loss.	Mortality of a small number of individual organisms; short-term effects on population or community parameters; general guideline of between 10 and 100 acres of habitat loss.	Mortality of a large number of individual organisms; long-term effects on population or community parameters; general guideline of more than 100 acres of habitat loss.

TABLE 4.2 (Cont.)

Area of Impact	General Criteria Used to Define Descriptor Term		
	Negligible to Low	Moderate	Large
Waste management	Little or no change in waste facility operations or capacity requirements (i.e., less than 10% increased waste loading or treatment/disposal capacity requirements).	Likely increase in capacity needed at existing facilities (i.e., increase of 10% to 100% in waste loading or treatment/ disposal capacity requirements).	Change in waste facility(s) operations and need for increased capacity (i.e., increase of more than 100% in waste loading or treatment/disposal capacity requirements.)
Resource requirements	Required quantities of commonly used materials for construction and operation of facilities less than 5% of existing local capacity. No use of uncommon materials such as Monel and Inconel.	Required quantities of commonly used materials for construction and operation of facilities more than 5% of existing local capacity. Use of small amounts of uncommon materials such as Monel and Inconel.	Required quantities of commonly used materials for construction and operation of facilities more than 90% of existing local capacity. Use of large amounts of uncommon materials such as Monel and Inconel.
Land use	No effect on land-use patterns and traffic flow; general guideline of land-use requirement of less than 50 acres.	Land-use patterns affected, land conversion likely; traffic congestion at intersections during peak hours, with change in level-of-service rating; general guideline of land-use requirement of between 50 and 200 acres.	Land-use patterns affected, land conversion in conflict with existing land-use plans and controls; traffic flow restricted, congestion at intersections, with a high level-of-service rating; general guideline of land-use requirement of greater than 200 acres.
Cultural resources	Cultural resource criteria are not defined because potential impacts could not be ranked (either they would occur or would not occur) and were considered only in a site-specific context.		
Environmental justice	Environmental justice criteria are not defined because potential impacts could not be ranked (either they would occur or would not occur) and were considered only in a site-specific context.		

could take place during incident-free (normal) operations or following potential accidents in the facilities or during transportation. Assessment methodologies for estimating the impacts resulting from normal facility operations are discussed in Sections 4.3.1.1 and 4.3.1.2. Methods for assessing facility accident impacts are described in Section 4.3.2, and transportation impacts are discussed in Section 4.3.3.

The nature of the potential impacts resulting from the three types of exposure would differ. Table 4.3 lists and compares the key features of these types of exposures. Because of the differences in these features, it is not always appropriate to combine impacts from different exposures to get a total impact for a given human receptor.

4.3.1.1 Radiological Impacts

4.3.1.1.1 Radiation

All of the PEIS alternatives would involve handling compounds of the element uranium, which is radioactive. Radiation, which occurs naturally, is released when one form of an element (an isotope) changes into some other atomic form. This process, called radioactive decay, occurs because unstable isotopes tend to transform into a more stable state. The radiation emitted may be in the form of particles such as neutrons, alpha particles, and beta particles; or waves of pure energy such as gamma rays.

The radiation released by radioactive materials (i.e., alpha, beta, and gamma radiation) can impart sufficient localized energy to living cells to cause cell damage. This damage may be repaired by the cell, the cell may die, or the cell may reproduce other altered cells, sometimes leading to the induction of cancer. An individual may be exposed to radiation from outside the body (called external exposure) or, if the radioactive material has entered the body through inhalation (breathing) or ingestion (swallowing), from inside the body (called internal exposure).

Everyone is exposed to radiation on a daily basis, primarily from naturally occurring cosmic rays, radioactive elements in the soil, and radioactive elements incorporated in the body. Man-made sources of radiation, such as medical X-rays or fallout from historical nuclear weapons testing, also contribute, but to a lesser extent. About 80% of background radiation originates from naturally occurring sources, with the remaining 20% resulting from man-made sources.

The amount of exposure to radiation is commonly referred to as "dose." The estimation of radiation dose takes into account many factors, including the type of radiation exposure (neutron, alpha, gamma, or beta), the different effects each type of radiation has on living tissues, the type of exposure (i.e., internal or external), and, for internal exposure, the fact that radioactive material may be retained in the body for long periods of time. The common unit for radiation dose that accounts for these factors is the rem (1 rem equals 1,000 mrem).

TABLE 4.3 Key Features of Potential Human Exposures to Radiological, Chemical, and Physical Hazards

	Potential exposures		
Feature	Radiological	Chemical	Physical Hazard
Materials of concern in the PEIS	Uranium and its compounds	Uranium and its compounds, HF, and ammonia.	Physical hazards associated with all facilities and transportation conditions.
Health effects	Radiation-induced cancer incidence and fatality would occur a considerable time after exposure (typically 10 to 50 years). The risks were assessed in terms of latent cancer fatalities (LCFs).	Adverse health effects (e.g., kidney damage and respiratory irritation or injury) could be immediate or could develop over time (typically less than 1 year).	Impacts would result from occurrences in the workplace or during transportation that were unrelated to the radiological and/or chemical nature of the materials being handled. Potential impacts would include bodily injury or death due to falls, lifting heavy objects, electrical fires, and traffic accidents.
Receptor	Generally the whole body of the receptor would be affected by external radiation, with internal organs affected by ingested or inhaled radioactive materials. Internal and external doses were combined to estimate the effective dose equivalent (see Appendix C).	Generally certain internal organs (e.g., kidneys and lungs) of the receptor would be affected.	Generally the whole body of the receptor could be affected.
Threshold	No radiological threshold exists before the onset of impacts, i.e., any radiation exposure could result in LCFs. To show the significance of radiation exposures, estimated radiation doses were compared with existing regulatory limits.	A chemical threshold exposure level exists (different for each chemical) below which exposures are considered safe (see Section 4.3.1.2). Where exposures were calculated at below threshold levels, "no impacts" were reported.	No threshold exists for physical hazards. Impact estimates were based on the statistical occurrence of impacts in similar industries and on the amount of labor required.

In the United States, the average dose from background radiation is about 360 mrem/yr per person, of which about 300 mrem is from natural sources. For perspective, the radiation doses resulting from a number of common activities are provided in Table 4.4. The total dose to an individual member of the general public from DOE and other federal activities is limited by law to 100 mrem/yr (in addition to background radiation), and the dose to a member of the public from airborne emissions released from DOE facilities must be below 10 mrem/yr (40 CFR Part 61).

4.3.1.1.2 Radiation Doses and Health Effects

Radiation exposure can cause a variety of adverse health effects in humans. Very large doses of radiation (about 450,000 mrem) delivered rapidly can cause death within days to weeks from tissue and organ damage. The potential adverse effect associated with the low doses typical of most environmental and occupational exposures is the inducement of cancers that may be fatal. This latter effect is called "latent" cancer fatality (LCF) because the cancer may take years to develop and cause death. In general, cancer caused by radiation is indistinguishable from cancer caused by other sources.

Key Concepts in Estimating Risks from Radiation

The health effect of concern from exposure to radiation at levels typical of environmental and occupational exposures is the inducement of cancer. Radiation-induced cancers may take years to develop following exposure and are generally indistinguishable from cancers caused by other sources. Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in detrimental health effects (cancer) and that the number of effects produced are in direct proportion to the radiation dose. Therefore, doubling the radiation dose is assumed to result in doubling the number of induced cancers. This approach is called the "linear-no-threshold hypothesis" and is generally considered to result in conservative estimates (i.e., overestimates) of the health effects from low doses of radiation.

For this PEIS, radiation effects were estimated by first calculating the radiation dose to workers and members of the general public from the anticipated activities required under each alternative. Doses were estimated for internal and external exposures that might occur during normal (or routine) operations and following hypothetical accidents. The analysis considered three groups of people: (1) involved workers, (2) noninvolved workers, and (3) members of the general public, defined as follows:

- ***Involved Workers*** — Persons working at a site who are directly involved with the handling of radioactive or hazardous materials:
  - Might be exposed to direct gamma radiation emitted from radioactive materials, such as depleted UF_6 or other uranium compounds.

TABLE 4.4 Comparison of Radiation Doses from Various Sources

Radiation Source	Dose to an Individual
Annual background radiation — U.S. average	
Total	360 mrem/yr
From natural sources (cosmic, terrestrial, radon)	300 mrem/yr
From man-made sources (medical, consumer products, fallout)	60 mrem/yr
Daily background radiation — U.S. average	1 mrem/d
Increase in cosmic radiation dose due to moving to a higher altitude, such as from Miami, Florida, to Denver, Colorado	25 mrem/yr
Chest X-ray	10 mrem
U.S. transcontinental flight (5 hours)	2.5 mrem
Dose from naturally occurring radioactive material in agricultural fertilizer — U.S. average	1 to 2 mrem/yr
Dose from standing 6 ft (2 m) from a full depleted UF_6 cylinder for 5 hours	1 mrem

Sources: NCRP (1987a,c).

- Would receive very small radiation doses from inhaling uranium compared with the direct radiation doses because most processes would be enclosed and ventilation controls would be used to inhibit airborne emissions in facilities.

- Would be protected by a dosimetry program to monitor and control doses below the regulatory limit of 5 rem/yr for workers (10 CFR Part 835).

- ***Noninvolved Workers*** — Persons working at a site but not directly involved with the handling of radioactive or hazardous materials:

  - Might be exposed to direct radiation from radioactive materials (although at a great distance) and to trace amounts of uranium released to the environment through site exhaust stacks.

  - Would receive radiation exposure primarily through inhalation of radioactive material in the air, external radiation from radioactive material deposited on the ground, and incidental ingestion of soil.

- ***Members of the General Public*** — Persons living within 50 miles (80 km) of the site:

  - Might be exposed to trace amounts of uranium released to the environment through exhaust stacks or wastewater discharges.

  - Would receive radiation exposures primarily through inhalation of radioactive material in the air, external radiation from deposited radioactive material on the ground, and ingestion of contaminated water, food, or soil.

For each of these groups, doses were estimated for the group as a whole (population or collective dose). For noninvolved workers and the general public, doses were also estimated for a MEI. The MEI was defined as a hypothetical person who — because of proximity, activities, or living habits — could receive the highest possible dose. The MEI for noninvolved workers and members of the general public usually was assumed to be at the location of the highest on-site or off-site air concentrations of contaminants, respectively — even if no individual actually worked or lived there. Under actual conditions, all radiation exposures and releases of radioactive material to the environment are required to be kept as low as reasonably achievable (ALARA), a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

Following estimation of the radiation dose, the number of potential LCFs was calculated using health risk conversion factors. These factors relate the radiation dose to the potential number of expected LCFs based on comprehensive studies of groups of people historically exposed to large doses of radiation, such as the Japanese atomic bomb survivors. The factors used for the analysis in this PEIS were 0.0004 LCF/person-rem of exposure for workers and 0.0005 LCF/person-rem of exposure for members of the general public (International Commission on Radiological Protection [ICRP] 1991). The latter factor is slightly higher because some individuals in the public, such as infants, are more sensitive to radiation than the average worker. These factors imply that if a population of workers receives a total dose of 2,500 person-rem, on average, 1 additional LCF will occur among the workers. Similarly, if the general public receives a total dose of 2,000 person-rem, on average, 1 additional LCF will occur.

The calculation of human health effects from radiation is relatively straightforward. For example, assume the following situation:

- Each of 100,000 persons receives a radiation dose equal to background, or 360 mrem/yr (0.36 rem/yr), and

- The health risk conversion factor for the public is 0.0005 LCF/person-rem.

In this case, the number of radiation-induced LCFs caused by 1 year of exposure among the population would be 1 yr × 100,000 persons × 0.36 rem/yr × 0.0005 LCF/person-rem, or about 18 cancer cases, which would occur over the lifetimes of the individuals exposed. For perspective,

in the same population of 100,000 persons, a total of about 23,000 (23%) would be expected to die of cancer from all causes over their lifetimes (Centers for Disease Control and Prevention 1996).

Sometimes the estimation of number of LCFs does not yield whole numbers and, especially in environmental applications, yields numbers less than 1. For example, if 100,000 persons were exposed to 1 mrem (0.001 rem) each, the estimated number of LCFs would be 0.05. The estimate of 0.05 LCF should be interpreted statistically — as the average number of deaths if the same radiation exposure were applied to many groups of 100,000 persons. In most groups, no one (zero persons) would incur an LCF from the 1 mrem exposure each person received. In some groups, 1 LCF would occur, and in exceptionally few groups, two or more LCFs would occur. The average number of deaths would be 0.05 (just as the average of 0, 0, 0, and 1 is 0.25). The result, 0.05 LCF, may also be interpreted as a 5% chance (1 in 20) of one radiation-induced LCF in the exposed population. In the PEIS, fractional estimates of LCFs were rounded to the nearest whole number for purposes of comparison. Therefore, if a calculation yielded an estimate of 0.6 LCF, the outcome is presented in the PEIS as 1 LCF, the most likely outcome.

The same concept is assumed to apply to exposure of a single individual, such as the MEI. For example, the chance that an individual exposed to 360 mrem/yr (0.36 rem/yr) over a lifetime of 70 years would die from a radiation-induced cancer is about 0.01 (0.36 rem/yr × 0.0005 LCF/rem × 70 yr = 0.01 LCF). Again, this should be interpreted statistically; the estimated effect of radiation on this individual would be a 1% (1 in 100) increase in the chance of incurring an LCF over the individual's lifetime. The risk to individuals in the PEIS is generally presented as the increased chance that the individual exposed would die from a radiation-induced cancer.

4.3.1.2 Chemical Impacts

4.3.1.2.1 Chemicals of Concern

All alternatives considered in the PEIS would involve the handling of chemicals that could adversely affect human health. The chemicals of greatest concern for this analysis are soluble and insoluble uranium compounds and HF. In addition to being radioactive, uranium compounds can cause chemical toxicity to the kidneys; soluble uranium compounds are more toxic than insoluble compounds because soluble compounds are more readily absorbed into the body. Hydrogen fluoride is a corrosive gas that can cause respiratory irritation in humans, with tissue destruction or death resulting from exposure to large concentrations of HF. The actual amount of this gas that could be fatal to humans is not known precisely because levels are difficult to measure; no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm (AIHA 1988).

Although uranium compounds and HF would be of greatest concern, potential human health impacts from the use of other chemicals were also considered. For example, conversion would

require the use of various chemicals (e.g., nitric acid, ammonia, and trichloroethylene). In general, during routine conditions, potential exposures to these chemicals would be limited to involved workers, who would be protected through industrial hygiene programs. In the engineering analysis report (LLNL 1997a), reported emissions through process stacks of chemicals other than uranium compounds and HF were generally for chemicals with very low toxicity (e.g., calcium, magnesium, phosphates, chloride) or for categories of chemicals with no toxicity criteria available (e.g., copolymers and phosphonates). Therefore, in the PEIS, quantitative risk analysis for exposure to chemicals under routine conditions was limited to uranium compounds and HF. (Limited calculations were also conducted for trichloroethylene emissions from one of the UO_2 conversion options; estimated emission levels were very low and would not result in adverse impacts.) For accident conditions, several chemicals were evaluated (e.g., hydrochloric acid, nitric acid, and sulfuric acid), but quantitative risk analysis was conducted only for uranium compounds, HF, and ammonia because the other compounds would be used in either small quantities or dilute formulations.

Key Concepts in Estimating Risks from Low-Level Chemical Exposures

Reference Dose:

- Intake level of a chemical below which adverse effects are very unlikely (also known as the threshold level).

Hazard Quotient:

- A comparison of the estimated intake level or dose of a chemical with its reference dose.
- Expressed as a ratio of estimated intake level to reference dose.
- For example:
  - The reference dose for ingestion of soluble compounds of uranium is 0.003 mg/kg of body weight per day.
  - If a 150-lb (70-kg) person ingested 0.1 mg of soluble uranium per day, the daily rate would be $0.1 \div 70 \approx 0.001$ mg/kg, which is below the reference dose and thus unlikely to cause adverse health effects. This would yield a hazard quotient of $0.001 \div 0.003 = 0.33$.

Hazard Index:

- Sum of the hazard quotients for all chemicals to which an individual is exposed.
- A value less than 1 indicates that the exposed person is unlikely to develop adverse human health effects.

4.3.1.2.2 Chemical Intakes and Health Effects

For long-term, low-level (chronic) exposures to uranium compounds and HF emitted during routine operations, potential adverse health effects for noninvolved workers and members of the public were calculated by estimating the intake levels associated with anticipated activities required under each alternative. Intake levels were then compared to reference doses below which adverse effects are very unlikely (i.e., a threshold) (see Appendix C for discussion of appropriate chemical-specific reference doses). Because the compounds of concern are not chemical carcinogens, cancer risk calculations were not applicable. Risks from routine operations were quantified as hazard quotients and hazard indices (see text box).

The same three groups of people evaluated for radiation exposures were considered in estimating chemical health impacts from chronic exposures: involved workers, noninvolved workers, and members of the general public. Chemical exposures for involved workers would depend in part on detailed facility designs to be determined during Phase II activities; the workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits. Potential chemical impacts (in terms of hazard indices) were estimated for noninvolved workers and members of the general public. The main source of impacts to noninvolved workers and members of the public would be the emission of trace amounts of uranium compounds or HF from exhaust stacks. Wastewater discharges also would be a potential source of chemical impacts for members of the public.

For routine operations, the potential impacts to the MEI of a group of people was estimated by calculating a hazard index. If no adverse effects would be expected for either the noninvolved worker MEI or member of the public MEI (i.e., the hazard index was less than 1), by definition no adverse effects would be expected in those populations. Therefore, in such cases, the calculation of population risks was not applicable. If the estimated hazard indices for the MEIs were greater than 1, the population risk would be estimated as the number of individuals who might experience adverse health impacts (the number expected to be exposed at levels that would result in a hazard index greater than 1).

4.3.2 Human Health — Facility Accidents

The PEIS analysis considered a range of potential accidents that could occur at the facilities required by each alternative. An accident is defined as a series of unexpected or undesirable events leading to a release of radioactive or hazardous material within a facility or into the natural environment. Because an accident could involve a large and uncontrolled release, such an event potentially could pose considerable health risks to workers and members of the general public. Two important elements must be considered in the assessment of risks from accidents: the consequence of the accident and the expected frequency (or probability) of the accident.

4.3.2.1 Accident Consequences

The term accident consequence refers to the estimated impacts if an accident were to occur — including health effects such as fatalities. For accidents involving releases of radioactive material, the consequences are expressed in the same way as the consequences from routine operations — that is, LCFs are estimated for the MEI and for populations on the basis of estimated doses from all important exposure pathways. As long as the dose to an individual from accidental exposure is less than 20 rem and the dose rate is less than 10 rem/h, the health risk conversion factors are applicable, and the only important health impact is the LCF — that is, at those relatively low doses and dose rates, other possible radiation effects such as fatalities from acute radiation syndrome, reproductive impairment, or cataract formation do not need to be considered.

Assessing the consequences of accidental releases of chemicals differs from the assessment of routine chemical exposures, primarily because the reference doses used to generate hazard indices for long-term, low-level exposures were not intended for use in the evaluation of the short-term (e.g., duration of several hours or less), higher-level exposures often accompanying accidents. Additionally, the analysis of accidental releases often requires evaluation of different chemicals, especially irritant gases, which can cause tissue damage at higher levels associated with accidental releases but are not generally associated with adverse effects from chronic, low-level exposures.

Health Effects from Accidental Chemical Releases

The impacts from accidental chemical releases were estimated by determining the numbers of people downwind who might experience adverse effects and irreversible adverse effects:

Adverse effects – Any adverse health effects from exposure to a chemical release, ranging from mild and transient effects, such as respiratory irritation or skin rash (associated with lower chemical concentrations), to irreversible (permanent) effects including death or impaired organ function (associated with higher chemical concentrations).

Irreversible adverse effects – A subset of adverse effects, irreversible adverse effects are those that generally occur at higher concentrations and are permanent in nature. Irreversible effects may include death, impaired organ function (such as central nervous system or lung damage), and other effects that may impair everyday functions.

To estimate the consequences of chemical accidents, two potential health effects endpoints were evaluated: (1) adverse effects and (2) irreversible adverse effects. Potential adverse effects range from mild and transient effects — such as respiratory irritation, redness of the eyes, and skin rash — to more serious and potentially irreversible effects. Potential irreversible adverse effects are defined as effects that generally occur at higher concentrations and are permanent in nature — including death, impaired organ function (such as damaged central nervous system or lungs), and other effects that may impair everyday functions. For uranium compounds, an intake of 10 mg or more was assumed to cause potential adverse effects (McGuire 1991), and an intake of 30 mg or more was assumed to cause potential irreversible adverse effects. This intake level is based on NRC guidance (NRC 1994a). For HF and ammonia, potential adverse effects levels were assumed to occur at levels that correspond to Emergency Response Planning Guideline (ERPG) No. 1 (ERPG-1) or ERPG-1-equivalent levels, and potential irreversible adverse effects levels were assumed to occur at levels that correspond to ERPG-2 or ERPG-2-equivalent levels. The ERPG values have been generated by teams of toxicologists who review all published (as well as some unpublished) data for a given chemical (AIHA 1996).

In addition, the number of fatalities from accidental chemical exposures was estimated. For exposures to uranium and HF, it was estimated that the number of fatalities occurring would be about 1% of the number of irreversible adverse effects (EPA 1993; Policastro et al. 1997). Similarly, for

exposure to ammonia, the number of fatalities was estimated to be about 2% of the number of irreversible adverse effects (Policastro et al. 1997).

Human responses to chemicals do not occur at precise exposure levels but can extend over a wide range of concentrations. However, in this PEIS, the values used to estimate the number of potential chemical effects should be applicable to most individuals in the general population. In all populations, there are hypersensitive individuals who will show adverse responses at exposure concentrations far below levels at which most individuals would normally respond (AIHA 1996). Similarly, many individuals will show no adverse response at exposure concentrations even somewhat higher than the guideline values. For comparative purposes in this PEIS analysis, use of the guideline values discussed above allowed a uniform comparison of the impacts from potential accidental chemical releases across all alternatives.

For both radiological and chemical accidents, consequences were estimated for noninvolved workers on the site and members of the public in the vicinity of the site. The consequences for these two groups were estimated for collective populations as well as hypothetical MEIs. The noninvolved worker population included all workers on the site who were more than 330 ft (100 m) from the accident location (including those working in the facility where the accident occurred). The general public consisted of the population living within 50 miles (80 km) of the accident location. The MEIs were generally assumed to be at the location that would yield the greatest impact following the accident.

During an accident, involved workers might be subject to severe physical and thermal (fire) forces and could be exposed to releases of chemicals and radiation. The risk to involved workers is very sensitive to the specific circumstances of each accident and would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers are possible from chemical, radiological, and physical forces if an accident did occur.

Accident consequences to noninvolved workers and the public were estimated by using air dispersion models to predict the downwind air concentrations following a release. These models consider a number of factors, including characteristics of the material released, location of the release, meteorological conditions, and whether or not the accident involves a fire. The air concentrations were used to estimate the number of persons potentially experiencing health effects, either LCFs for radiological releases or adverse and irreversible adverse effects for chemical releases (estimated fatalities from HF and ammonia exposures are also provided). The consequences were estimated with the assumption that the wind was blowing in the direction that would yield the

greatest impacts. Additional details concerning the accident assessment methodology are provided in Appendix C (Section C.4 for radiological accidents and Section C.5 for chemical accidents).

Accident Categories and Frequency Ranges

Likely (L): Accidents estimated to occur one or more times in 100 years of facility operations (frequency $\geq 1 \times 10^{-2}$/yr).

Unlikely (U): Accidents estimated to occur between once in 100 years and once in 10,000 years of facility operations (frequency = from 1×10^{-2}/yr to 1×10^{-4}/yr).

Extremely Unlikely (EU): Accidents estimated to occur between once in 10,000 years and once in 1 million years of facility operations (frequency = from 1×10^{-4}/yr to 1×10^{-6}/yr).

Incredible (I): Accidents estimated to occur less than one time in 1 million years of facility operations (frequency $< 1 \times 10^{-6}$/yr).

4.3.2.2 Accident Frequencies

The expected frequency of an accident, or its probability of occurrence, is the chance that the accident might occur while conducting an operation. Probabilities range from 0.0 (no chance of occurring) to 1.0 (certain to occur). If an accident is expected to happen once every 50 years, the frequency of occurrence is 0.02 per year: 1 occurrence every 50 years = 1 ÷ 50 = 0.02 occurrence per year. A frequency estimate can be converted to a probability statement. If the frequency of an accident is 0.02 per year, the probability of the accident occurring sometime during a 10-year program is 0.2 (10 years × 0.02 occurrence per year).

The accidents evaluated in this PEIS were anticipated to occur over a wide range of frequencies, from once every few years to less than once in 1 million years. In general, the more unlikely it would be for an accident to occur (the lower its probability), the greater the expected consequences. For the assessment of management alternatives, accidents were evaluated for each activity required for four frequency categories: likely, unlikely, extremely unlikely, and incredible (see text box). To interpret the importance of a predicted accident, the analysis considered the estimated frequency of occurrence of that accident. Although the predicted consequences of an incredible accident might be high, the lower consequences of a likely accident, that is, one much more likely to occur, might be considered more important.

4.3.2.3 Accident Risk

The term "accident risk" refers to a quantity that considers both the severity of an accident (consequence) and the probability that the accident will occur. Accident risk is calculated by multiplying the consequence of an accident by the accident probability. For example, if a facility accident has an estimated frequency of occurrence of once in 100 years (probability = 0.01 per year) and the estimated consequence, if the accident occurred, was 10 LCFs among the people exposed, then the risk of the accident would be reported as 0.1 LCF per year (0.01 per year × 10 LCFs). If the facility

were operated for a period of 20 years, the accident risk over the operational phase of the facility would be 2 LCFs (20 years × 0.1 LCF per year).

This definition of accident risk was used to compare accidents that have different frequencies and consequences. Certain high-frequency accidents that have relatively low consequences might pose a larger overall risk than low-frequency accidents that have potentially high consequences. When calculating accident risk, the consequences have been expressed in terms of LCFs for radiological releases or adverse health effects, irreversible adverse health effects, and fatalities for chemical releases.

4.3.2.4 Physical Hazard (On-the-Job) Accidents

Physical hazards, unrelated to radiation or chemical exposures, were assessed for each alternative by estimating the number of on-the-job fatalities and injuries that could occur among workers. These impacts were calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). The injury incidence rates were for injuries involving lost workdays (excluding the day of injury). The analysis calculated the predicted number of worker fatalities and injuries as the product of the appropriate annual incidence rate, the number of years estimated for the project, and the number of full-time-equivalent employees required for the project each year. Estimates for construction and operation of the facilities were computed separately because these activities have different incidence statistics. The calculation of fatalities and injuries from industrial accidents was based solely on historical industry-wide statistics and therefore did not consider a threshold (i.e., any activity would result in some estimated risk of fatality and injury). The selected alternative for managing depleted UF_6 would be implemented in accordance with DOE or industry best management practices, thereby reducing fatality and injury incidence rates.

4.3.3 Human Health and Safety — Transportation

Transportation of radioactive materials and chemicals would involve potential impacts to both crew members and members of the general public. In this PEIS, impacts were assessed that could arise from the radioactive or chemical nature of the cargo and also from the nature of transportation itself, independent of the cargo. Transportation risks were evaluated for all of the materials that could potentially be transported for each alternative, including UF_6 cylinders, uranium conversion products, HF and other chemicals, and process waste. Transportation impacts were estimated for shipment by both truck and rail modes for most materials. Because the location for some management activities will be determined in Phase II analyses and NEPA reviews, transportation impacts were estimated for a range of distances using representative route characteristics.

For radioactive materials, the cargo-related impacts on human health during transportation would be caused by exposure to ionizing radiation. Radiological risks (i.e., risks that result from the radioactive nature of the cargo) were assessed for both routine (normal) transportation and for accidents. The radiological risk associated with routine transportation results from the potential exposure of persons to low levels of external radiation in the vicinity of a loaded shipment. The radiological risk from transportation-related accidents is associated with the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of persons through multiple pathways (e.g., inhalation of airborne contaminants or the ingestion of contaminated food).

For chemicals, the cargo-related impacts to human health during transportation would be caused by exposure occurring as a result of container failure and chemical release during an accident. Therefore, chemical risks (i.e., risks that result from the toxicity of the chemical composition of the material transported) were assessed for cargo-related transportation accidents. The chemical risk from transportation-related accidents is associated with the potential release, transport, and dispersion of chemicals into the environment and the subsequent exposure of persons, primarily through inhalation exposure. Unlike the radiological risks, there are no chemical risks during routine transport because the materials are sealed in their shipping packages.

In addition to potential cargo-related impacts, impacts were assessed for vehicle-related hazards that are independent of the radioactive or chemical nature of the cargo and could be incurred for similar shipments of any commodity. Vehicle-related impacts were assessed for both routine conditions and accidents. Impacts during routine transportation could result from exposure to vehicular exhaust emissions. Impacts not related to the shipment contents during transportation accidents could result from physical trauma causing injury or death (i.e., typical traffic accidents).

4.3.4 Air Quality and Noise

The assessment of air quality impacts considered air pollutant emissions from normal facility operations associated with each alternative. Atmospheric dispersion of pollutant emissions from construction activities (e.g., engine exhaust and fugitive dust emissions), operations, and maintenance activities were estimated with conventional modeling techniques, such as those included in the EPA's SCREEN3 and Industrial Source Complex Short Term models (EPA 1995b-c). The estimated concentrations of these pollutants at facility boundaries were compared with existing air quality standards for criteria pollutants or with guidelines for pollutants that do not have corresponding standards.

Although noise impacts from facility construction and operations could occur during the implementation of any alternative, the extent of these impacts cannot be determined until the facility locations are known. Implementation of a management alternative might involve a variety of potentially noise-emitting equipment and operations. Examples include earthmoving and erecting equipment during construction, and process equipment, emergency generators, and both on-site and

off-site traffic during operations. Although some sensitive receptors might be affected by the noise, the specific equipment to be used during the construction and operation of facilities has not been determined, and facility and receptor locations are unknown. These considerations will be addressed in subsequent Phase II analyses and NEPA reviews associated with the construction and operation of facilities.

4.3.5 Water and Soil

Potential impacts on surface water, groundwater, and soil were evaluated for facility construction, normal operations, and potential accidents. Methods of quantitative impact analyses for actual and representative sites are described in the following paragraphs. Because site-specific parameters are needed to quantify impacts, the PEIS provides only a qualitative discussion of impacts for activities assumed to occur in generic environmental settings (i.e., discussion of non-site-specific parameters such as water use, effluent volumes, paved areas, and excavation volumes).

For surface water, impacts were assessed in terms of runoff, floodplain encroachment, and water quality. Changes in runoff were assessed by comparing runoff depths predicted for existing conditions at actual or representative sites with runoff depths predicted for the modified conditions. The main inputs to the model were the paved area that would result from construction of new facilities, the total area available, and the approximate distribution of pavement, forests, and pasturelands at actual or representative sites. Floodplain encroachment was assessed by comparing simulated water depths in nearby rivers for existing conditions with those for modified flows. Inputs to the floodplain assessment model included estimated facility effluent volumes and estimates of flow volumes, channel shapes, cross-sectional areas, and water velocities in actual or representative nearby rivers. Water quality impacts were estimated by using the proposed drinking water standard of 20 µg/L (EPA 1996) as a guideline. Where data were unavailable, assessment models that account for the types of contaminants and dilution estimates for the surface water features were used to estimate surface water conditions.

Potential impacts on groundwater were assessed in terms of changes in recharge to underlying aquifers, depth to groundwater, direction of groundwater flow, and groundwater quality. Changes to recharge of groundwater were evaluated by comparing the increase in impermeable area produced by construction and operations with the recharge area available at actual or representative sites. Impacts on the depth to groundwater were evaluated by performing groundwater simulations for existing and modified conditions at the sites. Changes in the direction of groundwater flow were evaluated by examining the changes in water levels produced by the increased water demand. A model that considers movement, dispersion, adsorption, and decay of the contaminant source material over time was used to estimate migration of contaminants from source areas to the groundwater (i.e., groundwater quality). Details of the model are provided in Tomasko (1997).

Potential impacts to soil were assessed in terms of changes in topography, permeability, quality, and erosion potential. Erosion potential was evaluated by comparing soil removal rates at

actual or representative sites with those for modified conditions using wind and water erosion models. Changes in topography were assessed by evaluation of excavation volumes required for facility construction. Changes in soil quality were evaluated on the basis of the amounts of contaminants deposited as a result of certain activities. No standard is available for limiting soil concentrations of uranium; a health-based guideline value of 230 μg/g (EPA 1995a), applicable for residential settings, was used as a guideline for comparison in the PEIS.

4.3.6 Socioeconomics

Potential impacts on socioeconomic conditions were considered during construction and operations of each facility. The analysis estimated these impacts within the ROIs around existing facilities and at representative or generic sites for facilities not yet sited. The analysis used annual material and labor expenditure data and detailed economic data describing the local industrial base and the proportion of procurement and wage and salary expenditures likely to occur in the local economy. These data were used to determine the direct (on-site) and indirect (off-site) impacts on employment and income. This information was then combined with additional demographic and local jurisdictional data to calculate the impact of each facility on population in-migration, local housing demand, and local public finances. Because the nature of local socioeconomic conditions was not known for the generic sites, the analysis of impacts for these sites was limited to the presentation of direct (on-site) employment and income impact of each facility.

4.3.7 Ecology

Potential impacts on ecological resources were assessed for terrestrial and aquatic biota, including impacts on vegetation and wildlife, wetlands, and federal- and state-listed threatened and endangered species. Where possible, the impact analysis focused on the radiological and chemical toxicity effects to biota resulting from exposure to uranium compounds and HF. Physical disturbances to biota and habitats were also evaluated. The general guidelines used to assess impacts of habitat loss and wildlife disturbance were as follows: (1) negligible to low impacts, corresponding to less than 10 acres of required land; (2) moderate impacts, corresponding to between 10 and 100 acres of required land; and (3) potential large impacts, corresponding to greater than 100 acres of required land. The potential for impacts to wetlands and federal- and state-listed threatened or endangered species is a site-specific consideration, and it would be determined in Phase II analyses and NEPA reviews.

4.3.8 Waste Management

Wastes generated during the management and use of depleted UF_6 have been subdivided into the following categories: radioactive waste (LLW and LLMW), nonradioactive hazardous and toxic waste, and nonhazardous, nonradioactive waste (solid waste and wastewater). Potential impacts

on the various waste management facilities were evaluated by comparing current treatment capacities in existence at these facilities and within the DOE system with the additional waste management demands estimated for the different PEIS alternatives. Where new waste management facilities would be needed, the analysis considered the impacts from construction of such facilities. Also addressed were impacts from storing treated or untreated waste and impacts from packaging or handling the treated waste in preparation for disposal.

In the future, it is possible that waste generated during UF_6 management activities may be considered DOE waste, or it may be considered commercial waste, depending on whether the facilities are owned and/or operated by the federal government or the private sector. For purposes of comparison in the PEIS, estimated waste generation rates for the alternative management strategies have been compared to DOE waste generation rates over the same time periods.

4.3.9 Resource Requirements

The alternative management strategies considered in the PEIS would require the use of resources, including energy and materials, in at least one of the component steps. Evaluation of resource requirements in the PEIS considered construction materials that could not be recovered or recycled, radioactive materials that could not be decontaminated, and materials consumed (e.g., miscellaneous chemicals). Use of energy sources was considered, as well as use of uncommon materials with small reserves. Given the uncertainty associated with some key components of the management alternatives, such as final facility design and siting, this evaluation relied largely on a qualitative assessment to provide a sense of the amount of resources required and how these quantities would compare with the total available resources, either locally or nationally.

4.3.10 Land Use

For activities occurring at the current storage sites, the evaluation of potential land-use impacts associated with alternative management strategies was based on estimates of land area required and potential incompatibility with existing land-use patterns. The land required under alternatives with known site locations was calculated as a percent of existing or available land. The analysis considered the potential for alternative management strategies to result in land conversion, land-use conflicts, and impacts to surrounding lands.

The determination of potential land-use conflicts and traffic flow problems is a site-specific consideration. However, for purposes of analysis in this PEIS, general criteria for estimation of impacts were as follows: land-use requirement of less than 50 acres corresponds to negligible impacts, land-use requirement of between 50 and 200 acres corresponds to potential moderate impacts, and land-use requirement of greater than 200 acres corresponds to potential large impacts. The actual potential for land conversion in conflict with existing land-use plans and controls and/or traffic flow problems will be determined during the Phase II analyses and NEPA reviews.

4.3.11 Cultural Resources

Potential impacts to cultural resources could result from the construction of facilities for all of the alternatives considered in this PEIS. Possible impacts would include the disturbance of properties (e.g., archaeological sites or historic structures) eligible for the *National Register of Historic Places*, visual impacts to the environmental setting of an eligible property, or reduced access to a traditional use area (such as a cemetery or a resource for Native Americans). Differences in the land area required for each option would not affect the impact potential because important cultural resources are not equally distributed. Only limited impact evaluation was possible because specific sites have not been chosen for activities other than continued cylinder storage and cylinder preparation. Site-specific evaluation would be conducted during the Phase II analyses and NEPA reviews.

4.3.12 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," was issued by President Clinton in February 1994 and directs federal agencies to incorporate environmental justice into all agency missions (U.S. President 1994). Under Executive Order 12898, federal agencies are directed to identify and address, as appropriate, high and adverse human health or environmental effects caused by agency programs, policies, or actions that unfairly or "disproportionately" impact minority or low-income populations. Guidance for environmental justice considerations in NEPA has been developed by the Council on Environmental Quality (1997), EPA (1998), and DOE (1995d). A determination of the potential for a given project or action to result in impacts is based on an examination of the composition of the population residing within a defined zone of impact — for this analysis, a 50-mile (80-km) radius around each current storage site.

The environmental justice analysis employed a two-step process. In the first step, geographic areas associated with each affected region that might experience high and adverse impacts were examined; the purpose of this step was to determine if any of these areas would contain disproportionately high percentages of low-income or minority populations compared with the state(s) that contain the affected regions. In the second step, potential impacts were examined to determine if they would be high and adverse with regard to the total population. The analysis emphasized human health impacts — notably those resulting from radioactive and chemical releases — but also considered other technical areas that might affect low-income or minority populations. Environmental justice concerns were identified if an area was disproportionately either minority or low-income and if any impact was high and adverse.

4.3.13 Cumulative Impacts

Cumulative impacts are those that would result from the incremental impacts of an action (in this case, depleted UF_6 management alternatives) when added to other past, present, and reasonably foreseeable future actions. Both Council on Environmental Quality regulations (40 CFR 1508.7) and DOE regulations for implementing NEPA (10 CFR Part 1021) require the assessment of cumulative impacts because significant impacts can result from several actions that considered individually may be quite small.

The cumulative impact analysis was conducted by examining those impacts resulting from depleted UF_6 management activities that would occur at the three current storage sites (Paducah, Portsmouth, and K-25). The impacts from these activities (continued cylinder storage and cylinder preparation) were then added to the impacts of other past, present, and reasonably foreseeable future actions to assess potential cumulative impacts at the three sites.

The cumulative impacts of conversion, long-term storage, and disposal activities could not be determined because specific sites and technologies have not been designated for these options. Further analyses of cumulative impacts would be performed as required by NEPA and DOE regulations for any technology or siting proposals that would involve these facilities.

4.4 UNCERTAINTY IN ESTIMATED IMPACTS

Estimating environmental impacts for alternative approaches to depleted UF_6 management is subject to considerable uncertainty. This uncertainty is a consequence primarily of the preliminary nature of facility designs, the unknown location of future facilities, and the characteristics of the methods used to estimate impacts. To account for this uncertainty, the impact assessment was designed to ensure — through uniform and careful selection of assumptions, models, and input parameters — that impacts would not be underestimated and that relative comparisons among the alternatives would be meaningful. This was accomplished by uniformly applying common assumptions to each alternative and by choosing assumptions intended to produce conservative estimates of impacts — that is, assumptions that would lead to overestimates of the expected impacts. Although there would be some uncertainty in the estimates of the absolute magnitude of impacts, a uniform approach to impact assessment should enhance the ability to make valid comparisons among alternatives.

5 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

Potential impacts to workers, members of the general public, and the environment were estimated for each of the alternative management strategies considered in this PEIS. This chapter presents those impacts associated with the management of the depleted UF_6 cylinder inventory generated by DOE prior to the formation of USEC in July 1993. The potential impacts associated with the management of USEC-generated cylinders that became the responsibility of DOE in May and June of 1998 are presented in Chapter 6. The general assessment methodologies and major assumptions used to estimate the impacts presented in this chapter are described in Chapter 4, with additional detailed methodology information provided in Appendix C.

Each of the PEIS alternatives is composed of combinations of several activities (see Chapter 2 and Figure 2.1). These management activities are addressed in detail in Appendices D through K:

- Appendix D — Environmental Impacts of Continued Cylinder Storage at Current Storage Sites
- Appendix E — Environmental Impacts of Options for Preparing Cylinders for Shipment or Long-Term Storage
- Appendix F — Environmental Impacts of Options for Conversion of UF_6 to Oxide or Metal
- Appendix G — Environmental Impacts of Options for Long-Term Storage as UF_6 and Uranium Oxide
- Appendix H — Environmental Impacts of Options for the Manufacture and Use of Uranium Oxide and Uranium Metal
- Appendix I — Environmental Impacts of Options for Disposal of Oxide
- Appendix J — Environmental Impacts of Transportation of UF_6 Cylinders, Uranium Oxide, Uranium Metal, and Associated Materials
- Appendix K — Parametric Analysis: Environmental Impacts for Processing Less than the Total Depleted UF_6 Inventory

Each appendix provides a discussion of the types of activities that would occur, the representative technologies and facilities considered, and the estimated environmental impacts associated with each option.

The potential environmental impacts assessed for this PEIS were determined by combining the impacts associated with each of the individual activities necessary to implement each alternative (as shown in Figures 2.1 through 2.7). Where appropriate, the impacts are presented as ranges, which account for differences in both the possible options and technologies that could be used and the effects that different environmental settings might have on the estimated environmental impacts. The discussion in this chapter focuses on the most significant issues and potential environmental impacts. Additional discussion of the analyses supporting the impacts reported here is presented in Appendices D through K.

Because sites for new facilities will be selected in Phase II of the Depleted Uranium Hexafluoride Management Program, the potential impacts presented for alternatives other than the no action alternative include a mixture of site-specific impacts and impacts calculated for representative or generic environmental settings. The level of analysis conducted depended on the specific activity considered. Continued cylinder storage and cylinder preparation activities would take place at the three current cylinder storage sites (Paducah, Portsmouth, and K-25). Potential impacts of these activities were thus assessed on a site-specific basis. Potential impacts of conversion and long-term storage (in buildings, vaults, and yards) were assessed for representative settings, and potential impacts of manufacture and use, long-term storage in a mine, and disposal were evaluated for generic settings (see Chapters 3 and 4 for descriptions of the environmental settings). Subsequent analysis with more site-specific environmental considerations will be performed during the Phase II analyses and NEPA reviews, as appropriate.

To provide a conservative analysis of transportation and construction impacts, it was assumed that facilities for conversion, long-term storage, manufacture and use, and disposal would be located at separate sites other than the three current storage sites. This approach was intended to provide a conservative estimate of the total impacts associated with the alternatives because it would require the transportation of materials between sites and the construction of new facilities and supporting infrastructure. The transportation impacts were analyzed using representative route characteristics for a range of possible distances between sites. Colocating facilities is consistent with Public Law 105-204 and DOE's current plan. Colocation could reduce or even eliminate the transportation of uranium and associated materials and possibly reduce the amount of land and construction activities required. The impacts of colocating facilities are discussed in Section 5.8.3.

For all alternatives, potential environmental impacts were evaluated for the period 1999 through 2039. For the continued storage component of all alternatives and for the disposal alternative, potential long-term impacts were also evaluated, primarily with respect to groundwater contamination. Because depleted uranium would require management beyond 2039, a discussion of potential actions and impacts that might occur beyond that date (i.e., life-cycle impacts) is provided in Section 5.9. Detailed analysis was generally not conducted beyond 2039 because actions and

impacts beyond that time are highly uncertain, and thus decisions related to them are not ready to be made at this time.

5.1 NO ACTION ALTERNATIVE

Under the no action alternative, depleted UF_6 cylinder storage would continue at each of the three current storage sites indefinitely. The potential environmental impacts were estimated through the year 2039. In addition, the long-term impacts from potential groundwater contamination were estimated. A detailed discussion of site-specific impacts of continued cylinder storage at each of the three current storage sites is presented in Appendix D. This section provides a summary of those impacts.

The potential environmental impacts of the no action alternative were based on the cylinder management activities that will take place at the sites in the future. Current detailed cylinder management plans extend through the year 2002 (LMES 1997i). The ongoing and planned activities are designed to ensure continued safe storage of cylinders. These activities include cylinder inspections, cylinder yard upgrades, cylinder painting, and cylinder maintenance and repair activities. Beyond 2002, a set of cylinder management assumptions was needed to define the activities that would probably occur at the sites through 2039 so that the potential impacts could be estimated. It was assumed that the types of activities that would occur generally would be similar to those that are now ongoing or planned (Parks 1997). The assumptions were chosen in such a way that the impacts would be overestimated rather than underestimated.

Specifically, the activities assumed to occur at the sites during the no action alternative include a comprehensive cylinder monitoring and maintenance program, with routine cylinder inspections, ultrasonic thickness testing of cylinders, radiological surveys, cylinder painting to prevent corrosion, cylinder yard surveillance and maintenance, construction of four new or improved storage yards at the Paducah site and one at K-25 site between 1999 and 2002, and relocation of some cylinders at all three sites. Cylinders were assumed to be painted every 10 years. These activities are described in greater detail in Appendix D.

An important issue with respect to potential environmental impacts of continued cylinder storage is the expected condition of the cylinders over time. During storage that has been ongoing from the mid-1950s to the present, previous substandard storage conditions have led to corrosion and pitting of many cylinder surfaces, and eight breached cylinders have been identified and repaired. These cylinders had holes in their walls in sizes ranging from very small (1/16 in. [0.16 cm]) to 15 in. (38 cm) in diameter. Corrosion of the cylinders in the past occurred while many of the cylinders were stored in substandard cylinder yard conditions. In addition, cylinders were not routinely painted to control corrosion. An intensive program has been ongoing for several years to improve the storage conditions of the cylinders. Some storage yards have been reconstructed, and new storage yards with concrete bases and controlled runoff have been added. Many cylinders have been relocated to better storage conditions. The improved storage yard conditions are expected to

decrease corrosion rates. In addition, the cylinder painting program is expected to control external corrosion of the cylinders (Pawel 1997).

For assessment of the no action alternative, it was assumed that the cylinder maintenance and painting program would protect the cylinders from further corrosion. The cylinders would continue to corrode at the historical rates until painted. Some future cylinder breaches were assumed to occur from handling damage after the initial painting. Although unlikely, for analysis purposes these breaches were assumed to go undetected for 4 years (the inspection interval for most cylinders) and to release some uranium and HF to the environment. The number of future cylinder breaches through 2039 was estimated to be 36 at the Paducah site, 16 at the Portsmouth site, and 7 at the K-25 site (see Appendix B).

Although it is expected that cylinder maintenance and painting will control cylinder corrosion, there are some uncertainties concerning the future condition of the cylinders. Current estimates suggest a paint effectiveness of at least 10 years (Pawel 1997). However, it is possible that the cylinders would not be painted every 10 years because of budget or other considerations. In addition, it is possible that the paint might not be effective for 10 years. Because of these uncertainties, an assessment was also conducted on the basis of the assumption that external corrosion would not be halted by improved storage conditions, cylinder maintenance, and painting. Assuming that corrosion rates would continue at the historical rate (poor storage conditions and no routine painting), many more breaches would be expected to occur over time at the three storage sites. The total number of breaches through 2039 was estimated to be about 440 at Paducah, 70 at Portsmouth, and 210 at K-25 (see Appendix B). The results of this assessment were used to provide an estimate of the earliest time when continued cylinder storage could begin to raise regulatory concerns if external corrosion of the cylinders was not controlled.

5.1.1 Human Health and Safety

Under the no action alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. In general, the impacts during normal facility operations at all sites would be limited to workers directly involved in handling cylinders. Under accident conditions, the health and safety of both workers and members of the general public around the sites could potentially be affected.

5.1.1.1 Normal Facility Operations

5.1.1.1.1 Workers

Cylinders containing depleted UF_6 emit low levels of gamma radiation. Involved workers would be exposed to this radiation when working near cylinders, such as during routine cylinder

monitoring and maintenance activities, cylinder relocation and painting, and when patching or repairing cylinders. It was estimated that a total of about 60 cylinder yard workers (on average) would be required at the three current storage sites (30 at Paducah, 16 at Portsmouth, and 13 at K-25). These workers would be trained to work in a radiation environment, they would use protective equipment as necessary, and their radiation exposure levels would be measured and monitored by safety personnel at the sites. Radiation exposure of workers is required by law to be maintained ALARA.

The radiation exposure of involved workers (cylinder yard workers) in future years through 2039 was estimated to be well within public health standards (10 CFR Part 835). If the same 60 workers conducted all cylinder management activities, the average annual dose to individual involved workers was estimated to be about 740 mrem/yr at Paducah, 600 mrem/yr at Portsmouth, and 410 mrem/yr at K-25. Worker doses are required by health regulations to be maintained below 5,000 mrem/yr (10 CFR Part 835). The estimated future doses did not account for standard ALARA practices that would be used to keep the actual doses as far below the limit as practicable. Thus, the future doses to workers would be expected to be less than those estimated because of the conservatism in the assumptions and models used to generate the estimates. In fact, from 1990 through 1995, the average measured doses to cylinder yard workers ranged from about 16 to 56 mrem/yr at Paducah, 55 to 196 mrem/yr at Portsmouth, and 32 to 92 mrem/yr at K-25 (Hodges 1996). For comparison, radiation doses from background radiation and some common activities are given in Table 4.4.

The total dose to all involved workers at the three current storage sites from 1999 through 2039 was estimated to be about 1,500 person-rem (the dose to noninvolved workers is negligible [i.e., less than 1%] compared to the dose to involved workers). This dose would be distributed among all of the workers involved with cylinder activities over the 41-year period. About 60 workers would be required each year; however, the number of different individuals involved over the period would probably be much greater than this because workers could be rotated to different jobs and could change jobs. This level of exposure was estimated to potentially result in about 1 LCF among all the workers exposed, in addition to the cancer cases that would result from all other causes.

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations are not expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposures of noninvolved workers from any airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the hazard indices were estimated to be less than 0.002 for noninvolved workers at all three sites).

5.1.1.1.2 General Public

Potential health impacts to members of the general public could occur if material released from breached cylinders entered the environment and was transported from the sites through the air, surface water, or groundwater. Off-site releases of uranium and HF are possible from breached cylinders. However, the predicted off-site concentrations of these contaminants in the future were estimated to be much less than levels expected to cause adverse effects. Potential exposures of members of the general public would be well within public health standards. No adverse effects (LCFs or chemical effects) were estimated to occur among the general public residing within 50 miles (80 km) of each site from depleted UF_6 management activities.

If all the uranium and HF assumed to be released from breached cylinders through 2039 were dispersed from the sites through the air, the total radiation dose to the general public (all persons within 50 miles [80 km]) was estimated to be less than 0.38 person-rem over the period 1999 through 2039 (all three sites combined). This level of exposure would most likely result in zero cancer fatalities among members of the general public. For comparison, the average radiation dose from natural background radiation to a single person in 1 year is about 0.36 person-rem (360 mrem). The maximum radiation dose to an individual near any one of the sites was estimated to be less than about 0.2 mrem/yr, well within health standards. Radiation doses to the general public are required by health regulations to be maintained below 10 mrem/yr from airborne sources (40 CFR Part 61) and below a total of 100 mrem/yr from all sources combined (DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year (1999–2039), the total dose would be about 8 mrem, resulting in an additional chance of dying from a latent cancer of about 1 in 200,000. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the estimated hazard index for a maximally exposed individual was estimated to be less than 0.1 at all three sites. This means that the total exposure would be at least 10 times less than exposure levels that might cause adverse effects.

The material released from breached cylinders could also potentially be transported from the sites in water, either in surface water runoff or by infiltrating the soil and contaminating groundwater. Members of the general public potentially could be exposed if this contaminated surface water or groundwater were used as a source of drinking water. The results of the surface water and groundwater analyses indicate that the maximum estimated uranium concentrations in surface water accessible to the general public and in groundwater beneath the sites would be less than the proposed EPA drinking water standard of 20 µg/L (EPA 1996) used as a guideline at all three sites (see Sections 5.1.4.1 and 5.1.4.2, respectively). Drinking water standards, meant to apply to water "at the tap" of the user, are set at levels protective of human health.

If a member of the public were to use contaminated water at the maximum concentrations estimated, adverse effects would be unlikely. Assuming a member of the general public used contaminated surface water or groundwater as their primary water source, the maximum radiation dose in the future was estimated to be less than 0.5 mrem/yr at each site. The corresponding risk to this individual of dying from a latent cancer would be less than 1 in 1 million per year. Noncancer

health effects from exposure to possible water contamination would not be expected — the estimated hazard index for an individual assumed to use the groundwater was less than 0.2. This means that the total exposure would be 5 times less than the exposure that might cause adverse effects.

If no credit is taken for reduced cylinder corrosion rates from cylinder maintenance and painting activities, the groundwater analysis indicates that the uranium concentration in groundwater at the three sites could exceed 20 μg/L sometime in the future (see Section 5.1.4.2). In such a case, mitigative measures, such as treatment of the water or supplying an alternative source of water, might be required to ensure the safety of those potentially using the water.

5.1.1.2 Facility Accidents

5.1.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 people in the United States were killed in accidents while at work, and approximately 3.5 million work-related injuries were reported (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured under the no action alternative, unrelated to any radiation or chemical exposures.

The numbers of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated. The estimates were based on the number of workers required over this period and on the historical accident fatality and injury rates in similar types of industries (see Appendix D, Section D.2). It was estimated that a total of about 0.1 accidental fatality (about 1 chance in 10 of a single fatality) might occur at the three sites over the 41-year period. Similarly, a total of about 140 accidental injuries (defined as injuries resulting in lost workdays) was estimated at the three sites combined. These rates would not be unique to the activities required for the no action alternative, but would be typical of any industrial project of similar size and scope.

5.1.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the no action alternative, accidents are possible that could release radiation and chemicals from cylinders. A wide range of different types of accidents was evaluated at each of the three current storage sites. The accidents included those initiated by operational events, such as equipment or operator failure; external hazards, such as aircraft crashes; and natural phenomena, such as earthquakes. The assessment considered accidents ranging from those that would be reasonably likely to occur (one or more times in 100 years on average) to those that would be extremely rare (estimated to occur less than once in 1 million years on average).

The accidents of most concern at the sites are accidents that could cause a release of UF_6 from cylinders. In a given accident, the amount potentially released would depend on the severity of the accident and the number of cylinders involved. Following a release, the UF_6 could combine with moisture in the air, forming gaseous HF and uranyl fluoride, a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public living near the sites to radiation and chemical effects. The workers considered in the accident assessment were those noninvolved workers not immediately in the vicinity of the accident; fatalities and injuries among involved workers are possible for severe accidents (see Section 4.3.2.1).

The estimated consequences of cylinder accidents are summarized in Table 5.1 for chemical effects and in Table 5.2 for radiation effects. The impacts are the maximums estimated for any of the three current storage sites (site-specific impacts are presented in Appendix D). The impacts are presented separately for accidents considered likely and for those rare, low-probability accidents that were estimated to result in the largest potential impacts. Although other accidents were evaluated (see Appendix D, Section D.2.2), the estimated consequences of other accidents at all three sites would be less than those summarized in the tables. The estimated consequences are conservative in nature because they were based on the assumption that the wind would be blowing in the direction of the greatest number of people at the time of the accident and that weather conditions would limit dispersion in the air, so that high concentrations would occur. In addition, the effects of protective measures, such as evacuation, were not considered.

Chemical Effects. The potential likely accident (defined as an accident that is estimated to occur one or more times in 100 years) that would cause the largest chemical health effects is the failure of a corroded cylinder spilling part of its contents under dry weather conditions. Such an accident could occur, for example, during cylinder handling activities. It was estimated that about 24 lb (11 kg) of UF_6 could be released in such an accident. The potential consequences from this type of accident would be limited to on-site workers. The off-site concentrations of HF and uranium were calculated to be less than the levels that would cause adverse effects from exposure to these chemicals, so that zero adverse effects were estimated to occur among members of the general public. If this accident did occur, it was estimated that up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that 3 noninvolved workers might experience potential irreversible adverse effects (such as lung or kidney damage). The number of fatalities following an HF or uranium exposure is expected to be somewhat less than 1% of the number of potential irreversible adverse effects (Policastro et al. 1997). Therefore, no fatalities would be expected. In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing solid UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers.

For assessment purposes, the estimated frequency of a corroded cylinder spill accident was assumed to be about once in 10 years. Therefore, over a 41-year period, about four such accidents

TABLE 5.1 Estimated Consequences of Chemical Exposures for Accidents under the No Action Alternative[a]

Receptor[b]	Accident Scenario	Site	Accident Frequency Category[c]	Effect[d]	Consequence[e] (persons affected)
		Likely Accident(s)			
General public	Corroded cylinder spill, dry conditions	All sites	L	Adverse effects	0
	Corroded cylinder spill, dry conditions	All sites	L	Irreversible adverse effects	0
	Corroded cylinder spill, dry conditions	All sites	L	Potential fatalities	0
Noninvolved Workers	Corroded cylinder spill, dry conditions	K-25	L	Adverse effects	70
	Corroded cylinder spill, dry conditions	K-25	L	Irreversible adverse effects	3
	Corroded cylinder spill, dry conditions	K-25	L	Potential fatalities	0
		Low Frequency-High Consequence Accident(s)			
General public	Vehicle-induced fire, 3 full 48G cylinders	Paducah	EU	Adverse effects	1,900
	Corroded cylinder spill, wet conditions – water pool	Portsmouth	EU	Irreversible adverse effects	1
	Corroded cylinder spill, wet conditions – water pool	Portsmouth	EU	Potential fatalities	0
Noninvolved Workers	Vehicle-induced fire, 3 full 48G cylinders	Portsmouth	EU	Adverse effects	1,000
	Corroded cylinder spill, wet conditions – water pool	Paducah	EU	Irreversible adverse effects	300
	Corroded cylinder spill, wet conditions – water pool	Paducah	EU	Potential fatalities	3

[a] The accidents listed are those estimated to result in the greatest impacts among all the accidents considered at all three sites. The site-specific impacts for a range of accidents at each of the three current storage sites are listed in Appendix D. The consequences are different at each site because of differences in the worker and public population distributions around the sites.

[b] Noninvolved workers are persons working at the site but not involved in handling of materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr).

[d] Potential adverse effects include exposures that could result in mild and transient injury, such as respiratory irritation. Potential irreversible adverse effects include exposures that could result in permanent injury (e.g., impaired organ function) or death. The majority of the adverse effects would be mild and temporary in nature. It is estimated that less than 1% of the predicted potential irreversible adverse effects would result in fatalities (see text).

[e] The consequence is expressed as the maximum number of individuals with a predicted exposure level sufficient to cause the corresponding health endpoint. The estimated consequences were based on the assumption that the meteorological conditions would be F stability with 1 m/s wind speed, considered to be the worst conditions, and that the wind would be blowing in the direction of the highest worker or public population density.

TABLE 5.2 Estimated Consequences from Radiation Exposures for Accidents under the No Action Alternative[a]

Receptor[b]	Accident Scenario	Site	Accident Frequency Category[c]	MEI		Population	
				Dose (rem)	Lifetime Risk of LCF	Dose (person-rem)	Number of LCFs
			Likely Accident(s)				
General public	Corroded cylinder spill, dry conditions	K-25	L	0.003	1×10^{-6}	0.43	0.0002
Noninvolved Workers	Corroded cylinder spill, dry conditions	Portsmouth	L	0.077	3×10^{-5}	2.2	0.0008
			Low Frequency-High Consequence Accident(s)				
General public	Vehicle-induced fire, 3 full 48G cylinders	Paducah	EU	0.015	7×10^{-6}	28	0.01
Noninvolved Workers	Vehicle-induced fire, 3 full 48G cylinders	K-25	EU	0.02	8×10^{-6}	16	0.006

[a] The accidents listed are those estimated to have the greatest impacts among all accidents considered at all three sites. The impacts for a range of accidents at each of the three current storage sites are listed in Appendix D. The estimated consequences were based on the assumption that the wind would be blowing in the direction of the highest worker or public population density and that weather conditions limited dispersion.

[b] Noninvolved workers are persons working at the site but not involved in handling of materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr).

would be expected. The accident risk (defined as consequence times probability) would be about 280 workers with potential adverse effects and 12 workers with potential irreversible adverse effects over the period 1999 through 2039. The number of workers actually experiencing these effects would probably be considerably less, depending on the actual circumstances of the accidents and the individual chemical sensitivity of the workers. In previous accidental exposure incidents involving liquid UF_6 in gaseous diffusion plants, a few workers have been exposed to amounts of uranium estimated to be approximately three times the guidelines used for assessing irreversible adverse effects in this PEIS, and none actually experienced irreversible adverse effects (McGuire 1991).

Accidents that are less likely to occur could have higher consequences. The potential cylinder accident at any of the sites estimated to result in the greatest total number of adverse chemical effects is an accident involving three cylinders in a fire caused by an on-site vehicle accident (although more cylinders than three might be affected by a fire, three was the most likely number based on estimates of the fuel available from a truck). If this accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse effects from HF and uranium exposure (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). This accident is considered extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years. If the frequency is assumed to be once in 100,000 years, the accident risk over the period 1999 through 2039 would be less than 1 adverse effect for both workers and members of the general public.

The potential cylinder accident estimated to result in the largest total number of irreversible adverse effects is a corroded cylinder spill under wet conditions, where the UF_6 was assumed to be released into a pool of standing water. This accident is also considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, it was estimated that about 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects from HF and uranium exposure (such as lung damage). The number of fatalities would be somewhat less than 1% of the estimated number of potential irreversible adverse effects (Policastro et al. 1997). Thus, no fatalities would be expected among the general public, although 3 fatalities could occur among noninvolved workers (1% of 300). If the frequency of this accident is assumed to be once in 100,000 years, the accident risk over the period 1999 through 2039 would be less than 1 (0.1) irreversible adverse health effect among workers and the general public, combined.

Radiation Effects. Potential cylinder accidents could release uranium, which is radioactive in addition to being chemically toxic. The potential radiation exposures of members of the general public and noninvolved workers were estimated for the same cylinder accidents discussed for chemical effects (Table 5.2). For all cylinder accidents considered, the radiation doses from released uranium were estimated to be considerably below levels likely to cause radiation-induced effects among noninvolved workers and the general public, and below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

For the corroded cylinder spill accident (dry conditions), the radiation dose to a maximally exposed member of the general public at any of the sites was estimated to be less than 3 mrem (lifetime dose), resulting in an increased risk of death from cancer of about 1 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be less than 1 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be 77 mrem, resulting in an increased risk of death from cancer of about 1 in 30,000. The total dose to all noninvolved workers was estimated to be about 2.2 person-rem. This dose to workers was estimated to result in zero LCFs. The risk (consequence times probability) of additional LCFs among members of the general public and workers combined would be much less than 1 over the period 1999 through 2039.

The cylinder accident estimated to result in the largest potential radiation doses would be the accident involving three cylinders in a fire. For this accident, the radiation dose to a maximally exposed member of the general public was estimated to be about 15 mrem, resulting in an increased risk of death from cancer of about 1 in 150,000. The total population dose to the general public within 50 miles (80 km) was estimated to be 28 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 20 mrem, resulting in an increased risk of death from cancer of about 1 in 100,000. The total dose to all noninvolved workers was estimated to be about 16 person-rem. This dose to workers was estimated to result in zero LCFs. The risk (consequence times probability) of additional LCFs among members of the general public and workers combined would be much less than 1 over the period 1999 through 2039.

5.1.2 Transportation

Continued cylinder storage under the no action alternative would potentially generate small amounts of LLW and LLMW during cylinder monitoring and maintenance activities. This material could require transportation to a treatment or disposal facility. Shipments would be made in accordance with all DOE and DOT regulations and guidelines. It was estimated that less than one waste shipment would be required each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would be negligible (see Appendix J).

5.1.3 Air Quality

Potential impacts to air quality for the no action alternative considered air pollutant emissions from continued cylinder storage activities, including construction of new yards (engine exhaust and particulate matter emissions [i.e., dust]), operations (cylinder painting and vehicle emissions), and HF emissions from breached cylinders. Atmospheric dispersion models were used to estimate the concentrations of criteria pollutants at the site boundaries. Criteria pollutants are those that have corresponding federal air quality standards — hydrocarbons (HC), CO, NO_x, sulfur oxides (SO_x), Pb, and PM_{10}. The site boundary concentrations were compared with existing air

quality standards or with guidelines for pollutants that do not have corresponding standards. These standards and guidelines are given in Chapter 3. For the no action alternative, estimated concentrations of criteria pollutants and HF were all within applicable standards and guidelines. However, because potential PM_{10} emissions during construction activities were estimated to be very close to the standards, procedures to reduce these emissions might have to be implemented during construction.

In general, the highest levels of criteria pollutants would be generated by construction activities occurring at the Paducah and K-25 sites. Except for PM_{10}, the air concentrations of all criteria pollutants resulting from no action alternative activities would be less than 3% of the respective standards. Particulate matter emissions from construction could result in maximum 24-hour average PM_{10} concentrations just below the standards (about 90 to 95% of the standard value of 150 $\mu g/m^3$), although the estimated annual average concentrations would be lower (about 30 to 55% of the standard value of 50 $\mu g/m^3$). During actual construction, mitigative measures would be taken to reduce the generation of particulate matter, such as spraying the soil with water and covering the excavated soil. Such measures are commonly employed during construction but were not accounted for in the modeling done for the PEIS analysis. Currently planned construction activities for the no action alternative are limited to the first few years of operations (through 2002).

Operations activities would emit much lower concentrations of criteria pollutants than would construction activities (all lower than 0.3% of standards). Painting activities could generate hydrocarbon emissions. There is no explicit air quality standard for hydrocarbon emissions, but these emissions are associated with ozone formation. For each of the three current cylinder storage sites, hydrocarbon emissions from painting activities would be less than 1.2% of the hydrocarbon emissions from the entire surrounding county. Because ozone formation is a regional issue affected by emissions for an entire area, these small additional contributions to the county totals would be unlikely to substantially alter the ozone levels of the county.

Estimated annual average site boundary concentrations of HF from hypothetical cylinder breaches occurring under the no action alternative ranged from 0.01 to 0.08 $\mu g/m^3$ for the three sites. The States of Kentucky and Tennessee have HF air standards, whereas no federal or State of Ohio standards exist. The annual average HF concentration for the Paducah site was estimated to be less than 0.002% of the standard. The estimated maximum 24-hour average HF concentration for the K-25 site is 0.67 $\mu g/m^3$, which is about 23% of the State of Tennessee 24-hour average standard for HF (the HF standards for Tennessee are much lower than those for Kentucky).

If no credit is taken for corrosion reduction through painting and continued maintenance, and if storage is continued at the three current storage sites indefinitely, calculations indicate that breaches occurring at the K-25 site by around the year 2020 could result in maximum 24-hour average HF concentrations at the site boundaries equal to approximately 2.9 $\mu g/m^3$ (3.5 parts per billion [ppb]) (Tschanz 1997b). This level corresponds to the primary standard for the State of Tennessee. For comparison, the maximum estimated 24-hour average HF concentrations at the Paducah and Portsmouth sites through the year 2039 were estimated to be 2 and 0.6 $\mu g/m^3$,

respectively. (The State of Kentucky primary standard for HF maximum 24-hour average is much higher, 800 $\mu g/m^3$; the State of Ohio does not have ambient air quality standards for HF.) Because of the ongoing painting and maintenance program, it is not expected that breaches occurring prior to 2039 would be sufficient to increase the HF concentrations above the applicable standards at any of the sites (Tschanz 1997a).

5.1.4 Water and Soil

Potential impacts on surface water, groundwater, and soil could occur during continued storage of the cylinders under the no action alternative. Important elements in assessing potential impacts for surface water include changes in runoff, floodplain encroachment, and water quality. Groundwater impacts were assessed in terms of changes in recharge to the underlying aquifers, depth to groundwater, direction of groundwater flow, and groundwater quality. Potential soil impacts considered were changes in topography, permeability, erosion potential, and soil quality.

For the no action alternative, very limited construction activity is planned, and that planned activity would occur in previously developed areas. Water use and waste water discharge would also be very limited. Therefore, the assessment area in which potentially important impacts might occur was determined to be quality of surface water, groundwater, and soil. The other potential impacts would all depend on changes in permeable land areas at the sites due to construction activities or on water use and effluent volumes.

The contaminant of concern for evaluating surface water, groundwater, and soil quality is uranium. Surface water and groundwater concentrations of contaminants are generally evaluated through comparison with the EPA MCLs, as given in *Safe Drinking Water Act* regulations (40 CFR Part 141), although these limits are only directly applicable "at the tap" of the water user. The proposed MCL for uranium is 20 µg/L (EPA 1996); this value has been used as a guideline for evaluating surface water and groundwater concentrations of uranium in this PEIS, although it is not directly applicable as a standard. There is also no standard available for limiting concentrations of uranium in soil; a health-based value of 230 µg/g (EPA 1995a), applicable for residential settings, has been used as a guideline for comparison in this PEIS.

The nearest surface waters to the current storage sites are Little Bayou Creek, Little Beaver Creek, and Poplar Creek for the Paducah, Portsmouth, and K-25 sites, respectively. These surface waters are tributaries to larger rivers at each of the sites; the larger rivers are used as drinking water sources. Because of very large dilution effects, even very high levels of contaminants in the nearest site surface waters would not be expected to cause levels exceeding guidelines at the drinking water intakes of the larger rivers.

Water use during construction activities would be 2 million and 0.8 million gal for the Paducah and K-25 sites, respectively. Maximum water use during operations would be 160,000, 60,000, and 32,000 gal/yr for the Paducah, Portsmouth, and K-25 sites, respectively.

5.1.4.1 Surface Water

Potential impacts on the nearest receiving water at each site (i.e., Little Bayou Creek, Little Beaver Creek, and Poplar Creek) were estimated for uranium released from hypothetical cylinder breaches occurring through 2039. The estimated maximum concentrations of uranium in these receiving waters were 0.3, 0.7, and 0.02 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. These concentrations are considerably below the 20 µg/L level used for comparison.

5.1.4.2 Groundwater

Potential impacts on groundwater quality from hypothetical releases of uranium from breached cylinders were also assessed. The maximum future concentrations of uranium in groundwater directly below the sites were estimated to be 6, 5, and 7 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Assuming a rapid rate of uranium migration, these concentrations were estimated to occur sometime after the year 2070. Lower concentrations would occur if uranium migration through the soil was slower. The groundwater concentrations at all three sites were estimated to be considerably below the 20 µg/L level used for comparison.

Groundwater in the vicinity of the Paducah and Portsmouth sites is used for domestic and industrial supplies. Groundwater in the vicinity of the K-25 site discharges to nearby surface waters and is not known to be used as a domestic or industrial source. (See Chapter 3 for a discussion of existing groundwater quality at each of the sites.) At Paducah, a municipal water supply has been supplied by the Paducah site to residents having wells within an area of groundwater contaminated with trichloroethylene and technetium-99. At Portsmouth, sampling results indicate that residential water supplies have not been affected by site operations. Activities associated with the no action alternative would not affect migration of existing groundwater contamination or off-site water supplies.

If no credit is taken for corrosion reduction through cylinder painting and maintenance, and if storage is continued at the three current storage sites indefinitely, calculations indicate that uranium releases from future cylinder breaches occurring at the Paducah site prior to about the year 2020 could result in a sufficient amount of uranium in the soil column to increase the groundwater concentration of uranium to 20 µg/L in the future (about 2100). The cylinders would have to undergo uncontrolled corrosion (without painting and maintenance) until about 2050 at the Portsmouth site and until about 2025 at the K-25 site before the same groundwater concentration guideline of 20 µg/L would be a concern. The groundwater concentration would not actually reach 20 µg/L at these sites until about 2100 or later. Because of the ongoing painting and maintenance program, it is not expected that breaches occurring prior to 2039 would be sufficient to increase the groundwater concentration to 20 µg/L at any of the sites.

5.1.4.3 Soil

Potential impacts on soil that could receive contaminated rainwater runoff from the cylinder storage yards were estimated. The source was assumed to be uranium released from hypothetical breached cylinders. The estimated maximum soil concentrations were 1, 1, and 3 μg/g for the Paducah, Portsmouth, and K-25 sites, respectively. These concentrations are considerably below the 230 μg/g guideline used for comparison.

5.1.5 Socioeconomics

The potential socioeconomic impacts of construction and operational activities under the no action alternative would be low. Construction activities at the Paducah and K-25 sites would create short-term employment (30 direct jobs, 110 total jobs in the peak construction year); operational activities occurring at the three sites would create 110 direct jobs and 210 total jobs per year. Direct and total income from construction in the peak year would be $1.4 million and $3.5 million, respectively. During operations, direct and total income would be $5.1 million/yr and $6.7 million/yr, respectively.

The employment and income created in the ROIs for the three sites would represent a change of less than 0.005% of projected growth in these indicators of overall regional activity. The in-migration expected into each region with each activity would have only a low impact on regional population growth rates and would require less than 2% of vacant housing stock at each of the three sites. No significant impacts on local public finances would be expected.

5.1.6 Ecology

The no action alternative would have a negligible impact on ecological resources in the area of the three current storage sites. Very limited construction activity is planned, and the planned activities would all occur in previously developed areas. Thus, impacts on wetlands and federal- and state-protected species due to facility construction would also be negligible.

The assessment results indicate that impacts to ecological resources from facility operations would be negligible. Analysis of potential impacts was based on exposure of biota to airborne contaminants or contaminants released to soil, groundwater, or surface water. Predicted concentrations of contaminants in environmental media were compared to benchmark values of toxic and radiological effects (see Appendix C, Section C.3.3). At all three sites, soil, groundwater, and surface water concentrations would be considerably below levels harmful to biota.

5.1.7 Waste Management

Under the no action alternative, construction and operations at the current storage sites would generate relatively small amounts of LLW and LLMW. The volume of LLW generated by continued storage activities would represent less than 1% of the annual generation at each of the three sites.

The maximum annual amount of LLMW generation from stripping/painting operations at the Paducah site would generate about 20% of the site's total annual LLMW load, constituting a potential moderate impact on LLMW management. LLMW generation for the Portsmouth and K-25 sites would be less than 1% of site LLMW generation, resulting in negligible waste management impacts for these sites. The total volume of LLMW generated at all three sites would also be less than 1% of the projected annual DOE LLMW treatment volume (i.e., 68,000 m^3/yr; see Appendix C, Section C.10), so that the overall impact on waste management operations from the no action alternative would be negligible to low.

5.1.8 Resource Requirements

Construction and operation of facilities under the no action alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantities of commonly used materials would be small compared to local sources and would not affect local, regional, or national availability of these materials. No strategic or critical materials are projected to be consumed during construction or operations. The anticipated utilities requirements would be within the supply capacities at each site. The required material resources during construction and operations at all three sites would be readily available.

5.1.9 Land Use

Very limited construction activity is planned under the no action alternative. For the Paducah site, only reconstruction of storage yards within the boundaries of existing yards is planned, so additional land clearing would not be necessary. For the K-25 site, construction of a new storage yard with an area of approximately 6.7 acres (2.7 ha) is planned, but this yard is expected to be located in an area already dedicated to similar use. No new construction is planned for the Portsmouth site. Therefore, impacts of the no action alternative with respect to land use would be none or negligible.

5.1.10 Cultural Resources

Under the no action alternative, impacts to cultural resources would not be likely at the Paducah or Portsmouth sites during continued cylinder storage. (See Chapter 3 for a discussion of

cultural resources existing at the three storage sites.) The existing storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the *National Register of Historic Places*. No new storage yards are proposed at Portsmouth, so no cultural resources would be affected. A new storage yard is proposed at the K-25 site; although the exact location of the yard is unknown, it would probably be located in an area already dedicated to similar use.

5.1.11 Environmental Justice

A review of the potential human health and safety impacts occurring under the no action alternative indicates that no disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the three current storage sites during normal operations. Although such populations reside within 50 miles (80 km) of the sites (see Appendix C), no disproportionate impacts would be expected. The results of accident analyses for the no action alternative also did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than one fatality for all accidents considered).

5.2 LONG-TERM STORAGE AS UF_6

Under the long-term storage as UF_6 alternative, the depleted UF_6 inventory was assumed to be stored in cylinders at a consolidated storage site through 2039. Three options were considered for the long-term storage of cylinders: storage in yards (similar to those currently used), storage in buildings, and storage in an underground mine (see Appendix G). To provide a conservative estimate of potential impacts, it was assumed that long-term storage would take place at a newly constructed, independent facility and that cylinders would be transported from the three current storage sites by either truck or rail.

The following is a summary of the activities analyzed under the long-term storage as UF_6 alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to a consolidated storage facility. The cylinder management activities that would occur at the sites were assumed to be similar to those for the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** In the future, a number of cylinders might not be suitable for transportation and might thus require some type of preparation prior to off-site shipment (see

Section 4.2 and Appendix E). Two cylinder preparation options were considered for these cylinders: (1) a cylinder overcontainer option and (2) a cylinder transfer option. The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites. Preoperations for transfer facilities were assumed to occur between 1999 and 2008 (with actual construction requiring 4 years). Operations would occur between 2009 and 2028. Cylinder preparation impacts were evaluated for a range in the number of cylinders prepared at each site (as summarized in Section 4.2.2).

- ***Long-Term Storage (Representative Site).*** The three long-term storage options considered are storage in yards, storage in buildings, and storage in an underground mine (see Appendix G). Cylinders would be received at the storage facility from 2009 through 2028. Construction activities would also be ongoing from 2009 through 2028. Monitoring and maintenance were evaluated through 2039.

- ***Transportation (Representative Routes).*** All cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent long-term storage site.

Under the long-term storage as UF_6 alternative, the cylinder management activities at the current storage sites were assumed to be similar to those that would occur under the no action alternative, including cylinder painting. However, because of impending cylinder movement or content transfer, cylinder yard improvement and cylinder painting might not occur at the same rate as they would under the no action alternative. Because the painting schedule that would be followed under the action alternatives (including long-term storage as UF_6) is not known, and to present reasonable upper bound estimates of impacts, no credit was taken for the effectiveness of cylinder yard improvements and painting in reducing cylinder corrosion rates. The number of hypothetical breached cylinders at the three current storage sites was estimated by assuming historical corrosion rates. Therefore, for analytical purposes, more cylinder breaches were assumed to occur under this alternative than under the base case for the no action alternative, even though the storage time at the current storage sites would be less.

5.2.1 Human Health and Safety

During implementation of the long-term storage as UF_6 alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. Potential impacts are discussed in Sections 5.2.1.1 and 5.2.1.2.

5.2.1.1 Normal Facility Operations

5.2.1.1.1 Workers

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a long-term storage facility would be exposed to radiation during the placement of cylinders into long-term storage. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

Similar to the no action alternative, the radiation exposure of individual workers under the long-term storage as UF_6 alternative would be well within public health standards; average doses were estimated to be much less than the limit of 5,000 mrem/yr (10 CFR Part 835). The total radiation exposure of involved workers would be similar to, but slightly greater than, that under the no action alternative. The total exposure would be greater because of the additional cylinder handling required for preparation of cylinders for shipment and placement of cylinders into consolidated long-term storage. The estimated total number of potential radiation-induced LCFs among involved workers from 1999 through 2039 is summarized in Figure 5.1. (The totals include the radiation exposure during cleaning of empty cylinders that would be required if a cylinder transfer facility were used.) For all three storage options, about 1 additional LCF was estimated among the involved worker population, similar to the no action alternative. Impacts to noninvolved workers would be less than 1% of those to involved workers.

In addition to about 50 cylinder yard workers, 40 to 230 involved workers would be required under the long-term storage as UF_6 alternative (the exact number would depend on the cylinder preparation and storage options selected).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, workers would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations was estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three sites and at a consolidated storage facility).

5.2.1.1.2 General Public

The potential impacts to members of the public during normal operations would be similar to those under the no action alternative — all exposures were estimated to be within applicable

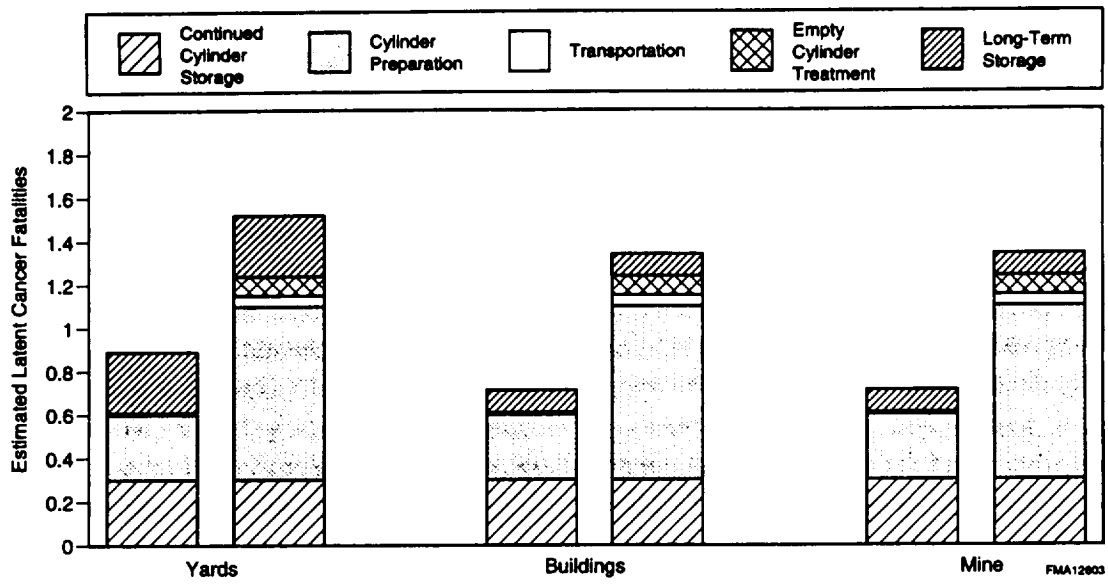

FIGURE 5.1 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Long-Term Storage as UF_6 Alternative, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites or near a consolidated long-term storage facility from depleted UF_6 management activities.

At the current storage sites, potential public exposures to radiation and chemicals were estimated to be slightly greater than under the no action alternative because, for the action alternatives, no credit was taken for reduced corrosion rates from cylinder painting and maintenance, resulting in an increased number of estimated cylinder breaches at the sites. However, the potential exposures of members of the general public were still estimated to be well within all applicable health standards and guidelines.

The total collective radiation dose to the general public around the three current storage sites from potential airborne emissions of uranium from breached cylinders was estimated to be about 1.1 person-rem over the period 1999 through 2028 (all cylinders were assumed to be removed by 2029). This level of exposure was estimated to result in zero LCFs among members of the general public. The maximum radiation dose to an individual near any of the sites was estimated to be less than 0.5 mrem/yr from airborne emissions, well within applicable health standards. Radiation doses to members of the general public are required by health regulations to be maintained below 10 mrem/yr from airborne sources (40 CFR Part 61) and below a total of 100 mrem/yr from all sources combined (DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year (1999 through 2028), the total dose would be about 15 mrem, resulting in an

additional chance of dying from a latent cancer of about 1 in 100,000. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the estimated hazard index for an individual was estimated to be less than 0.1 at all three sites. This means that the total exposure would be at least 10 times less than exposure levels that might cause adverse effects.

The results of the surface water and groundwater analyses indicate that the maximum estimated uranium concentrations would be less than the guideline level of 20 µg/L (EPA 1996) at all three sites. This is true even though a higher cylinder breach rate was assumed under the long-term storage as UF_6 alternative than under the no action alternative, because the cylinder inventory at the three sites would be steadily decreasing (see Sections 5.2.4.1 and 5.2.4.2). If a member of the general public near one of the sites were to use contaminated surface water or groundwater as a primary water source (at the maximum concentrations estimated to occur in the future), the annual radiation dose was estimated to be about 1 mrem/yr at all three sites. The corresponding chance of this individual dying from a radiation-induced latent cancer would be less than 1 in 1 million per year.

At a consolidated long-term storage site, cylinders would have undergone appropriate preparation at the current storage sites and would be inspected before being placed in storage. Once placed in storage, cylinders would be subjected to routine monitoring and maintenance activities similar to those occurring at the three current storage sites. If a breach occurred, storage in buildings or a mine would provide an additional level of containment when compared with yard storage. Consequently, impacts to members of the general public near a consolidated storage facility would be less than or equal to those discussed for the three current storage sites.

5.2.1.2 Facility Accidents

5.2.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the long-term storage as UF_6 alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 was estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries (see Appendix D, Section D.2). The estimated number of worker fatalities and injuries would be slightly greater than that under the no action alternative because of the additional construction and operational activities required for cylinder preparation and consolidated long-term storage facilities. It was estimated that a total of about 1 accidental fatality might occur over the 41-year period. Similarly, a total of between 240 and

900 accidental injuries was estimated. These rates would not be unique to the activities required for the alternative but would be typical of any industrial project of similar size and scope.

5.2.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the long-term storage as UF_6 alternative, accidents that could release radiation and chemicals from cylinders are possible. A wide range of different types of accidents was evaluated at the current storage sites during continued cylinder storage and cylinder preparation activities and at a consolidated long-term storage facility. The accidents at these facilities that could result in a release of radiation or chemicals would all involve cylinders, either while in storage or during handling.

The consequences of the potential cylinder accidents that could occur at the current storage sites under the long-term storage as UF_6 alternative would be the same as those described under the no action alternative (see Section 5.1.1.2.2). In addition, the consequences of cylinder accidents at a consolidated storage facility would also be the same as those discussed for the no action alternative because the types of accidents possible are the same, and, for assessment purposes, the environmental conditions of the three current storage sites were assumed to be representative of the conditions at a long-term storage facility.

5.2.2 Transportation

The major materials assumed to be transported under the long-term storage as UF_6 alternative are summarized in Table 5.3. To provide a conservative estimate of potential transportation impacts, it was assumed that all depleted UF_6 cylinders (46,422) would be transported from the three current storage sites to a consolidated long-term storage facility. All shipments would be made in accordance with applicable DOE and DOT regulations and guidelines. Transport by rail would require about 11,600 railcar shipments (with four cylinders per railcar), and transport by truck would require about 46,422 truck shipments (with one cylinder per truck). The operation of a cylinder transfer facility at each of the current storage sites would also produce waste, including LLW and LLMW, that would require shipment to a disposal facility. A total of about 600 truck shipments of radioactive waste would be required over the duration of the program. Because of the relatively small number of shipments and the low concentration of radioactive and chemical contaminants expected, the potential impacts associated with waste shipments were estimated to be negligible compared to those associated with the transportation of UF_6 cylinders. All shipments were assumed to take place over a 20-year period.

The assessment of transportation impacts considered truck and rail shipment options and evaluated impacts from both incident-free transportation operations as well as accidents. Because the location of a long-term storage site is unknown, for assessment purposes it was assumed that all

TABLE 5.3 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Long-Term Storage as UF_6 Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Consolidated long-term storage site	46,422	11,600[d]	2	1
LLW/LLMW	Current storage sites	Treatment/disposal site	520 - 640	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments when either the truck or rail mode is assumed to be used.

[c] Number of estimated traffic accident fatalities when each shipment is assumed to travel 620 miles (1,000 km) and national average accident statistics are used. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. The transportation assumptions and impacts for a range of shipment distances are discussed in detail in Appendix J. The transportation impacts could be reduced or eliminated by colocating facilities.

5.2.2.1 Normal Transportation (Incident-Free) Operations

During normal operations, radioactive materials and chemicals would be contained in their transport packages. Potential impacts would be possible from exposure to external radiation in the vicinity of cylinders and from exposure to vehicle engine exhaust emissions. Incident-free transportation operations were estimated to result in zero fatalities among workers and the general public, combined, for both truck and rail transportation. Members of the public living along truck and rail transportation routes were estimated to receive extremely small doses of radiation, much less than 0.1 mrem even if a single person were to be exposed to every shipment of radioactive material during the program.

5.2.2.2 Transportation Accidents

Transportation accidents could occur during the shipment of UF_6 cylinders. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public. Two types of accident impacts were estimated: (1) impacts from typical traffic accidents that could cause deaths from physical trauma, unrelated to the cargo being shipped, and (2) accidents that would involve the release of radioactive material or chemicals from a shipment.

5.2.2.2.1 Traffic Accidents with No Release

Shipments of cylinders and waste could be involved in truck or rail traffic accidents, with a chance that fatalities could result. To predict the number of traffic fatalities that might result from future shipments, historical traffic accident statistics were used. The estimated number of traffic fatalities depends on the total number of shipments, the shipment distance, the shipment mode (truck or rail), and the historical accident fatality rates.

The number of traffic fatalities estimated assuming the shipment of all 46,422 cylinders by truck or rail over a 20-year period are presented in Table 5.3 (for purposes of comparison, shipments were assumed to travel 620 miles [1,000 km]). If truck shipments were used, it was estimated that about 2 traffic fatalities could result. If rail shipments were used, it was estimated that about 1 traffic fatality could result. Rail transport results in a lower number of estimated traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The estimated number of fatalities would be reduced if the number of shipments and shipment distances were reduced.

5.2.2.2.2 Traffic Accidents Involving Releases of Radiation or Chemicals

Traffic accidents that could cause a release of UF_6 from cylinders are possible. The amount released would depend on the severity of the accident and the number of cylinders involved. Following a release, the UF_6 would combine with moisture in the air, forming gaseous HF and UO_2F_2. The depleted uranium and HF would be dispersed downwind, potentially exposing members of the general public to radiation and chemical effects. The consequences of such a release would depend on the location of the accident and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have greater potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material was dispersed and diluted to lower concentrations as it moved downwind.

Severe rail accidents could have higher consequences than truck accidents because each railcar would carry four cylinders, compared to one cylinder per truck. The accident estimated to

have the largest potential consequences would be a severe rail accident involving four cylinders. The consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). In such a case, it was estimated that approximately 4 persons might experience irreversible adverse effects (such as lung or kidney damage) from exposure to HF and uranium. The number of fatalities expected following an HF or uranium chemical exposure is expected to be somewhat less than 1% of the potential irreversible adverse effects. Thus, no fatalities would be expected (1% of 4). Over the long term, radiation effects are possible from exposure to the uranium released. In a highly populated urban area, it was estimated that about 3 million people could be exposed to small amounts of uranium as it was dispersed by the wind. Among those exposed, it was estimated that approximately 60 LCFs could occur in the urban population in addition to those occurring from all other causes. In a population of 3 million people, approximately 700,000 would be expected to die of cancer from all causes.

The occurrence of a severe rail accident breaching four cylinders in an urban area under stable weather conditions would be expected to be rare. The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 (8×10^{-5}) for shipping all the cylinders by rail over 20 years (the actual probability would depend on the route selected). The total accident risk from cylinder shipments was calculated by using the probability and consequences of the range of possible accident severities. The results indicate that zero fatalities from accidental radioactive and chemical releases would be expected over the 20-year shipment period (see Appendix J, Table J.6).

The consequences of cylinder accidents occurring in rural environments, during unstable weather conditions (typical of daytime) or involving a truck shipment, were also assessed. The consequences of all other accident conditions were estimated to be considerably less than those described above for the severe urban rail accident. These considerations are discussed further in Appendix J.

Although accidents involving shipments of LLW and LLMW could occur, the consequences of even the most severe accidents involving these materials would not be expected to cause any LCFs from radiation exposures or any irreversible adverse effects from exposure to chemicals if a release occurred.

5.2.3 Air Quality

The analysis of potential impacts to air quality for the long-term storage as UF_6 alternative considered the potential for air pollutant emissions from continued cylinder storage activities through 2028, cylinder preparation activities, and long-term storage activities at a consolidated site. The analysis of continued cylinder storage at the current sites considered construction of new yards, maintenance and operations, and HF emissions from breached cylinders, as described in Section 5.1.3. Estimated concentrations of criteria pollutants for continued storage activities were

all within applicable standards and guidelines. However, because potential PM_{10} concentrations during construction activities were estimated to be close to the standards, procedures to reduce these emissions might have to be implemented during actual construction activities. In addition, the maximum 24-hour average HF concentrations at the K-25 site could be as high as 92% of the State of Tennessee standard for HF. This HF value is greater than that estimated under the no action alternative because, for the action alternatives, no credit was taken for reduced corrosion rates from cylinder painting and maintenance, thus resulting in an increased number of estimated cylinder breaches at the sites. Actual HF concentrations would be lower because improved cylinder storage conditions and painting activities are expected to reduce corrosion rates.

For construction activities that could occur as a part of cylinder preparation (i.e., if a transfer facility was constructed), estimated PM_{10} concentrations would also be within standards (62, 36, and 87% of the standards at Paducah, Portsmouth, and K-25, respectively). Procedures to reduce these emissions might have to be implemented during actual construction of a cylinder transfer facility. All other activities occurring as a part of cylinder preparation and consolidated storage facility construction and operations were estimated to result in criteria pollutant concentrations of less than 20% of standards. The analysis indicated that potential HF emissions from cylinder preparation and consolidated storage activities would be less than those estimated for continued cylinder storage at the current sites and thus would be within applicable standards.

5.2.4 Water and Soil

Water use from continued cylinder storage construction activities would range from 0.8 to 2 million gal. For operations, the water use would range from 32,000 to 160,000 gal/yr. The amounts of wastewater generated would be very small.

Construction activities for cylinder preparation would require from 6.5 to 10 million gal/yr (about 26 to 40 million gal total) of water if a transfer facility was constructed; operation of a transfer facility would require between 6 and 9 million gal/yr of water. Wastewater generated would be between 3 and 7 million gal/yr.

For consolidated storage in yards, buildings, or a mine, water use during construction would be between 0.5 and 6.4 million gal/yr; maximum water use during operations would be about 1.2 million gal/yr. Wastewater generation would be about 1.1 million gal/yr for all storage options.

5.2.4.1 Surface Water

Under the long-term storage as UF_6 alternative, potential impacts on surface water at the current storage sites could occur during continued storage of the cylinders through 2028. As for the no action alternative (Section 5.1.4), the only area with potentially important impacts was determined to be water quality. Impacts to the nearest receiving water at each site (Little Bayou Creek at

Paducah, Little Beaver Creek at Portsmouth, and Poplar Creek at K-25) were estimated for uranium released from hypothetical cylinder breaches occurring through 2028. The estimated maximum concentrations of uranium in receiving waters were estimated to be less than 2 μg/L for all three sites. These concentrations are considerably below the 20-μg/L guideline used for comparison. The water would then mix with water in the Ohio River, Scioto River, or Clinch River, resulting in even lower uranium concentrations.

Surface water impacts with respect to runoff and floodplain encroachment from cylinder preparation activities would be none to negligible (none for the cylinder overcontainer option; changes of less than 0.0006% in average river flows for the cylinder transfer facility option). Concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 μg/L in the surface waters to which wastewaters would be released.

For consolidated storage of UF_6 cylinders, the changes in average river flows for the representative sites would be less than 0.0001%, so impacts to runoff and floodplain encroachment, although dependent on the actual site location, would probably be negligible. Concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 μg/L in the surface waters to which wastewaters would be released.

5.2.4.2 Groundwater

Potential impacts on groundwater quality at the current storage sites from uranium releases due to hypothetical breached cylinders were assessed for continued storage through 2028; the maximum concentrations of uranium in groundwater beneath the sites were estimated to be 20, 4, and 9 μg/L for the Paducah, Portsmouth, and K-25 sites, respectively. These estimated concentrations would occur some time after the year 2070 and are based on the assumption of a rapid rate of uranium migration through the soil to the groundwater. Lower concentrations would occur if uranium migration through the soil was slower. Although the estimated groundwater concentration for Paducah is equal to the 20 μg/L guideline used for comparison, this is the maximum concentration estimated to occur and, because of conservatism in the calculations (e.g., the effects of cylinder painting in limiting corrosion were not considered), it is unlikely that groundwater concentrations would actually reach 20 μg/L at the Paducah site. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. (See Section 5.1.4 for a discussion of groundwater use in the vicinity of the three current storage sites.)

For cylinder preparation activities, impacts on depth to groundwater and flow direction would be none or negligible, depending on whether facility construction was required and whether groundwater or surface water was used during construction and operations. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction. No releases to groundwater would occur during normal operations.

At a consolidated storage facility, the potential impacts to groundwater would depend on the actual facility location and on whether yards, buildings, or mines were used. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction. If yards were used for storage, impacts would be less than those described for continued storage under the no action alternative because the cylinders in need of improvement would all have been subject to cylinder preparation (e.g., transferred to new cylinders) prior to consolidated storage. (Under the no action alternative, concentrations of uranium in groundwater from continued cylinder storage were estimated to be less than 5 µg/L.) No releases to groundwater were assumed to occur during normal operations under the building or mine storage options because rainwater would not come into contact with cylinders in buildings and mine storage was assumed to be in a dry environment.

5.2.4.3 Soil

Under the storage as UF_6 alternative, potential impacts to soil at the three current storage sites could occur during continued storage of the cylinders through 2028. As for the no action alternative (Section 5.1.4), impacts to soil receiving contaminated runoff from the cylinder storage yards were estimated by assuming the source to be uranium released from hypothetical breached cylinders. The estimated maximum soil concentration was 7 µg/g for the three current storage sites. This maximum soil concentration was higher than that calculated for the no action alternative because of conservatism in the calculations (e.g., the effects of cylinder painting in limiting corrosion were not considered). This concentration is well within the 230-µg/g guideline used for comparison.

For cylinder preparation activities, if a transfer facility were constructed at each of the current storage sites, from 0.4 to 0.7% of available land would be required. Even if this construction occurred on previously undisturbed land, which is unlikely, the impacts with respect to permeability and erosion potential would be negligible, and remaining unpaved areas would be returned to their former condition with regrading and reseeding.

At a consolidated storage facility, soil impacts would depend on whether yards, buildings, or a mine were the selected option and on the facility location. The impacts, which would tend to be temporary, would generally result from material excavated during construction that would be left on-site. The largest potential impacts on soil would occur for storage in a mine. Construction of a mine for storage could require excavating about 1.8 million yd^3 (1.4 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be minor. If a previously existing mine were used for storage, excavation requirements could be significantly reduced and potential impacts to soils would be much less. Potential impacts to soil for yard and building storage facilities would be much less than storage in a mine.

5.2.5 Socioeconomics

The potential socioeconomic impacts of construction and operational activities would be low for continued storage at the current sites through 2028. Construction activities at the Paducah and K-25 sites would create short-term employment (30 direct jobs, 110 total jobs in the peak construction year); operational activities occurring at the three sites would create 120 direct jobs and 260 total jobs per year. Direct and total income from construction in the peak year would be $1.4 million and $3.5 million, respectively. During operations, direct and total income would be $6 million/yr and $7.9 million/yr, respectively. Differences from the no action alternative would be due to different painting schedules and different assumptions concerning the number of breached cylinders. Employment and income created would represent a change of less than 0.01% of projected growth in these indicators of overall regional activity. The in-migration expected into each region with each activity would have only a minor impact on regional population growth rates and would require less than 2% of vacant housing stock at each of the three sites. No significant impacts on local public finances would be expected.

The potential socioeconomic impacts of construction and operational activities for cylinder preparation at the current sites would also be minor. If the largest number of cylinders required overcontainers or transfer at the three sites, from 0 to 580 direct jobs and 0 to 960 total jobs would be created during preoperations (0 corresponds to use of overcontainers; the high end of the ranges corresponds to construction of transfer facilities at each site). Operational activities for cylinder preparation occurring at the three sites would create from 300 to 490 direct jobs and from 610 to 1,230 total jobs. Direct and total income from preoperations in the peak year would range from 0 to $26 million and 0 to $33 million, respectively. During operations, direct and total income would range from $19 to $25 million/yr and $22 to $37 million/yr, respectively. Employment and income created would represent a change of less than 0.04% of projected growth in these indicators of overall regional activity for any of the three sites. The in-migration expected into each region would have only a small impact on regional population growth rates and would generally require less than 5% of vacant housing stock at each of the three sites. (During the peak year of construction at the Paducah site, 10% of rental housing units could be required.) No significant impacts on local public finances would be expected.

The potential socioeconomic impacts of construction and operational activities at a consolidated storage facility would depend on the facility location and whether yards, buildings, or a mine were selected. Construction activities would create employment (100 to 500 direct jobs in the peak construction year); operational activities would create 50 to 60 direct jobs per year. Direct income from construction in the peak year would be from $5 to $29 million. During operations, direct income would be about $3 million/yr. For long-term storage, construction and operations would be occurring concurrently over the 20-year emplacement period.

For the representative settings used for analysis, the employment and income created would represent a change of less than 0.02% of projected growth in these indicators of overall regional activity (see Appendix G, Section G.3.5). The in-migration expected into the region of a consolidated

storage facility would have only a small impact on regional population growth rates. Negligible impacts on local public finances would be expected. The impacts of mine storage were calculated for a generic site; therefore, no estimates of indirect impacts on employment and income were made for mine options.

5.2.6 Ecology

The long-term storage of UF_6 cylinders at a consolidated facility could potentially impact ecological resources, primarily from construction. A very limited amount of construction activity is planned for continued storage at the current storage sites, and that planned would all occur in previously developed areas. Thus, impacts to wetlands and state and federally protected species due to facility construction would be negligible. Construction of a transfer facility at any of the three current storage sites would require at most up to 21 acres (11 ha), which would be expected to result in only moderate ecological impacts because of the large amounts of previously disturbed land at these sites. The construction of a long-term storage facility would disturb between 96 and 144 acres (38 to 58 ha), depending on the type of storage facility. Existing vegetation at the site would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the location of the facility; however, some permanent loss of habitat could result. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility location. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to ecological resources from facility operations at the current storage sites or a long-term storage site would be negligible to low. The concentrations of radioactive and chemical contaminants in air and water emissions would be considerably below levels considered harmful to vegetation and wildlife.

Facility and transportation accidents, as discussed in Sections 5.2.1 and 5.2.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as accident location, season, and meteorological conditions.

5.2.7 Waste Management

Under the long-term storage as UF_6 alternative, construction and operations for continued storage at the three current storage sites through 2028 would generate relatively small amounts of LLW and LLMW. The volume of LLW generated by continued storage activities would represent less than 1% of the annual generation at each of the three sites, and the total would be less than 1% of projected annual DOE LLW treatment volumes, indicating negligible impacts associated with LLW disposal. The maximum annual amount of LLMW generation from stripping/painting operations at the Paducah site would generate about 20% of the site's total annual LLMW load,

constituting a potential moderate impact on LLMW management. (The maximum annual LLMW generation amount is not decreased in comparison with the no action alternative, because most of the cylinder painting would occur in the early years of maintenance under both alternatives.) LLMW generation for the Portsmouth and K-25 sites would be less than 1% of site LLMW generation, resulting in negligible waste management impacts for these sites. The total volume of LLMW generated at all three sites would also be less than 1% of the total DOE LLMW load, so that overall waste management impacts from continued storage through 2028 would be negligible to small.

The waste management impacts from cylinder preparation activities would be greater if the cylinder transfer option were implemented than if the cylinder overcontainer option were implemented (see Section E.3.7). The cylinder transfer option would require construction and operation of both cylinder transfer and cylinder treatment facilities at each site. The waste management impacts from cylinder transfer facilities would be minimal, representing less than 7% of the various types of waste loads at any of the three sites.

The waste management impacts from operating a cylinder treatment facility capable of treating the entire cylinder inventory are presented in Section F.3.7.4. Construction of this cylinder treatment facility would generate about 18 m^3 of hazardous waste; its operation would generate about 48 m^3/yr of LLW, 0.2 m^3/yr of LLMW, and 2 m^3/yr of hazardous waste. These volumes would represent negligible impacts to the waste management system. However, they exclude the crushed cylinders, which would represent a volume of about 6,200 m^3/yr. It was assumed that treated crushed cylinders would become part of the DOE scrap metal inventory. If a decision to dispose of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume. Under the cylinder transfer option, an unknown number of empty cylinders requiring treatment would be generated. The number of empty cylinders would range from about 9,600 to 28,351 at the Paducah site, 2,600 to 13,388 at the Portsmouth site, and 2,342 to 4,683 at the K-25 site. The impacts from disposal of the empty crushed cylinders would be proportional to the percentage of the inventory requiring cylinder transfer.

The operation and construction of a consolidated long-term storage facility would generate LLW and LLMW. The generation of LLW would result from the repair or repackaging of failed cylinders. The long-term storage of UF_6 would generate a total of approximately 2,150 m^3 of LLW and 560 m^3 of LLMW for storage in yards, and about 60 m^3 of LLW for storage in either buildings or a mine. Compared with national and regional waste management capabilities (see Appendix C, Section C.10), the generation of waste under the long-term storage as UF_6 alternative would have a negligible to small impact.

5.2.8 Resource Requirements

Construction and operation of facilities under the long-term storage as UF_6 alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that

are generally irretrievable resources. The total quantities of commonly used materials are not expected to be significant and would not affect local, regional, or national availability of these materials. Very small amounts of strategic or critical materials are projected to be consumed during construction or operation of the facilities. In general, facility operational requirements are not resource intensive, and the resources required are not considered rare or unique. However, for storage in a mine, large quantities of electrical energy would be required during construction (about 840 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would be dependent on the location of the facility and the existing infrastructure. If a previously existing mine were used for storage, excavation and construction requirements would probably be reduced, depending on the characteristics and condition of the mine, and the electrical requirements would be subsequently reduced.

5.2.9 Land Use

The long-term storage as UF_6 alternative would result in negligible impacts to land use at the current cylinder storage sites. The maximum amount of additional land required for continued cylinder storage at any of the current storage sites would be less than 7 acres (2.8 ha), representing much less than 1% of the land available for development at the sites. Construction of a cylinder transfer facility at the current storage sites could require up to 21 acres (9 ha), but such an areal requirement would result in negligible land-use impacts at these sites.

Impacts on land use for consolidated long-term storage would depend on the location of the facility. The construction and operation of a long-term storage facility would require between 96 and 144 acres (38 to 58 ha), constituting a potentially moderate land use impact. For storage in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. Impacts to land use outside the boundaries of facilities would be negligible and limited to temporary traffic impacts associated with construction.

5.2.10 Cultural Resources

Impacts to cultural resources under the long-term storage as UF_6 alternative would be unlikely at the Paducah or Portsmouth sites. The existing and proposed storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the *National Register of Historic Places*. No new storage yards are proposed at Portsmouth, so no cultural resources would be affected. A new storage yard is proposed at the K-25 site; although the exact location of the yard is unknown, it would probably be located in an area already dedicated to similar use. See Chapter 3 for a discussion of cultural resources existing at the three storage sites.

No impacts to cultural resources would be expected at the three current storage sites as a result of the cylinder overcontainer option because construction of a new facility would not be required. Impacts could result from the cylinder transfer option during construction of the transfer facilities. Specific impacts cannot be determined at this time and would depend on the future location of the facilities and whether listed or eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources. The impacts to cultural resources from the construction and operation of a consolidated long-term storage facility cannot be determined until the location of the facility is selected. However, impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.2.11 Environmental Justice

A review of the potential human health and safety impacts occurring for continued storage and cylinder preparation activities indicates that no disproportionately high and adverse effects to minority and low-income populations would be expected in the vicinity of the three current storage sites during normal operations. Although such populations reside within 50 miles (80 km) of the sites (see Appendix C), no disproportionate impacts would be expected. The results of accident analyses for continued cylinder storage and cylinder preparation activities also did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1). Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents would affect minority or low-income populations disproportionately.

5.3 LONG-TERM STORAGE AS URANIUM OXIDE

Under the long-term storage as uranium oxide alternative, depleted UF_6 was assumed to be chemically converted to an oxide at a conversion facility and the oxide placed in long-term storage. Conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone facility dedicated to the conversion process. Potential impacts were evaluated for conversion to and storage as both U_3O_8 and UO_2 (see Appendices F and G). For each, several long-term storage options were considered, including storage in buildings, belowground vaults, and an underground mine. To provide a conservative estimate of potential transportation and construction impacts, the conversion and long-term storage facilities were assumed to be located at sites other than the three current cylinder storage sites. Thus, transportation of cylinders from the three current storage sites to a conversion facility and transportation of uranium oxide from the conversion facility to a long-term storage facility were assumed.

The following is a summary of the activities analyzed under the long-term storage as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to a conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to those under the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options for cylinders not meeting transportation requirements were considered: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three current storage sites.

- ***Conversion (Representative Site).*** Conversion was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility. Preoperations for conversion facilities were assumed to occur between 1999 and 2008 (with actual construction requiring 4 years).[1] As described in Appendix F, two representative conversion technologies were assessed for conversion to U_3O_8, and three for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to a conversion site. Following conversion, the U_3O_8 or UO_2 produced was assumed to be transported in drums by truck or rail to a long-term storage facility. In addition, HF and CaF_2 were assumed to require transportation to either a user or disposal facility.

- ***Long-Term Storage (Representative Site).*** Three options were considered for the storage of oxide, including storage in buildings, vaults, and a mine (see Appendix G). Drums of oxide were assumed to be received at the storage facility from 2009 through 2028. Construction of the facility would continue over a 20-year period while drums were being received. Following the

[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

placement of the last container of oxide at the storage facility, monitoring and maintenance would occur from 2029 through 2039.

As described for the long-term storage as UF_6 alternative, cylinder management activities at the current storage sites for the long-term storage as oxide alternative were assumed to be similar to those that would occur under the no action alternative, including cylinder painting. As described for the long-term storage as UF_6 alternative, to provide a conservative estimate of impacts, no credit was taken for the effectiveness of cylinder yard improvements, cylinder maintenance, and painting in reducing cylinder corrosion rates. The number of hypothetical breached cylinders at the three current storage sites was estimated by assuming historical corrosion rates. Therefore, it was assumed that more cylinder breaches would occur under the long-term storage as oxide alternative than under the no action alternative, even though the cylinder storage time at the current storage sites would be shorter.

In terms of potential environmental impacts, the most important difference between the long-term storage as oxide alternative and the no action alternative is the requirement of a conversion facility. Conversion of UF_6 to uranium oxide would require process chemicals, most notably ammonia. Conversion could also produce large quantities of anhydrous HF. If accidentally released, both of these chemicals could cause serious adverse effects. Accidental releases of these chemicals could potentially occur at a conversion facility or during transportation. If the HF produced by conversion were neutralized to form CaF_2, shipments of anhydrous HF could be avoided. The potential environmental consequences of all activities under the storage as uranium oxide alternative, as outlined above, are provided in Sections 5.3.1 through 5.3.11.

The DOE plan for the management of the depleted UF_6 inventory that was in place during most of the preparation of this PEIS (described in Sewell 1992) is summarized in Section 1.1. The activities described under the former plan are very similar to those considered under the long-term storage as oxide alternative. The primary difference between the former plan and the long-term storage as oxide alternative is one of timing. Under the former plan, conversion of UF_6 to uranium oxide was anticipated to begin in 2020 and to continue for 20 years, through 2039. Under the long-term storage as oxide alternative, conversion is assumed to begin in 2009 and also to continue for 20 years, through 2028 (storage of the oxide was evaluated from 2029 through 2039). Therefore, under the former plan, cylinders would remain at the sites for about 10 years longer than is assumed under the long-term storage as oxide alternative. However, the environmental impacts for the long-term storage as oxide alternative are considered to be representative of those that would occur under the former management plan.

5.3.1 Human Health and Safety

During implementation of the long-term storage as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a consolidated long-term storage facility. These impacts are discussed in Sections 5.3.1.1 and 5.3.1.2.

5.3.1.1 Normal Facility Operations

5.3.1.1.1 Workers

The total radiation exposure of involved workers under the long-term storage as oxide alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and long-term storage operations. However, the exposures would still be well within all applicable health standards.

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a long-term storage facility, involved workers would be exposed to radiation during the placement of drums of uranium oxide into long-term storage. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The estimated number of potential radiation-induced LCFs among involved workers from 1999 through 2039 is summarized in Figure 5.2. About 1 to 2 additional LCFs were estimated among the involved worker population, compared with 1 for the no action alternative. The impacts to involved workers would be similar for the storage of U_3O_8 and UO_2. In addition, the impacts would be essentially the same for storage in buildings, vaults, or a mine because all three options would involve handling the same amount of radioactive material and would require the same general types of activities. Radiological impacts to noninvolved workers were estimated to be negligible compared to those for involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations are not expected. The workplace would be monitored to ensure that airborne chemical concentrations are within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, workers would be provided with appropriate protective equipment, as necessary. The potential chemical exposure of noninvolved workers from any airborne releases during normal operations was estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a consolidated storage facility).

5.3.1.1.2 General Public

The potential impacts to members of the general public during normal operations would be similar to those under the no action alternative — all exposures were estimated to be within

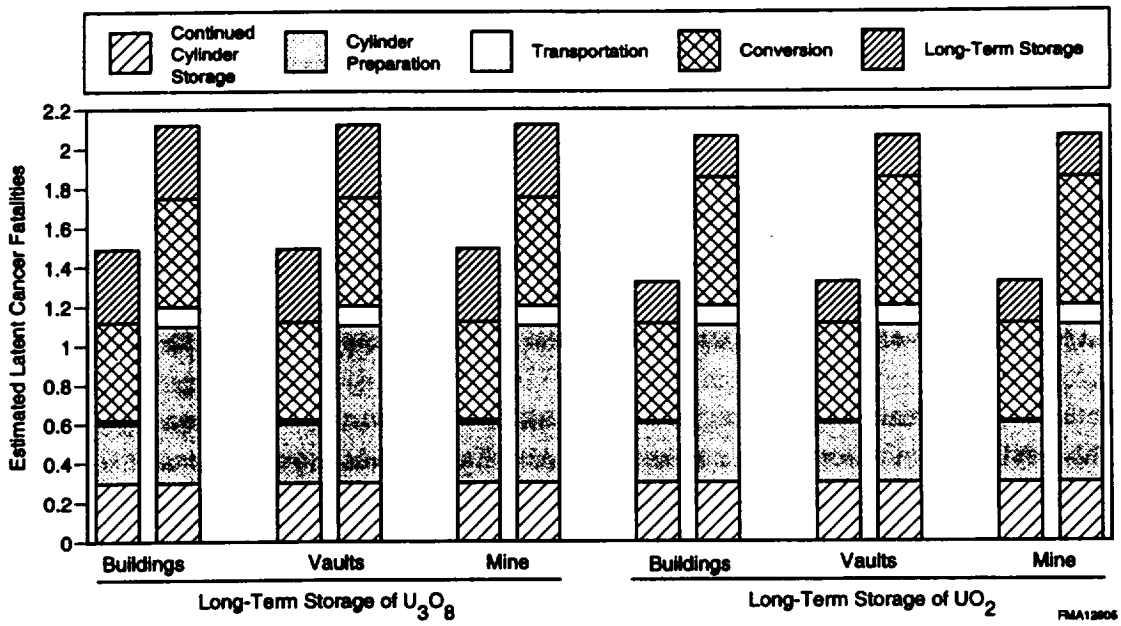

FIGURE 5.2 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Long-Term Storage as Oxide Alternative, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a consolidated long-term storage facility from depleted UF_6 management activities.

At the current storage sites, potential public exposures to radiation and chemicals released from the sites would be exactly the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative.

At a conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 1.0 to 10 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among members of the general public. The maximum radiation dose to an individual near a conversion site was estimated to be less than about 0.03 mrem/yr from airborne emissions, well within applicable health standards (40 CFR Part 61; DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, with a resulting chance of dying from a radiation-induced latent cancer of less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF

releases would be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a consolidated long-term storage site, drums of uranium oxide would be stored within buildings, vaults, or a mine. The engineering analysis report indicates that emissions of uranium or chemicals from the storage facilities during normal operations would be negligible (LLNL 1997a). Drums would be routinely inspected and repaired, if necessary, and the storage facilities would include high-efficiency air filters. Therefore, no adverse health impacts to the general public in the vicinity of the storage site would be expected during normal operations.

5.3.1.2 Facility Accidents

5.3.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be killed or injured during the long-term storage as oxide alternative as a result of accidents unrelated to any radiation or chemical exposures.

The accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than it would be under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and consolidated long-term storage facilities. The number of fatalities and injuries would depend on the specific cylinder preparation, conversion, and long-term storage options. Considering all options, a range of 1 to 2 accidental worker fatalities was estimated over the 41-year period.

The number of estimated worker injuries (injuries resulting in lost workdays) is shown in Figure 5.3. Considering all storage facility options, the estimated total number of injuries would range from about 700 to 1,600 over the 41-year period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries was estimated at the three sites combined. Approximately 460 to 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 100 to 200 worker injuries were estimated to occur at a long-term storage facility. The total number of injuries for storage as U_3O_8 or UO_2 would be similar. These rates would not be unique to the activities required for the alternative but would be typical of any industrial project of similar size and scope.

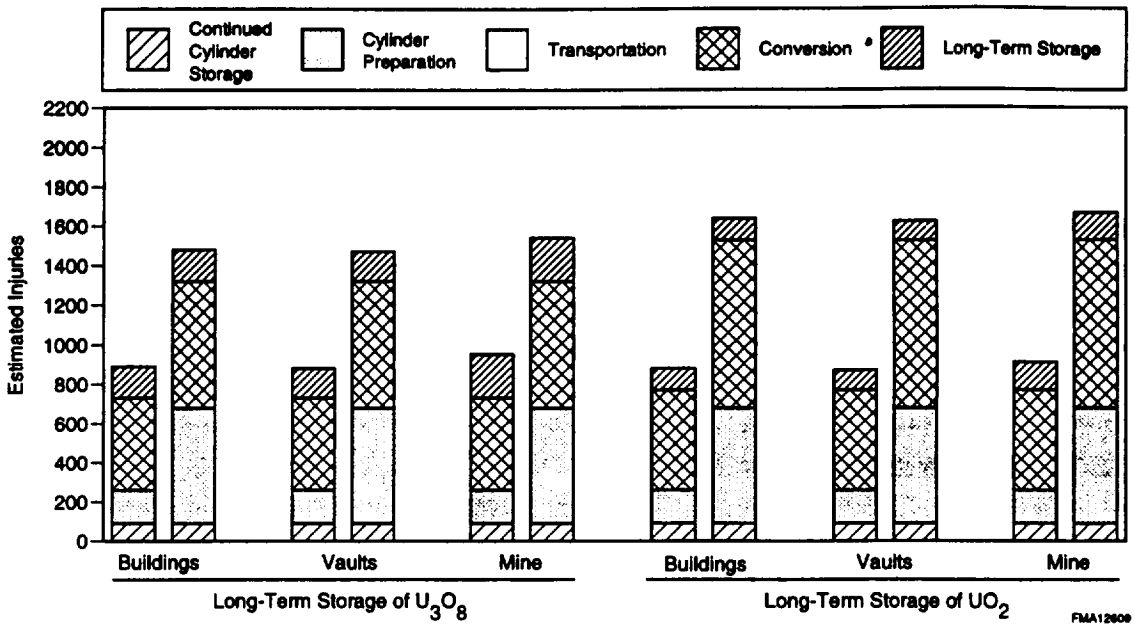

FIGURE 5.3 Total Estimated Number of On-the-Job Injuries (defined as injuries resulting in lost workdays) among All Workers from Construction and Operation of Facilities for the Long-Term Storage as Oxide Alternative, 1999 through 2039 (The two bars for each option represent the minimum and maximum impacts estimated.)

5.3.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the long-term storage as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at a conversion site, and at a long-term storage site. At each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix G, Section G.3.2, for long-term storage. The consequences of accidents were estimated for both the noninvolved workers at the sites and the general public living around the sites. Fatalities and injuries to involved workers who are near the accident site when an accident occurs are possible from all accidents (see Section 4.3.2.1).

At the three current storage sites, the potential cylinder accidents that could result in a release would be the same as the accidents discussed for the no action alternative. The estimated consequences of cylinder accidents at the current storage sites are discussed in Section 5.1.1.2.2.

At a conversion site, potential accidents could result in releases of depleted UF_6 from cylinders (a small inventory of cylinders would be temporarily stored at the conversion site awaiting processing). In addition, accidents involving releases of chemicals, such as ammonia and HF, would

be possible. Ammonia is required for conversion, and HF is produced as a conversion by-product. The potential consequences of conversion accidents are discussed below and in detail in Appendix F.

The estimated consequences of conversion facility accidents are summarized in Table 5.4 for chemical effects and in Table 5.5 for radiation effects. The impacts are presented separately for accidents considered likely (defined as accidents with an estimated frequency greater than once per 100 years) and for those rare, low-probability accidents estimated to result in the largest potential impacts. Although other accidents were evaluated, including those at a long-term storage site, the consequences of other accidents would be less than those summarized in the tables. The consequences presented are conservative because they are based on the assumption that the wind would be blowing in the direction of the greatest number of people at the time of the accident and that weather conditions would limit dispersion in the air, resulting in high concentrations. In addition, the effects of protective measures, such as evacuation, were not considered. The actual consequences of accidents would be expected to be less than those discussed.

Chemical Effects. The potential consequences from chemical exposures of all conversion accidents considered likely to occur (i.e., a frequency greater than once per 100 years) would be zero adverse effects among members of the general public (Table 5.4); the off-site concentrations of chemicals released and transported downwind were estimated to be below levels causing adverse chemical health effects.

Noninvolved workers at a conversion site could be affected by chemical releases from accidents considered likely. The likely accident estimated to result in the greatest total number of adverse chemical effects among noninvolved workers is the failure of a corroded cylinder, spilling part of its contents under dry weather conditions. Such an accident could occur, for example, during handling of the cylinders. An estimated 24 lb (11 kg) of UF_6 could be released in such an accident. If this accident occurred at a conversion facility, it was estimated that up to 240 noninvolved workers might suffer potential adverse effects from exposure to HF and uranium (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). The number of affected noninvolved workers for the same accident is greater at the conversion facility than at the current storage sites (Table 5.1) because of the number and closer proximity of the workers at the conversion facility. A different accident was estimated to result in the greatest potential number of irreversible adverse effects among noninvolved workers. The likely conversion accident estimated to result in the greatest total number of irreversible adverse effects would be an accident involving the release of ammonia vapor from a stripping column. If such an accident occurred, up to 40 noninvolved workers might experience irreversible adverse effects (such as organ damage). Exposure to ammonia is expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, 1 noninvolved worker fatality was estimated if the accident occurred (2% of 40).

TABLE 5.4 Estimated Consequences of Chemical Exposures for Accidents under the Long-Term Storage as Oxide Alternative[a]

Receptor[b]	Accident Scenario	Activity	Accident Frequency Category[c]	Effect[d]	Consequence[e] (persons affected)
		Likely Accident(s)			
General public	All accidents	Conversion	L	Adverse effects	0
	All accidents	Conversion	L	Irreversible adverse effects	0
	All accidents	Conversion	L	Potential fatalities	0
Noninvolved workers	Corroded cylinder spill, dry conditions	Conversion	L	Adverse effects	240
	Ammonia stripper overpressure	Conversion	L	Irreversible adverse effects	40
	Ammonia stripper overpressure	Conversion	L	Potential fatalities	1
		Low Frequency-High Consequence Accident(s)			
General public	HF tank rupture	Conversion	I	Adverse effects	41,000
	Ammonia tank rupture	Conversion	I	Irreversible adverse effects	1,700
	Ammonia tank rupture	Conversion	I	Potential fatalities	30
Noninvolved workers	HF tank rupture	Conversion	I	Adverse effects	1,100
	Corroded cylinder spill, wet conditions – water pool	Conversion	EU	Irreversible adverse effects	440
	Corroded cylinder spill, wet conditions – water pool	Conversion	EU	Potential fatalities	4

[a] The accidents listed are those estimated to result in the greatest impacts among all the accidents considered. The impacts for a range of accidents at a conversion facility are listed in Appendix F.

[b] Noninvolved workers are persons working at the site but not involved in hands-on depleted UF_6 management activities. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Potential adverse effects include exposures that could result in mild and transient injury, such as respiratory irritation. Potential irreversible adverse effects include exposures that could result in permanent injury (e.g., impaired organ function) or death. The majority of the adverse effects would be mild and temporary in nature. For HF exposures, it is estimated that less than 1% of the predicted potential irreversible adverse effects would result in fatalities. For exposures to ammonia, it is estimated that about 2% of the predicted irreversible adverse effects would result in fatalities.

[e] The consequence is expressed as the maximum number of individuals with the predicted exposure level sufficient to cause the corresponding health endpoint. The estimated consequences were based on the assumption that the meteorological conditions would be F stability with 1 m/s wind speed, considered to be the worst conditions, and that the wind would be blowing in the direction of the highest worker or public population density.

TABLE 5.5 Estimated Consequences from Radiation Exposures for Accidents under the Long-Term Storage as Oxide Alternative[a]

Receptor[b]	Accident Scenario	Activity	Accident Frequency Category[c]	MEI		Population	
				Dose (rem)	Lifetime Risk of LCF	Dose (person-rem)	Number of LCFs
			Likely Accident(s)				
General public	Corroded cylinder spill, dry conditions	Conversion	L	0.0023	1×10^{-6}	0.3	0.0002
Noninvolved workers	Corroded cylinder spill, dry conditions	Conversion	L	0.077	3×10^{-5}	7.1	0.003
			Low Frequency-High Consequence Accident(s)				
General public	Earthquake	Conversion	EU	0.27	0.0001	20	0.01
Noninvolved workers	Earthquake	Conversion	EU	9.2	0.004	840	0.3

[a] The accidents listed are those estimated to have the greatest impacts among all accidents considered. The impacts for a range of accidents at a conversion facility are listed in Appendix F. The estimated consequences were based on the assumption that the wind would be blowing in the direction of the highest worker or public population density and that weather conditions would limit dispersion.

[b] Noninvolved workers are persons working at the site but not involved in hands-on depleted UF_6 management activities. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr).

The engineering analysis report (LLNL 1997a) gave the frequency of likely accidents as greater than once in every hundred years; for assessment purposes, the specific frequency of likely accidents was assumed to be about once in 10 years (0.1 per year). Therefore, over a 20-year operational period, about 2 such accidents would be expected. Over the operational period of the conversion facility, the maximum accident risk (defined as consequence times probability) of likely accidents would be about 480 noninvolved workers with potential adverse effects and 80 noninvolved workers with potential irreversible adverse effects. The risk of fatalities would be about 2% of the 80 irreversible adverse effects, or about 2 fatalities. The number of noninvolved workers actually experiencing these effects would probably be considerably smaller, depending on the actual circumstances of the accident and the individual chemical sensitivity of the workers.

Conversion accidents that are less likely to occur could have much greater consequences. These rare accidents (low probability of occurrence) could cause adverse effects among both workers and members of the general public living around a conversion facility.

The conversion accident estimated to result in the greatest potential number of adverse chemical effects to members of the general public would be an accident involving rupture of an HF tank. In this accident, a tank was assumed to be ruptured by an earthquake or other major event, releasing about 8,000 lb (3,600 kg) of anhydrous HF. The occurrence of such an accident is considered incredible, expected to occur less than once in 1 million years. If this accident did occur, it was estimated that up to 41,000 members of the general public might experience adverse effects from HF exposure, mostly mild and transient effects such as respiratory irritation. A different accident, also considered incredible, was estimated to result in the greatest number of potential irreversible adverse effects among the general public. An ammonia tank rupture, caused by an earthquake, was assumed to release about 120,000 lb (55,000 kg) of ammonia. If such an accident were to occur, it was estimated that up to 1,700 members of the general public could experience irreversible adverse effects such as organ damage (the HF tank rupture accident would cause fewer than 1,700 irreversible effects). Exposure to ammonia would be expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, about 30 fatalities could occur (2% of 1,700).

Rupture of an HF tank would also cause the greatest potential number of adverse effects among noninvolved workers. An HF tank rupture could cause up to 1,100 noninvolved workers to experience adverse effects, mostly mild and transient effects such as respiratory irritation. However, a corroded cylinder spill accident (under wet conditions) was estimated to result in the greatest potential number of irreversible adverse effects among conversion facility workers. This accident is considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, it was estimated that up to 440 noninvolved workers might experience irreversible adverse effects (such as lung damage) from exposure to HF and uranium. For HF exposure, the number of fatalities would be expected to be less than 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Thus, about 4 fatalities among noninvolved workers could occur (1% of 440).

Although these accidents could have serious consequences to workers and members of the general public, they would not be expected to occur during the lifetime of the conversion facility. The most likely number of people (both workers and the general public) who would suffer from an irreversible adverse health effect or fatality as a result of one of these accidents is estimated to be zero (calculated by be multiplying the consequence times the probability of these accidents).

Radiation Effects. Potential conversion accidents could release uranium, which is radioactive in addition to being chemically toxic. Uranium could be released as UF_6 from cylinders or as uranium oxide. For conversion accidents, the potential impacts from radiation exposures were estimated to be much less than the impacts from chemical exposures. The radiation impacts from potential conversion accidents are given in Table 5.5. For all conversion accidents considered, the radiation doses from released uranium were estimated to be considerably below levels likely to cause radiation-induced effects among noninvolved workers and members of the general public and below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

The accident considered likely (i.e., a frequency greater than once in 100 years) that would have the largest consequences from radiation exposures would be a corroded cylinder spill accident (dry conditions). If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be less than 3 mrem, resulting in an increased risk of death from cancer of about 1 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be less than 1 person-rem, estimated to most likely result in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be 77 mrem, resulting in an increased risk of death from cancer of about 1 in 30,000. The total dose to all noninvolved workers was estimated to be about 7.1 person-rem. This dose to workers was estimated to most likely result in zero LCFs.

The potential conversion accident estimated to result in the largest estimated radiation doses would be an earthquake releasing uranium from an oxide storage building. This accident is considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 270 mrem, resulting in an increased risk of death from cancer of about 1 in 10,000. The total population dose to the general public within 50 miles (80 km) was estimated to be 20 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 9 rem (9,000 mrem), resulting in an increased risk of death from cancer of about 4 in 1,000. The total dose to all noninvolved workers was estimated to be about 840 person-rem. This dose to workers was estimated to most likely result in zero LCFs.

5.3.2 Transportation

Long-term storage as oxide could potentially require the shipment of both radioactive material and chemicals. The major materials assumed to be transported are summarized in Table 5.6. Potential materials transported include depleted UF_6 cylinders, uranium oxide, chemicals required for conversion, and products of conversion. In addition, some shipments of LLW and LLMW produced during processing would be required. The assessment of potential transportation impacts considered both truck and rail shipment options and evaluated impacts from both normal (incident-free) transportation operations and accidents. Because the locations of conversion and long-term storage sites will be evaluated in Phase II studies and NEPA reviews, for purposes of comparison, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. The transportation assumptions and estimated impacts for a range of shipment distances are discussed in detail in Appendix J.

TABLE 5.6 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Long-Term Storage as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (U_3O_8 or UO_2)	Conversion site	Long-term storage site	25,500 – 26,800	8,480 – 8,960	1	1
Ammonia	Supplier	Conversion site	520 (U_3O_8 conversion)	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion sites	Treatment/disposal site	900 - 2,360	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Collocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments when either the truck or rail mode is assumed to be used.

[c] Number of estimated traffic accident fatalities when each shipment is assumed to travel 620 miles (1,000 km) and national average accident statistics are used. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

The transportation assessment was intended to provide a conservative estimate of the potential impacts that could occur. Therefore, it was assumed that all depleted UF_6 cylinders (46,422) would be transported from the three current storage sites to an independent conversion facility. Approximately 11,600 railcar shipments (four cylinders per railcar) or 46,422 truck shipments (one cylinder per truck) would be required. Furthermore, following conversion, the uranium oxide (either U_3O_8 or UO_2) was assumed to be packaged into drums and transported to a long-term storage facility. If all the UF_6 were converted, shipment of the oxide produced would require about 26,000 truck shipments or 9,000 railcar shipments. Collocating conversion and long-term storage facilities would minimize the potential amount of transportation required.

Conversion to oxide might require and might produce chemicals that could have adverse health impacts if accidentally released, primarily ammonia and anhydrous HF. Both ammonia and HF are potentially toxic chemicals commonly transported as liquids in trucks and rail tank cars. Depending on the conversion process, about 500 truck shipments of ammonia to a U_3O_8 conversion facility and up to about 1,100 rail shipments of ammonia to a UO_2 conversion facility would be required over the 20-year operational period. Anhydrous HF could be produced as a by-product of conversion and could be transported to a user. Up to about 5,000 railcars of anhydrous HF would be produced if all the UF_6 were converted to oxide. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

5.3.2.1 Normal Transportation (Incident-Free) Operations

During normal transportation operations, radioactive material and chemicals would be contained in their transport packages. Potential health impacts would be possible from exposure to low-level external radiation in the vicinity of shipments of cylinders and uranium oxide. In addition, exposure to vehicle engine exhaust emissions could cause adverse effects.

The total impacts during normal operations were estimated by assuming that all the cylinders, uranium oxide, process chemicals, and by-products required or produced would be shipped 620 miles (1,000 km). During normal operations, a total of 0 fatalities was estimated among workers and members of the general public, combined, if rail shipments were used, and 1 fatality was estimated if truck shipments were used. Rail transport results in smaller overall impacts because fewer shipments would be required. There would be no difference in impacts from the transportation of U_3O_8 or UO_2. Members of the general public living along truck and rail transportation routes were estimated to receive less than 0.1 mrem, even if a single person were to be exposed to every shipment of radioactive material during the program.

5.3.2.2 Transportation Accidents

Transportation accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public. Potential impacts were estimated for two types of accidents: (1) typical traffic accidents that could cause deaths from physical trauma, unrelated to the cargo being shipped, and (2) accidents that could involve the release of radioactive material or chemicals from a shipment.

5.3.2.2.1 Traffic Accidents with No Release

All shipments could be involved in truck or rail traffic accidents, with a chance that fatalities could result. Historical traffic accident statistics were used to predict the number of traffic fatalities that might result from future shipments. The expected number of traffic fatalities depends on the total number of shipments, the shipment distance, the shipment mode (truck or rail), and the historical accident fatality rates.

The total numbers of traffic fatalities were estimated by assuming that all the cylinders, uranium oxide, process chemicals, and by-products required or produced would be shipped 620 miles (1,000 km) by either truck or rail (see Table 5.6). If truck shipments were used, an estimated 4 traffic fatalities could result; if rail shipments were used, an estimated 2 traffic fatalities could result. Rail transport would result in a lower number of estimated traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

5.3.2.2.2 Traffic Accidents Involving Releases of Radiation or Chemicals

In most accidents, the radioactive material or chemicals being shipped would remain in the transport packages. However, in severe accidents, there is a potential for serious consequences if releases of anhydrous HF, ammonia, and depleted UF_6 (from cylinders) were to occur. If accidentally released, anhydrous HF and ammonia were estimated to have the greatest potential consequences of the materials that might require transportation. The consequences and risks of transportation accidents involving UF_6 cylinders are discussed in Section 5.2.2.2. Severe accidents involving the shipment of uranium oxide could also result in adverse effects from exposure to radiation, although the effects would be considerably less adverse than the consequences of UF_6 cylinder accidents (see Appendix J).

During the shipment of HF or ammonia, a severe accident could cause a release to the air from a truck or railcar. The amount released would depend on the severity and conditions of the accident. The material released could be dispersed downwind, potentially exposing members of the

general public to chemical effects. The consequences would depend on the material released, the amount released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions). The consequences would be greater under stable conditions because the stability of the weather would determine how quickly the released material was dispersed and diluted to lower concentrations as it moved downwind.

The accident estimated to have the highest potential consequences would be a severe rail accident involving a release from a railcar containing anhydrous HF. The consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). The probability of such an accident would depend on the total number of shipments, the distance between the origin and destination sites, and the characteristics of the route. For conversion of the entire UF_6 inventory to oxide, the amount of anhydrous HF produced could be enough to fill about 5,000 railcars. On the basis of assuming that each shipment would travel 620 miles (1,000 km) and using the national average accident statistics for railcars and representative route characteristics, the probability of an accidental HF release in an urban area would be about 1 in 30,000 (3×10^{-4}). If the HF were neutralized to CaF_2, no shipments of HF would be required.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site (including crew members) could potentially suffer irreversible adverse effects from chemical exposure to HF. In a densely populated urban area, it was estimated that up to 30,000 persons might experience irreversible adverse effects such as lung damage. The number of fatalities following HF exposure would be expected to be somewhat less than 1% of the number of potential irreversible adverse effects (Policastro et al. 1997). Thus, up to 300 fatalities could occur (1% of 30,000). If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, resulting in about 1 fatality.

The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF rail accident would be much smaller under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and in lower downwind concentrations. Under unstable conditions, a downwind area of about 1 mi^2 (2 km^2) could be affected by a railcar accident. In such a case, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, including about 30 fatalities, if the accident occurred in an urban area. If the accident occurred in a rural area during unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with less than 1 fatality.

The estimated probability of occurrence of this accident in an urban area is about 0.00003. Therefore, at most, one individual would be estimated to experience an irreversible adverse effect because of this accident over the 20-year shipping period (calculated by multiplying the probability [0.00003] times the consequence [30,000] for an urban area under stable weather conditions). The number of fatalities estimated over the same period would be zero (1% of 1).

Another way to interpret the risk posed by an HF accident is to examine the risk of potential irreversible adverse effects to a specific individual who lived along a transportation route. Following a severe accident under stable weather conditions (which would result in the highest concentrations and consequences), HF air concentrations high enough to cause potential irreversible adverse effects could extend as far as 12 miles (20 km) downwind in a narrow band covering approximately 7 mi^2 (18 km^2). Therefore, an individual living near a route could be affected by an accident that occurred up to approximately 12 miles (20 km) in either direction (although the wind would have to be blowing in the direction of the individual). If all 5,000 HF shipments were along the same route, the probability of a severe HF accident occurring within 12 miles (20 km) in either direction of an individual near the route would be about 0.0005 (1 chance in 2,000) based on national statistics for severe accidents. However, the risk of the individual suffering potential irreversible adverse effects as a result of the accident would actually be less than 1 chance in 2,000 because the estimate was based on the assumption that the wind was blowing in the direction of the individual under stable weather conditions (the wind could be blowing in any direction and stable conditions occur, on average, about one-sixth of the time in the United States).

The consequences discussed for anhydrous HF accidents are meant to provide a conservative estimate of potential impacts. To provide perspective, anhydrous HF is routinely shipped commercially in the United States for industrial applications. Since 1971, the period covered by DOT records (Process Safety Engineering, Inc. 1994), there have been no fatal or serious injuries to members of the general public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars (only one since 1985) have been reported. The amounts of HF released in these incidents were less than 1% of the shipment contents, except in one case. The only major release occurred in 1985 and resulted in approximately 100 minor injuries. The last HF release during transportation was a minor release in 1990. The improved safety record of transporting anhydrous HF in the past 10 years may be attributed to such practices as installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center (CHEMTREC).

Accidents involving ammonia could also result in severe consequences, but much less severe than those for the anhydrous HF accidents discussed above. Some conversion options could require up to about 1,000 railcar shipments over the duration of the program. On the basis of conservative assumptions, a severe railcar accident releasing ammonia in an urban area under stable weather conditions could result in up to 5,000 persons experiencing potential irreversible adverse effects. In a rural area, it was estimated that about 20 persons could experience potential irreversible adverse effects. However, because fewer shipments of ammonia than of anhydrous HF would be

required, the risk associated with ammonia shipments would be less than the risk posed by anhydrous HF shipments. Exposure to ammonia would be expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, up to 100 fatalities could occur (2% of 5,000) for an urban accident and less than 1 fatality for a rural accident (2% of 20). As discussed for anhydrous HF accidents, when the probability of occurrence of ammonia accidents is considered, the number of fatalities that could occur over the 20-year shipping campaign because of a severe ammonia accident was estimated to be zero. Ammonia is also commonly shipped in the United States for industrial applications.

Although accidents involving shipments of LLW and LLMW could occur, the consequences of the most severe accidents involving these materials would not be expected to cause any LCFs from radiation exposures or any irreversible adverse effects from exposure to chemicals.

5.3.3 Air Quality

The analysis of potential impacts on air quality for the long-term storage as oxide alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and long-term storage activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3).

At a conversion facility, air quality impacts would depend on the actual facility location; however, concentrations of criteria pollutants for the representative settings were all estimated to be within standards. Concentrations of PM_{10} during construction were estimated to be as high as 90% of the corresponding standard; procedures to reduce these emissions might have to be implemented during actual construction activities. Concentrations of the other criteria pollutants and HF were estimated to be less than 30% of respective standards during construction and less than 5% of respective standards during operations. An oxide conversion facility would emit between about 2 to 11 lb/yr (0.9 to 5 kg/yr) of uranium as either U_3O_8 or UO_2. No air quality standards exist for uranium compounds; however, potential health impacts of these emissions were evaluated in Section 5.3.1.1.

Concentrations of criteria pollutants and HF from a facility for long-term storage as oxide were estimated to be less than 12% of respective standards for all options.

5.3.4 Water and Soil

Water use during continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as that discussed in Section 5.2.4. At an oxide conversion facility, water use during construction would be between 4 and 12 million gal/yr; maximum water

use during operations would be between 34 and 285 million gal/yr. Wastewater generation would range from about 15 to 140 million gal/yr.

For long-term storage in buildings, vaults, or a mine, water use during construction would be between 0.3 and 1.3 million gal/yr; maximum water use during operations would be about 1.4 million gal/yr. Wastewater generation would range from about 0.1 to 1.4 million gal/yr for all storage options. Impacts to surface water, groundwater, and soil are discussed in Sections 5.3.4.1 through 5.3.4.3.

5.3.4.1 Surface Water

Under the long-term storage as oxide alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as those discussed for storage as UF_6 (Section 5.2.4.1). At an oxide conversion facility, impacts to surface water would depend on the actual location of the facility. However, an assessment of the representative settings considered in the PEIS indicates that impacts to runoff and floodplain encroachment would be negligible. Concentrations of uranium in effluents from a conversion facility would range from about 25 to 400 µg/L. After dilution in nearby surface water, concentrations probably would be much less than the 20 µg/L used as a guideline. Operation of any conversion facility would be contingent on meeting all applicable regulations and site-specific permit requirements.

Although dependent on the actual site location, impacts to runoff and floodplain encroachment during storage as oxide would probably be negligible. An assessment of the representative settings considered in the PEIS indicates that concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 µg/L in the surface waters to which wastewaters would be released.

5.3.4.2 Groundwater

Potential impacts on groundwater quality for continued cylinder storage through 2028 at the current storage sites are discussed in detail in Section 5.2.4.2. Conservative calculations indicated that uranium concentrations in groundwater directly below the sites could reach maximums of 20, 4, and 9 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Groundwater directly beneath the surface contamination source would be unlikely to be used as a drinking water source; estimated maximum concentrations at 1,000 ft (305 m) downgradient were 16, 3, and 8 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. Impacts to groundwater from cylinder preparation would be none to negligible because no releases to groundwater would be expected during operations.

At an oxide conversion facility, the impacts to groundwater would depend on the actual location of the facility. However, an assessment of the representative settings considered in the PEIS indicates that impacts on recharge, depth to groundwater, or direction of flow would be negligible (the maximum increase over current groundwater use was estimated to be 5%). Because discharges to groundwater are not planned (facility effluents would be released to nearby surface waters), there would be no direct impacts to groundwater quality.

For storage as oxide, the potential impacts to groundwater would also depend on the actual location. Potential impacts during construction would include groundwater contamination with construction chemicals. By adopting good engineering practices (e.g., covering material to prevent interaction with rain and promptly cleaning any chemical spills), the potential for adverse impacts to groundwater would be minimized. During operations, impacts to groundwater would be negligible because the building, vault, or mine would isolate contaminants released during normal operations.

5.3.4.3 Soil

Potential impacts on soil from continued cylinder storage through 2028 and from cylinder preparation activities at the current storage sites would be the same as those discussed in Section 5.2.4.3. Impacts on soil at conversion and long-term storage facilities would depend on the facility location. Potential impacts, which would tend to be temporary, would generally result from material excavated during construction that would be left on-site. The largest potential impacts on soil would occur for long-term storage in a mine. Construction of a mine for storage could require excavating between about 1.2 and 2.2 million yd^3 (930,100 to 1.7 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be minor. If a previously existing mine were used for storage, excavation requirements could be significantly reduced, and potential impacts on soil would be much smaller. Potential impacts on soil from a conversion facility or from storage in buildings or vaults would be minor and temporary, much smaller than from storage in a mine.

5.3.5 Socioeconomics

Potential socioeconomic impacts at the current storage sites from continued cylinder storage through 2028 and cylinder preparation activities are discussed in Section 5.2.5. No significant impacts to ROI employment and population growth rates, vacant housing, or public finances would be expected.

The potential socioeconomic impacts of construction and operation of an oxide conversion facility (including impacts from cylinder treatment) would depend on the facility location. Construction activities would create short-term employment (340 to 730 direct jobs and 560 to 1,600 total jobs in the peak construction year); operational activities would create from 330 to

490 direct jobs and from 700 to 1,500 total jobs per year. Direct and total income from construction in the peak year would be from $16 to $33 million and from $19 to $48 million, respectively. During operations, direct and total income would be between $20 and $28 million/yr and from $27 to $42 million/yr, respectively. For the representative settings used for analysis, the employment and income created would represent a change of less than 0.1% of projected growth in these indicators of overall regional activity. The in-migration expected into the region containing an oxide conversion facility would have only a small impact on regional population growth rates. A moderate impact to housing could occur, with about 30% of the projected number of vacant rental housing units in the representative ROIs being required. Small impacts on local public finances would be expected, with all increases over forecasted baseline revenues and expenditures being less than 1%.

The potential socioeconomic impacts of construction and operation of a long-term storage facility would depend on facility location, oxide form (U_3O_8 or UO_2), and whether buildings, vaults, or a mine was selected. Construction activities would create employment (120 to 410 direct jobs in the peak construction year); operational activities would create from 60 to 70 direct jobs per year. Direct income from construction in the peak year would range from $5 to $20 million. During operations, direct income would range from $3 to $4 million/yr. For long-term storage, construction and operations would be occurring concurrently over the 20-year emplacement period.

For the representative settings used for analysis of building and vault options, the employment and income created would represent a change of less than 0.02% of projected growth in these indicators of overall regional activity (see Appendix G, Section G.3.5). The in-migration expected into the region containing an oxide storage facility would have only a small impact on regional population growth rates. Negligible impacts on local public finances would be expected. The impacts for mine storage were calculated for a generic site; therefore, no estimates of indirect impacts on employment and income were made for mine options.

5.3.6 Ecology

Potential ecological impacts of continued storage and cylinder preparation at the current storage sites would be the same as those discussed in Section 5.2.6. For conversion and long-term storage facilities, construction would disturb about 30 to 40 acres (12 to 16 ha) for conversion, 120 to 210 acres (49 to 85 ha) for long-term storage as U_3O_8, and 75 to 110 acres (30 to 45 ha) for long-term storage as UO_2. Existing vegetation at the conversion and long-term storage sites would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; however, some permanent loss of habitat could result. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to ecological resources from facility operations at a conversion or long-term storage site would be negligible to small. The concentrations of radioactive and chemical contaminants in air and water emissions would be considerably below levels considered harmful to vegetation and wildlife.

Facility and transportation accidents (see Sections 5.3.1 and 5.3.2) could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of accident, season, and meteorological conditions.

5.3.7 Waste Management

The impacts on waste management operations from continued storage and cylinder preparation activities at the current sites through 2028 would be the same as those discussed in Section 5.2.7. The operation and construction of a conversion facility would also generate radioactive, hazardous, and sanitary solid wastes. Construction of U_3O_8 and UO_2 conversion facilities would generate a maximum of approximately 115 and 200 m^3, respectively, of hazardous waste. Conversion to U_3O_8 would generate about 140 to 600 m^3/yr of LLW, 1 m^3/yr of LLMW, and 7 m^3/yr of hazardous waste during operations. Conversion to UO_2 would generate about 170 to 740 m^3/yr of LLW, 0 to 18 m^3/yr of LLMW, and 7 to 17 m^3/yr of hazardous waste during operations (ranges are the result of assessing different conversion technologies).

During conversion, nonhazardous solid waste and wastewater generation rates could exceed the current rates at the representative settings considered in the analysis, but the actual facilities would be designed to meet appropriate waste treatment demands. Under the various oxide conversion options, CaF_2 could be produced. It is currently unknown whether this CaF_2 would be sold; whether its low uranium content would allow it to be disposed of as nonradioactive, nonhazardous solid waste; or whether it would have to be disposed of as LLW. The projected low level of uranium contamination (i.e., less than 1 ppm) suggests that sale or disposal as nonradioactive, nonhazardous solid waste would be most likely. If disposed of as nonradioactive, nonhazardous solid waste, approximately 380 to 11,000 m^3/yr would be generated, which would be 18 to 500% of current nonradioactive, nonhazardous solid waste loads at the representative settings; such an increased input could be managed by expanding the capacity for sanitary waste disposal at an actual conversion facility. If CaF_2 were considered to be LLW, it would probably have to be stabilized through grouting prior to disposal, increasing the volume to 21,300 m^3/yr for 20 years. This volume of LLW (up to 426,000 m^3 total) would represent about 10% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e, 4.25 million m^3; see Appendix C, Section C.10). Disposal of CaF_2 as LLW could result in moderate impacts for waste management, if the LLW were considered to be DOE waste. Overall, the waste input resulting from normal operations at a conversion facility might have a moderate impact on waste management operations.

Conversion would also require construction and operation of a cylinder treatment facility. Construction of a cylinder treatment facility would generate about 18 m^3 of hazardous waste. Operation of the treatment facility would generate about 48 m^3/yr of LLW, 0.2 m^3/yr of LLMW, and 2 m^3/yr of hazardous waste; these volumes represent negligible impacts to the waste management system. These volumes exclude the crushed cylinders, which would represent a volume of about 6,200 m^3/yr. It was assumed that the treated crushed cylinders would become part of the DOE scrap metal inventory. If a decision for disposing of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume.

The operation and construction of a long-term oxide storage facility would also generate radioactive LLW and nonradioactive, nonhazardous solid wastes. The generation of LLW would result from the repair or repackaging of failed storage containers (i.e., drums). The long-term storage as oxide alternative would generate a maximum of approximately 20 m^3 of LLW for storage in buildings, vaults, or a mine.

Compared with national and regional waste management capabilities (see Appendix C), the generation of waste under the long-term storage as oxide alternative would have a negligible to moderate impact.

5.3.8 Resource Requirements

Construction and operation of conversion and long-term storage facilities would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantity of commonly used materials is not expected to be significant for conversion or storage for both U_3O_8 and UO_2 and would not affect local, regional, or national availability of these materials. Small to moderate amounts of specialty materials (i.e., Monel, Inconel, and titanium) would be required for construction of conversion facilities; no specialty materials would be required for construction or operation of a long-term storage facility. In general, facility operational requirements are not resource intensive, and the resources required are not considered rare or unique. However, for storage in a mine, large quantities of electrical energy would be required during construction (up to 1,000 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would depend on the location of the facility and the existing infrastructure. If a previously existing mine were used for storage, excavation and construction requirements would probably be reduced, and, depending on the characteristics and condition of the mine, the electrical requirements might also be reduced.

5.3.9 Land Use

Potential impacts for continued storage and cylinder preparation at the current storage sites would be the same as those discussed in Section 5.2.9. Impacts on land use for conversion and long-term storage facilities would depend on the locations of the facilities. The amount of land required would range from about 30 to 40 acres (12 to 16 ha) for conversion, 120 to 210 acres (49 to 85 ha) for long-term storage as U_3O_8, and 75 to 110 acres (30 to 45 ha) for long-term storage as UO_2, constituting potential land use impacts ranging from negligible to moderate. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres (380 ha) around the facility. For storage in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. The potential for such impacts would be evaluated in the Phase II analyses and NEPA reviews. Impacts to land use outside the boundaries of facilities would be limited to temporary traffic impacts associated with construction.

5.3.10 Cultural Resources

Potential impacts to cultural resources during continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as those discussed in Section 5.2.10. The impacts to cultural resources for conversion and long-term storage facilities cannot be determined until the locations of the facilities are selected. However, impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.3.11 Environmental Justice

Potential environmental justice impacts from continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as those discussed in Section 5.2.11. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and long-term storage facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.4 USE AS URANIUM OXIDE

The use as uranium oxide alternative considers the use of 100% of the depleted UF_6 inventory. Under the use as uranium oxide alternative, it was assumed for assessment purposes that the depleted UF_6 would be converted to UO_2, which would be used in the manufacture of casks for storing spent nuclear fuel or HLW. (Although storage casks were assumed for assessment purposes,

other uses for depleted uranium are possible). The uranium oxide in the storage casks would serve as radiation shielding. The casks would be transported to a user facility, such as a commercial nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. To provide a conservative estimate of potential transportation and construction impacts, the conversion, manufacturing, and use facilities were assumed to be at different locations. Issues associated with depleted uranium management after use are discussed in Section 5.9.

The following is a summary of the activities analyzed under the use as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped to an independent conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options were considered for cylinders not meeting transportation requirements: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites.

- ***Conversion (Representative Site).*** Conversion of UF_6 to an oxide, assumed to be UO_2 for assessment purposes, was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[2] As described in Appendix F, three representative conversion technologies were assessed for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the UO_2 produced was assumed to be transported in drums by truck or rail to a manufacturing site. In addition, HF or CaF_2 would require transportation to either a user or disposal facility. The uranium-oxide-shielded casks were

[2] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

assumed to be transported by rail from the manufacturing facility to a user site.

- ***Manufacture and Use (Representative Site).*** The manufacture of uranium oxide shielded casks was assumed to take place at a stand-alone facility dedicated to the cask manufacturing process. Casks would be manufactured and sent to a user facility, such as a nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. Manufacturing was assumed to occur concurrently with conversion (i.e., from 2009 through 2028). Preoperation of manufacturing facilities would occur between 1999 and 2008 (with actual construction requiring 7 years).

During use of depleted-uranium-concrete casks, impacts would be expected to be negligible. No release of depleted uranium would be expected during use because the uranium would be a solid material encased between thick stainless steel shells. In addition, radiation emitted from the uranium shielding material would be shielded by the steel cask shells and would be negligible compared with the highly radioactive spent nuclear fuel or HLW contained within the casks during use. Finally, the use of a radiation shield implies that there would be a net benefit because the radiation levels would be reduced.

5.4.1 Human Health and Safety

During implementation of the use as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a cask manufacturing facility. Potential impacts are discussed in Sections 5.4.1.1 and 5.4.1.2.

5.4.1.1 Normal Facility Operations

5.4.1.1.1 Workers

The total radiation exposure of involved workers under the use as uranium oxide alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and manufacture of oxide-shielded storage casks for use. At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a cask manufacturing facility, involved workers would be exposed to radiation during the manufacture of casks. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The number of potential radiation-induced LCFs among involved workers from 1999 through 2039 was estimated to range from about 1 to 2, compared with 1 for the no action alternative. In addition to about 60 cylinder yard workers, between 290 and 470 involved workers would be required for the use as oxide alternative (the exact number would depend on the cylinder preparation and conversion options selected). Impacts to noninvolved workers would be negligible compared to those for the involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment, as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and at a cask manufacturing facility).

5.4.1.1.2 General Public

The potential impacts to members of the general public during normal operations would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a cask manufacturing facility from depleted UF_6 management activities. At the current storage sites, potential impacts to the members of the general public would be the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative.

At an oxide conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 2 to 10 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different UO_2 conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among the general public. The maximum radiation dose to an individual near a UO_2 conversion site was estimated to be less than about 0.03 mrem/yr from airborne emissions, well within the applicable health standards (see Section 5.2.1.1.2). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a cask manufacturing facility, the potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. The total radiation dose to the general public (2009 through 2028) was estimated to be about 0.1 person-rem, which would be expected to most likely result in zero LCFs. The maximum radiation dose to an individual near a manufacturing site was estimated to be less than 0.001 mrem/yr from airborne emissions, well within the applicable health standards (see Section 5.2.1.1.2). No noncancer health effects from chemical exposures would be expected — the hazard index for an individual near a manufacturing facility was estimated to be less than 0.00001.

5.4.1.2 Facility Accidents

5.4.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the use as oxide alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and cask manufacturing facilities. The number of fatalities and injuries would depend on the specific cylinder preparation and conversion options.

Considering all conversion and manufacturing options, from 2 to 3 total accidental worker fatalities were estimated over the 41-year period. Approximately 1,300 to 2,000 injuries (defined as injuries resulting in lost workdays) were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 640 worker injuries were estimated to occur at a cask manufacturing facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.4.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the use as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at an oxide conversion site, and at a cask manufacturing site. At each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix H, Section H.3.2, for cask manufacturing.

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are described in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. Although the use as oxide alternative would involve only conversion to UO_2, compared to UO_2 and U_3O_8 for the long-term storage as oxide alternative, the only difference in the results of the accident assessment would be in the radiological consequences for an earthquake accident at a conversion facility. The consequences of that accident were estimated to be somewhat less at a UO_2 conversion facility than at a U_3O_8 conversion facility (see Appendix F, Tables F.8 and F.9).

At a uranium oxide cask manufacturing facility, the potential consequences of all the accidents considered were estimated to be much less than potential conversion or cylinder accidents (see Appendix H, Section H.3.2). For all cask manufacturing accidents, chemical exposures of noninvolved workers and members of the general public were estimated to be much less than levels expected to cause adverse effects. The radiation dose to a maximally exposed noninvolved worker from an accident was estimated to be about 80 mrem, with a corresponding risk of death from cancer of about 1 chance in 30,000 (0.00003). The dose to a maximally exposed member of the general public was estimated to be less than 3 mrem, considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents. The risk of death from cancer to an individual from this dose would be about 1 chance in 1 million. No LCFs were estimated to occur among noninvolved workers or members of the general public for the highest consequence accident evaluated. As described in Section 4.3.2.1, fatalities and injuries among involved workers are possible for all accidents.

5.4.2 Transportation

The major materials assumed to be transported under the use as oxide alternative are summarized in Table 5.7. The transportation activities for the use as oxide alternative would be very similar to those described for the long-term storage as oxide alternative in Section 5.3.2. For both alternatives, it was assumed that cylinders would be transported from the current storage sites to an oxide conversion facility. The two alternatives differ in the destination of the uranium oxide after conversion: it would be shipped either to a long-term storage facility or to a cask manufacturing

TABLE 5.7 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Use as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (UO_2)	Conversion site	Manufacturing site	26,260 – 26,800	8,480 – 8,800	1	1
Ammonia	Supplier	Conversion site	–	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion/manu-facturing sites	Treatment/disposal site	1,220 – 2,680	–	0	0
Casks	Manufacturing site	User	–	9,600	–	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

facility. However, because the locations of future long-term storage and cask manufacturing sites will be decided in Phase II of the management program, in both cases the potential impacts from these shipments were estimated assuming a representative route of 620 miles (1,000 km). Although the long-term storage as oxide alternative would involve both U_3O_8 and UO_2, the transportation risks would be very similar for shipments of U_3O_8 and UO_2 (see Appendix J, Section J.3.5, Tables J.11 through J.14). Consequently, the estimated impacts from shipments of oxide under the use as oxide alternative are almost identical to the impacts discussed in Section 5.3.2 for the long-term storage as oxide alternative. Both alternatives would also require the transportation of essentially the same amounts of process chemicals (ammonia), products of conversion (anhydrous HF or CaF_2), and

waste generated during processing. Thus, the potential impacts for shipments of these materials would be the same as those described in detail in Section 5.3.2 during both normal conditions and accidents.

In addition to the materials and impacts discussed in Section 5.3.2, the use as oxide alternative would also require the shipment of casks from the manufacturing facility to a user. These casks, because of their large size, were assumed to be shipped by rail. A maximum of about 9,600 railcar shipments would be required to transport all the casks to users. The risk associated with cask shipments would be from typical traffic accidents, unrelated to the depleted uranium contained in the casks (external radiation dose rates would be extremely low near a cask and only negligible releases of uranium would be expected in extremely severe accidents because the uranium would be a solid encased between steel shells). If the 9,600 casks were shipped by rail over a distance of 620 miles (1,000 km), it was estimated on the basis of rail accident statistics that less than 1 traffic fatality would result. For comparison, shipment of all the cylinders, uranium oxide, and associated materials was estimated to potentially result in between 2 and 4 traffic fatalities, depending on whether truck or rail shipments would be used (see Section 5.3.2). Consequently, the estimated overall risks from transportation for the use as oxide alternative are essentially the same as those described for the long-term storage as oxide alternative.

5.4.3 Air Quality

The analysis of potential impacts on air quality from the use as oxide alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and manufacturing activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3). At a conversion facility, air quality impacts would be the same as discussed under the long-term storage as oxide alternative (Section 5.3.3).

At a cask manufacturing facility, air quality impacts would depend on the actual facility location; however, concentrations of criteria pollutants were all estimated to be within standards at the representative sites considered. Concentrations of criteria pollutants were estimated to be less than 9% of standards during construction and operations. The oxide cask manufacturing facility would emit 0.02 lb/yr (0.008 kg/yr) of uranium as UO_2. No air quality standards exist for uranium compounds; however, the potential health impacts of these emissions were evaluated in Section 5.4.1.1.

5.4.4 Water and Soil

Water use from continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.4. At a conversion facility, water use

would be the same as described in Section 5.3.4. At a cask manufacturing facility, water use during facility construction (duration of about 7 years) would be 35 million gal/yr, and water use during operations would be about 7.5 million gal/yr. Wastewater generation would range from about 5 million gal/yr during operations to 8 million gal/yr during construction.

5.4.4.1 Surface Water

Under the use as oxide alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a conversion facility, potential impacts to surface water would be the same as discussed for long-term storage as oxide (Section 5.3.4.1).

At a cask manufacturing facility, water use and wastewater generation during operations would be less than half that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.4.4.2 Groundwater

Potential impacts on groundwater quality for continued cylinder storage through 2028 and for cylinder preparation activities at the three current storage sites would be the same as discussed in Section 5.2.4.2. At a conversion facility, the potential impacts would be the same as discussed in Section 5.3.4.2. Groundwater impacts at a cask manufacturing facility would depend on the size of the site in comparison with the size of the facility, on the proximity of the site to a river with relatively large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the manufacturing facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for these facilities (effluents would be released to nearby surface waters), there would be no direct impacts on groundwater quality. Good engineering and construction practices would be followed to minimize the potential for adverse effects during construction.

5.4.4.3 Soil

Potential impacts on soil at the current storage sites and at a conversion facility would be the same as discussed in Sections 5.2.4.3 and 5.3.4.3, respectively. Potential impacts at a manufacturing facility would depend on the actual location of the facility. Depending on the location of facilities and the amount of land area available, construction activities could cause changes in site topography, permeability, erosion potential, and soil quality. However, mitigative actions (e.g., contouring and reseeding excavated material, construction of retention basins, and prompt cleanup of chemical spills) would probably result in negligible impacts to soil.

5.4.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities at the three current storage sites are discussed in Section 5.2.5. Socioeconomic impacts for an oxide conversion facility are summarized in Section 5.3.5.

The potential socioeconomic impacts of construction and operation of an oxide cask manufacturing facility would depend on the facility location. Construction of a cask manufacturing facility would create 160 direct jobs and $7 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operation.

5.4.6 Ecology

Potential ecological impacts of continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.6. Potential impacts at a conversion facility would be the same as discussed in Section 5.3.6.

A cask manufacturing facility would require about 90 acres (36 ha). Existing vegetation at the site would be destroyed during land-clearing activities. In addition, wildlife could be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the location of the facility; in general, a loss of 90 acres would constitute a potential moderate adverse impact in terms of habitat loss. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility location. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents (see Sections 5.4.1 and 5.4.2) could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of accident, season, and meteorological conditions.

5.4.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current sites are discussed in Section 5.2.7; waste management impacts at a conversion facility, including treatment of empty cylinders, are discussed in Section 5.3.7.

The operation of a cask manufacturing facility would generate about 130 m^3/yr of LLW, 290 m^3/yr of hazardous waste, and 250 metric tons/yr of nonradioactive, nonhazardous solid waste; an additional 72 m^3 of hazardous waste and 60,000 m^3 of nonradioactive, nonhazardous solid waste

would be generated during construction. The LLW generated would be only about 0.2% of the LLW projected annual treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr; see Appendix C, Section C.10).

5.4.8 Resource Requirements

Resource requirements for continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.8. Resource requirements for a conversion facility are discussed in Section 5.3.8. For a cask manufacturing facility, the total quantity of commonly used materials required for construction and operation would not be significant. Specialty materials would not be required. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique.

5.4.9 Land Use

Land-use impacts from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.9. Impacts on land use for conversion are discussed in Section 5.3.9. The amount of land required would be about 90 acres (36 ha) for a cask manufacturing facility, constituting potential moderate land use impacts. The potential for such impacts would be evaluated in the site-specific Phase II studies and NEPA reviews. Impacts to land use outside the boundaries of facilities would consist of potential temporary traffic impacts associated with project construction.

5.4.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the three current storage sites are discussed in Section 5.2.10. The impacts to cultural resources for conversion and manufacturing facilities would depend on the specific locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided as necessary and appropriate.

5.4.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as those discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and manufacturing facilities would depend on the actual locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who

would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.5 USE AS URANIUM METAL

The use as metal alternative considers the use of 100% of the depleted UF_6 inventory. The use as uranium metal alternative would be very similar to the use as oxide alternative, except under the metal alternative, the depleted UF_6 would be converted to uranium metal, which was assumed to be used in the manufacture of casks for storing spent nuclear fuel or HLW. The uranium metal would serve as radiation shielding. The casks would be transported to a user facility, such as a commercial nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. Issues associated with the management of depleted uranium after use are discussed in Section 5.9.

The following is a summary of the activities analyzed under the use as uranium metal alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped to an independent conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options were considered for cylinders not meeting transportation requirements: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites.

- ***Conversion (Representative Site).*** Conversion of UF_6 to uranium metal was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[3] As described in Appendix F, two representative conversion technologies were assessed for conversion to uranium metal. The principal product of conversion would be either HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal. In

[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

addition, conversion to metal would also potentially produce MgF_2, which would be disposed of as nonhazardous, nonradioactive waste or LLW.

- ***Transportation (Representative Routes).*** For assessment purposes, it was assumed that all UF_6 cylinders would be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the uranium metal produced would be transported by truck or rail to a manufacturing site. In addition, MgF_2 and either HF or CaF_2 would require transportation to either a user or disposal facility. The casks would be transported by rail from the manufacturing facility to a user site.

- ***Manufacture and Use (Representative Site).*** The manufacture of uranium-metal-shielded casks was assumed to take place at a stand-alone facility dedicated to the cask manufacturing process (see Appendix H). Casks would be fabricated and sent to a user facility, such as a nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel. Manufacturing was assumed to occur concurrently with conversion (i.e., from 2009 through 2028). Preparation of manufacturing facilities would occur between 1999 and 2008 (with actual construction requiring 7 years).

The potential environmental consequences of all of the activities under the use as metal alternative, as outlined above, are discussed in Sections 5.5.1 through 5.5.11.

5.5.1 Human Health and Safety

During implementation of the use as metal alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a cask manufacturing facility. These impacts are discussed in Sections 5.5.1.1 and 5.5.1.2.

5.5.1.1 Normal Facility Operations

5.5.1.1.1 Workers

The total radiation exposure of involved workers under the use as uranium metal alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and manufacture of metal-shielded casks for use. At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting,

cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a metal conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium metal. At a cask manufacturing facility, involved workers would be exposed to radiation during the manufacture of casks. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The number of potential radiation-induced latent cancer fatalities among involved workers from 1999 through 2039 was estimated to range from about 1 to 2, compared with 1 for the no action alternative. In addition to about 60 cylinder yard workers, from 390 to 690 involved workers would be required for the use as metal alternative (the exact number would depend on the cylinder preparation and conversion options selected). Impacts to noninvolved workers would be negligible compared to those for involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from any airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a cask manufacturing facility).

5.5.1.1.2 General Public

The potential impacts to members of the general public during normal operations for the use as metal alternative would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards (40 CFR Part 61; DOE Order 5400.5). No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a metal conversion facility, or near a cask manufacturing facility from depleted UF_6 management activities. At the current storage sites, potential impacts to members of the general public under the use as uranium metal alternative would be the same as described in Section 5.2.1.1.2.

At a metal conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 0.3 to 8 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different metal conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among members of the general public. The maximum radiation dose to an individual near a metal conversion site was estimated to be less than 0.03 mrem/yr from airborne emissions, well within the

applicable health standards (see Section 5.2.1.1.2). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a cask manufacturing facility, the potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. The total radiation dose to the general public (2009 through 2028) was estimated to be about 0.7 person-rem, resulting in zero LCFs. The maximum radiation dose to an individual near a manufacturing site was estimated to be less than 0.002 mrem/yr from airborne emissions, well within applicable health standards (see Section 5.2.1.1.2). No noncancer health effects from chemical exposures would be expected — the hazard index for an individual near a manufacturing facility was estimated to be less than 0.00001.

5.5.1.2 Facility Accidents

5.5.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the use as metal alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and cask manufacturing facilities. The number of fatalities and injuries would depend on the specific cylinder preparation and conversion options.

The number of accidental fatalities and injuries would be similar to the use as oxide alternative; a total of 2 to 3 accidental worker fatalities were estimated over the 41-year period. Approximately 1,300 to 2,100 injuries (defined as injuries resulting in lost workdays) were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three

sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 670 worker injuries were estimated to occur at a cask manufacturing facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.5.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the use as metal alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at a metal conversion site, and at a cask manufacturing site. For each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix H, Section H.3.2, for cask manufacturing.

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are discussed in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. For the use as metal alternative, UF_6 would be converted to uranium metal rather than uranium oxide. However, the types and consequences of accidents at a metal conversion facility would be generally similar to those at an oxide conversion facility (see Appendix F, Section F.3.2). Differences between oxide conversion and metal conversion accident consequences are highlighted below.

For conversion to metal, the most severe chemical accidents would be the same as described for conversion to oxide: rupture of either an ammonia tank or an HF tank. The potential consequences of these low-probability accidents are described in Section 5.3.1.2.2. Among the accidents considered likely to occur at each facility, metal conversion accidents were estimated to have slightly lower chemical consequences to workers compared with oxide conversion accidents. At most, 5 noninvolved workers were estimated to experience potential irreversible adverse effects from likely metal conversion accidents, compared with 40 during conversion to oxide, with no noninvolved worker fatalities (this difference results because conversion to metal would not involve a potential ammonia stripper accident). For both conversion to oxide and metal, members of the general public would not be expected to experience adverse effects from likely accidents because off-site concentrations of released materials were estimated to be below levels expected to cause such effects. Injuries and fatalities among involved workers are possible for all accidents (see Section 4.3.1).

For the metal conversion accidents considered likely to occur, the consequences from radiation exposures would be the same as those described in Section 5.3.1.2.2. However, the radiological consequences of the most severe (low-probability) metal conversion accidents were estimated to be much less than those described for conversion to oxide accidents in Section 5.3.1.2.2.

Much of the difference in predicted consequences between accidents involving U_3O_8 and accidents involving uranium metal is associated with the form of the material. U_3O_8 is an easily dispersed powder, whereas on uranium metal billets, only the oxide coating can be readily dispersed. Therefore, the assumed release amounts for some of the accidents at metal conversion facilities are considerably lower than those assumed for oxide conversion facilities. At a metal conversion facility, the accident estimated to have the highest consequences from radiation exposures would be a fire involving three UF_6 cylinders, which is considered extremely unlikely (estimated to occur between once in 10,000 years and once in 1 million years). If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 15 mrem (compared with 270 mrem for the highest-consequence oxide conversion accident), resulting in an increased risk of death from cancer of about 7 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be 56 person-rem, resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 20 mrem (compared with 9,000 mrem for oxide conversion), resulting in an increased risk of death from cancer of about 8 in 1 million. The total dose to all noninvolved workers was estimated to be about 8 person-rem, resulting in zero LCFs.

At a uranium metal cask manufacturing facility, the potential consequences of the accidents considered were estimated to be less than those for potential conversion or cylinder accidents (see Appendix H). For all likely accidents, chemical concentrations were estimated to be below levels that would cause adverse effects among workers and members of the general public. In addition, the chance of a radiation-induced cancer fatality among noninvolved workers and members of the general public was estimated to be much less than 1 in 1 million if a likely accident occurred.

The metal cask manufacturing facility accident estimated to have the highest potential consequences was an accident involving the failure of a uranium metal furnace caused by an earthquake. Such an accident is considered incredible, occurring less than once in 1 million years. If such an accident occurred, it was estimated that up to 1 member of the general public and 4 noninvolved workers could experience adverse effects from chemical exposures, with no fatalities expected. If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 7 mrem, resulting in an increased risk of death from cancer of about 4 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be 1.9 person-rem, resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to range up to 230 mrem, resulting in an increased risk of death from cancer of about 9 in 100,000. The total dose to all noninvolved workers was estimated to be about 0.087 person-rem. (The dose to the MEI noninvolved worker was estimated to be greater than the population dose among workers because the MEI worker was assumed to be at the location of maximum possible impact, very close to the accident. The worker population distribution was assumed to be evenly distributed over a large area.) All doses would be considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

5.5.2 Transportation

The major materials assumed to be transported under the use as metal alternative are summarized in Table 5.8. The transportation activities would be very similar to those described for the use as oxide alternative in Section 5.4.2. All cylinders were assumed to be transported from the current storage sites to a conversion facility. The uranium metal would be transported from the conversion facility to a cask manufacturing facility. The transportation of process chemicals (ammonia), products of conversion (anhydrous HF and MgF_2), and waste generated during processing would also be required. The casks were assumed to be transported from the manufacturing facility to a user by rail.

The overall impacts from transportation activities were estimated to be generally similar to those described for the long-term storage as oxide (Section 5.3.2) and use as oxide alternatives (Section 5.4.2). During normal transportation operations, it was estimated that up to 1 fatality could occur among workers and members of the general public from exposure to external radiation and vehicle exhaust emissions if truck shipments were used; if rail shipments were used, 0 fatalities were estimated during normal operations. The estimated number of fatalities from traffic accidents (unrelated to the cargo) are presented in Table 5.8. If truck shipments were used, it was estimated that about 3 traffic fatalities could result. If rail shipments were used, it was estimated that about 2 traffic fatalities could result. Rail transport results in a lower number of traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced. Details are provided in Appendix J.

Transportation risks would also be associated with the potential release of radiation or chemicals during accidents. The materials of greatest concern would be anhydrous HF, ammonia, and depleted UF_6 cylinders. The consequences and risks of accidents involving releases of these materials are described in detail in Section 5.3.2. Conversion to metal would result in about one-third the number of shipments of anhydrous HF compared with conversion to oxide.

5.5.3 Air Quality

The analysis of potential impacts to air quality for the use as metal alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and manufacturing activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3).

At a metal conversion facility, air quality impacts would depend on the actual facility location; however, estimated concentrations of criteria pollutants for the representative settings were all estimated to be within standards. Concentrations of the criteria pollutants and HF were estimated to be less than 20% of respective standards during construction and less than 5% of respective

TABLE 5.8 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Use as Metal Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium metal	Conversion site	Manufacturing site	20,840 – 21,500	7,360 – 7,520	1	0
Ammonia	Supplier	Conversion site	–	920	0	0
Anhydrous HF	Conversion site	User	–	1,640	0	0
MgF_2	Conversion site	Disposal site	10,320 – 10,780	3,800 – 3,980	0	0
LLW/LLMW	Current storage/ conversion/manu-facturing sites	Treatment/disposal site	2,460 – 6,060	–	0	0
Casks	Manufacturing site	User	–	9,060	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

standards during operations. A metal conversion facility would emit between about 4 and 11 lb/yr (1.8 and 5 kg/yr) of uranium as either U_3O_8 or UF_4. No air quality standards exist for uranium compounds; however, potential impacts of these emissions were evaluated in Section 5.5.1.1.

At a metal cask manufacturing facility, impacts on criteria pollutant emissions from construction and operation would be identical to those discussed for the use of uranium oxide alternative (Section 5.4.3). The metal cask manufacturing facility would emit 0.1 lb/yr (0.05 kg/yr) of uranium as U_3O_8. No air quality standards exist for uranium compounds; however, the potential impacts of these emissions were evaluated in Section 5.5.1.1.

5.5.4 Water and Soil

Water use from continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as discussed in Section 5.2.4. At a metal conversion facility, water use during construction (duration of about 4 years) would be between 10 and 12 million gal/yr; maximum water use during operations would be about 55 million gal/yr. Wastewater generation would range from about 25 to 30 million gal/yr. At a cask manufacturing facility, water use during construction (duration of about 7 years) would be 43 million gal/yr, and water use during operations would be about 7 million gal/yr. Wastewater generation would range from about 5 million gal/yr during operations to 9 million gal/yr during construction.

5.5.4.1 Surface Water

Under the use as metal alternative, potential impacts on surface water at the current storage sites during continued cylinder storage and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a metal conversion facility, impacts to surface water would depend on the actual location of the facility. However, based on the assessment for the representative settings considered in the PEIS, impacts to runoff and floodplain encroachment would be negligible. Concentrations of uranium in effluents from a conversion facility would range from about 25 to 53 µg/L. After dilution in nearby surface water, concentrations would be much less than the guideline of 20 µg/L.

At a cask manufacturing facility, water use and wastewater generation during operations would be less than half that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.5.4.2 Groundwater

Potential impacts on groundwater quality from continued cylinder storage through 2028 and cylinder preparation activities at the current storage sites are discussed in Section 5.2.4.2. For conversion to metal and for cask manufacturing, the impacts on groundwater would depend on the actual locations of the facilities. However, the assessment for conversion to metal at representative settings indicated that impacts on recharge, depth to groundwater, or direction of flow would probably be negligible (the maximum increase over current groundwater use at the representative settings was estimated to be 0.8%). Impacts to these parameters for the manufacturing facility would depend on the size of the site in comparison with the facility, on the proximity of the site to a river with relatively large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the manufacturing facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for either conversion or manufacturing facilities (effluents would be released to nearby surface waters), direct impacts to groundwater quality would be unlikely. Good engineering and construction practices

would be followed to minimize the potential for adverse impacts on groundwater resources during construction.

5.5.4.3 Soil

Potential impacts on soil at the current storage sites would be the same as discussed in Section 5.2.4.3. Potential impacts on soil at conversion to metal and manufacturing facilities would depend on their actual locations. Depending on the location of facilities and the amount of land area available, construction activities could cause changes in site topography, permeability, erosion potential, and soil quality. However, mitigative measures (e.g., contouring and reseeding excavated material, construction of retention basins, and prompt cleanup of chemical spills) would result in the impacts to soil being negligible.

5.5.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities at the current storage sites are discussed in Section 5.2). The potential socioeconomic impacts of construction and operational activities of a metal conversion facility (including impacts from cylinder treatment) would depend on the facility location. Construction activities would create short-term employment (480 to 540 direct jobs and 760 to 1,100 total jobs in the peak construction year); operational activities would create between 340 and 500 direct jobs and between 780 and 1,200 total jobs per year. Direct and total income in the peak construction year would range from $17 to $21 million and from $20 to $31 million, respectively. During operations, direct and total income would range from $20 to $28 million and from $28 to $41 million per year, respectively. Employment and income totals given include estimates for a cylinder treatment facility.

For the representative settings used for analysis, the employment and income created from conversion to metal would represent a change of less than 0.1% of projected growth in these indicators of overall regional activity. The in-migration expected into the region of a metal conversion facility would have only a low impact on regional population growth rates. A moderate impact to housing could occur, with about 22% of the projected number of vacant rental housing units in the representative ROIs being required. Low impacts on local public finances would be expected; with all increases over forecasted baseline revenues and expenditures being less than 1%.

The potential socioeconomic impacts of construction and operation of a metal cask manufacturing facility would depend on facility location. Construction would create 190 direct jobs and $9 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operations.

5.5.6 Ecology

The potential ecological impacts of continued cylinder storage and cylinder preparation at the three current storage sites are discussed in Section 5.2.6. Depending on the types of facilities, construction would disturb about 30 to 35 acres (12 to 14 ha) for a metal conversion facility and 90 acres (36 ha) for a manufacturing facility. Existing vegetation at the conversion and manufacturing sites would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; in general, losses of 35 and 90 acres would constitute potential moderate adverse impacts in terms of habitat loss. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents could result in adverse impacts to ecological resources (see Sections 5.5.1 and 5.5.2). The affected species and degree of impact would depend on a number of factors such as location of accident, season, and meteorological conditions.

5.5.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current storage sites are discussed in Section 5.2.7. During construction of the metal conversion facility, a maximum of approximately 180 m^3/yr of hazardous waste would be generated. During operations, about 190 to 1,900 m^3/yr of LLW, 1 m^3/yr of LLMW, and 7 to 10 m^3/yr of hazardous waste would be generated (ranges are the result of assessing different conversion technologies). Operation of the metal conversion facility would generate up to about 6,800 m^3/yr of nonradioactive, nonhazardous solid waste; about 90% of this would be MgF_2 produced in the conversion process. Nonradioactive, nonhazardous solid waste generation rates for conversion could exceed the current rates at the representative settings considered in the analysis, but the actual facilities would be designed to meet appropriate waste treatment demands. A cylinder treatment facility would also be required for the emptied cylinders; impacts of such a facility are discussed in Section 5.3.7.

It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonradioactive, nonhazardous solid waste. The uranium level in the MgF_2 is estimated to be about 90 ppm (LLNL 1997a). Disposal as LLW might require the MgF_2 waste to be grouted, generating up to 12,300 m^3/yr of LLW for disposal. This volume would represent less than 6% of the projected DOE complexwide LLW disposal volume, constituting a low impact with respect to DOE complexwide LLW management if the LLW were considered to be DOE waste. For the metal conversion option, neutralization of HF to produce CaF_2 could result in approximately 3,500 m^3/yr of CaF_2. It is currently unknown if the CaF_2 would be sold, disposed of as nonradioactive, nonhazardous solid waste, or disposed of as LLW. If disposed

of as DOE LLW, the CaF_2 would constitute approximately 3% of the projected DOE complexwide LLW disposal volume.

The operation of a metal manufacturing facility would generate about 650 m^3/yr of LLW, 320 m^3/yr of hazardous waste, and 300 metric tons/yr of nonhazardous waste; an additional 80 m^3 of hazardous waste and 70,000 m^3 of nonradioactive, nonhazardous waste would be generated during construction. The LLW generated would be about 0.3% of the projected annual treatment volume for all DOE facilities nationwide.

5.5.8 Resource Requirements

Resource requirements for continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.8. Construction and operation of facilities under the use as metal alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantity of commonly used materials is not expected to be significant and would not affect local, regional, or national availability of these materials. Some specialty materials (i.e., up to 100 tons of Monel, 4 tons of Inconel, and 10 tons of titanium) would be required for construction of conversion facilities; specialty materials would not be required for construction of manufacturing facilities. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique.

5.5.9 Land Use

Land-use impacts from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.9. Impacts on land use for conversion and manufacture would depend on the locations of these facilities. The amount of land required would range from about 30 to 35 acres (12 to 14 ha) for a conversion facility and 90 acres (36 ha) for a manufacturing facility, constituting potential moderate land use impacts. A protective action distance for emergency planning would need to be established around a metal conversion facility. This protective action distance would incorporate an area of about 960 acres (384 ha) around the facility. The potential for such impacts would be evaluated in the Phase II studies and NEPA reviews. Impacts to land use outside the boundaries of facilities would consist of potential temporary traffic impacts associated with project construction.

5.5.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.10. The impacts to cultural resources for metal conversion and manufacturing facilities would depend on specific

locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.5.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of metal conversion and manufacturing facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.6 DISPOSAL AS URANIUM OXIDE

Under the disposal as uranium oxide alternative, depleted UF_6 would be chemically converted to a more stable oxide form and disposed of belowground as LLW. Prior to disposal, conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone facility dedicated to the conversion process. Potential disposal impacts were evaluated for two different uranium oxides, U_3O_8 and UO_2 (similar to the long-term storage as oxide alternative). Both oxide forms have low-solubility in water and are relatively stable over a wide range of environmental conditions (see Appendix A). For each form, several disposal options were considered, including disposal in shallow earthen structures, belowground vaults, and an underground mine. To provide a conservative estimate of potential impacts, the conversion and disposal facilities were assumed to be located at sites other than the three current cylinder storage sites. Thus, transportation of cylinders from the three current storage sites to a conversion facility, and transportation of uranium oxide from the conversion facility to a disposal facility, was assumed.

Two physical waste forms were considered in the PEIS, ungrouted and grouted uranium oxide. Ungrouted waste refers to U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process. This bulk material would be disposed of in either 55-gal (208-L) drums for U_3O_8 or 30-gal (110-L) drums for UO_2. Grouted waste refers to the solid material obtained by mixing the uranium oxide with cement and repackaging it in drums. Grouting is intended to increase structural strength and stability of the waste and to reduce the solubility of the waste in water. However, because cement is added to the uranium oxide, grouting would increase the total volume requiring disposal. Grouting of waste was assumed to occur at the disposal facility.

The potential impacts from disposal were estimated for two phases: (1) the operational phase, which includes the construction and operation of facilities and is the period during which drums would be actively placed into disposal units, and (2) the post-closure phase, which extends

up to 1,000 years in the future after the assumed failure of the disposal units. No matter how well designed, all disposal facilities would be expected to release material to the environment (or "fail") eventually. In general, shallow earthen structures would be expected to contain waste material for at least several hundred years before failure, and vaults and mines would be expected to last even longer. For purposes of analysis in this PEIS, failure of all three types of disposal facilities was assumed to occur at the end of a period of institutional control, 100 years after closure. Because of the infiltration of water, uranium could ultimately migrate through the soil and eventually contaminate the groundwater. The potential impacts during the post-closure phase would result from using contaminated groundwater that could affect members of the general public.

The estimated impacts associated with the disposal alternative are subject to a great deal of uncertainty — especially during the post-closure phase. In general, the degree of uncertainty associated with potential post-closure impacts is greater than that for the other impacts considered in the PEIS. The analysis of post-closure impacts considered an extremely long period of time and was based on predicting the behavior of the uranium material after disposal as it interacts with soil and water in a complex and changing environment. Consequently, the estimated impacts are very dependent on the assessment assumptions. Key assumptions included such factors as soil characteristics, water infiltration rates, depth to the underlying groundwater table, chemistry of different uranium compounds in the soil, and locations of future human receptors. These factors could vary widely, depending on site-specific conditions. In response, the assumptions used in the PEIS were generally selected in a manner intended to produce conservative estimates of impacts, that is, the assumptions tend to overestimate the potential impacts.

The following is a summary of the activities analyzed for the disposal as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to an independent conversion facility. The cylinder management activities that were assumed to occur at the sites would be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options for cylinders not meeting transportation requirements were considered: (1) a cylinder overcontainer option and (2) a cylinder transfer option. The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three current storage sites.

- ***Conversion (Representative Site).*** Conversion was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[4] As described in Appendix F, two representative conversion technologies were assessed for conversion to U_3O_8, and three for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the U_3O_8 or UO_2 produced was assumed to be transported in drums by truck or rail to a disposal facility. In addition, HF and CaF_2 would require transportation to either a user or disposal facility.

- ***Disposal (Generic Site).*** Three options were considered for the disposal of oxide, including disposal in shallow earthen structures, vaults, or a mine (see Appendix G). Drums of oxide would be received and disposed of at the disposal facility from 2009 through 2028. Construction of the disposal units would continue over a 20-year period while the drums were being received. Grouting would also occur at the disposal facility, if necessary.

The potential environmental consequences of all of the activities under the disposal as uranium oxide alternative, as outlined above, are provided in Sections 5.6.1 through 5.6.11.

5.6.1 Human Health and Safety

During implementation of the disposal as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a disposal facility. These impacts are discussed in Sections 5.6.1.1 and 5.6.1.2.

5.6.1.1 Normal Facility Operations

5.6.1.1.1 Workers

The total radiation exposure of involved workers under the disposal as oxide alternative would be greater than under the no action alternative because of the additional activities required for

[4] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

preparation of cylinders for shipment, conversion operations, and disposal operations. Impacts to workers would only occur during the operational phase of disposal.

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a disposal facility, involved workers would be exposed to radiation during the placement of drums of uranium oxide into the disposal areas or during the grouting of waste. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The estimated numbers of potential radiation-induced LCFs among involved workers from 1999 through 2039 are summarized in Figure 5.4, assuming that the oxide would be grouted before disposal, and in Figure 5.5, assuming that the oxide would not be grouted. A total of about 1 to 2 additional LCFs were estimated among the involved worker population, compared with 1 LCF for the no action alternative. (The impacts to noninvolved workers were estimated to be negligible compared to involved workers.) The impacts to involved workers would be similar for the disposal of U_3O_8 and UO_2, with slightly higher doses estimated for the disposal of grouted waste compared to ungrouted waste because of the additional worker activities required by grouting. The impacts to involved workers also would be similar for disposal in shallow earthen structures, vaults, or a mine because all three options would involve handling the same amount of radioactive material and require the same general types of activities.

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a disposal facility).

5.6.1.1.2 General Public

Potential impacts to members of the general public were estimated for the operational phase of the disposal as oxide alternative, which is the time that UF_6 would be converted to oxide and actively disposed of, and for the post-closure (long-term) phase, defined to be within 1,000 years in the future after the disposal facility was assumed to fail.

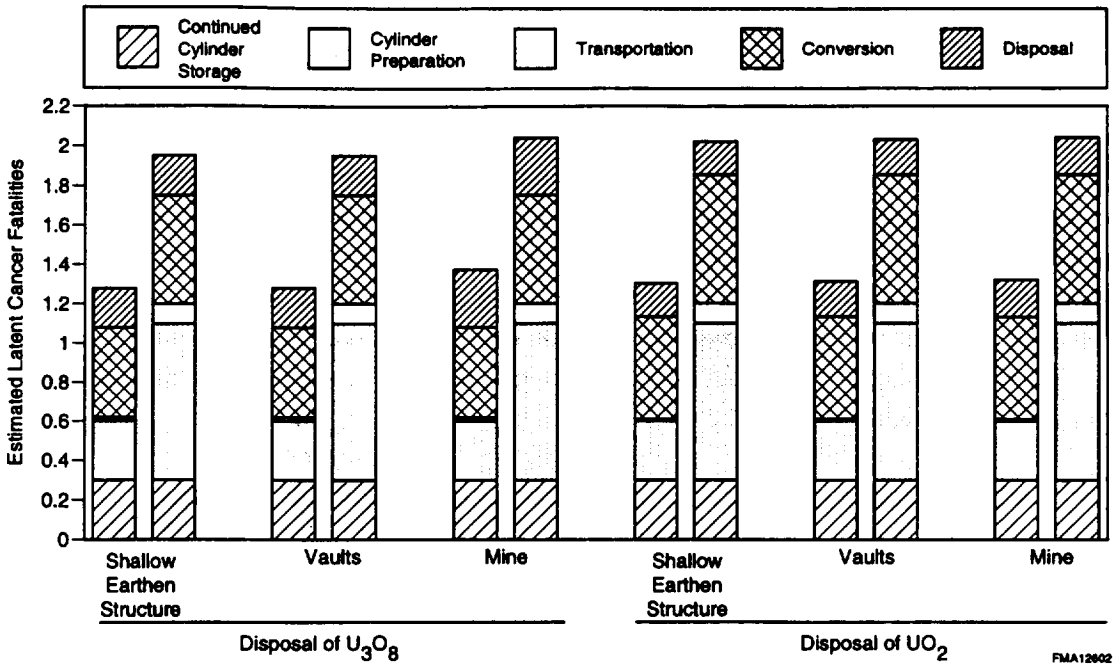

FIGURE 5.4 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Disposal as Oxide Alternative, Assuming Grouted Waste, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

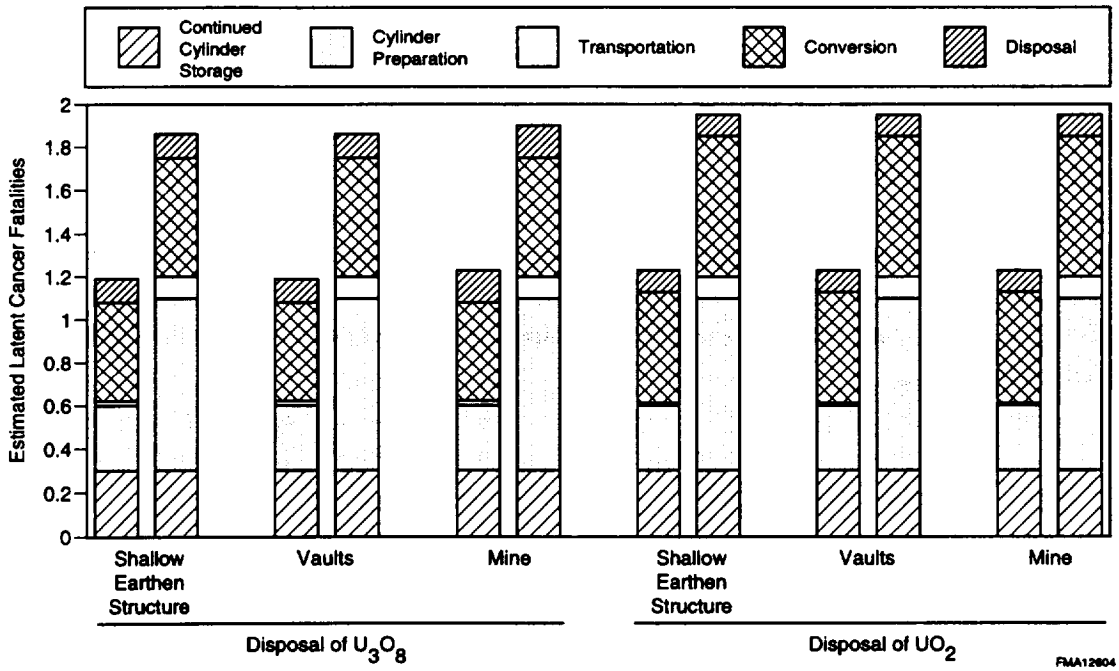

FIGURE 5.5 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Disposal as Oxide Alternative, Assuming Ungrouted Waste, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

Operational Phase. The potential impacts to members of the general public during the operational phase of the disposal as oxide alternative would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a disposal facility from depleted UF_6 management activities.

At the current storage sites, potential impacts to members of the general public under the disposal as uranium oxide alternative would be exactly the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative. In addition, impacts to members of the general public in the vicinity of an oxide conversion facility would be the same as those described for the long-term storage as oxide alternative in Section 5.3.1.1.2.

At a disposal facility, potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. During the disposal of ungrouted oxide, the drums would be disposed of without being reopened at the disposal facility; therefore, no releases would be expected during normal operations, and no off-site impacts to members of the general public would occur. Small airborne releases of uranium (through process filters) would occur if the oxide were grouted because the drums would be opened and the oxide mixed with cement prior to disposal. The total radiation dose to the general public (1999 through 2039) in the vicinity of a disposal site from airborne releases was estimated to be about 0.2 person-rem, resulting in zero LCFs. The maximum radiation dose to an individual near a disposal site was estimated to be about 0.05 mrem/yr from airborne emissions, well within applicable health standards (40 CFR Part 61; DOE Order 5400.5). No noncancer health effects from chemical exposures would be expected — the estimated hazard index for an individual near a disposal site was estimated to be less than 0.0002.

Post-Closure Phase (Long-Term Impacts). Potential impacts to members of the general public near the disposal site would be possible in the future if the groundwater became contaminated or if a person inadvertently intruded on the disposal facility. The extent of possible groundwater contamination would depend on the location and characteristics of the disposal site, such as the annual rainfall rate, the depth to the groundwater, and soil properties, as well as on the design of the disposal facility. Because of site selection and design considerations, groundwater contamination would not be expected to occur until hundreds to thousands of years after the disposal facility had been closed.

The potential effects on human health in the future were estimated by assuming that a person lived at the edge of the disposal site and used groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. In addition, it was assumed that, at some point in the future, the engineered barriers of the disposal facility would fail, allowing uranium to be released into the soil. To address uncertainties related to the disposal site properties, the facility was assumed to be located at either a dry setting (typical of the western United States) or a wet setting (typical of the eastern

United States). In addition, it was assumed that the site had soil properties that permitted uranium to either move rapidly through the soil (mobile situation) or slowly through the soil (immobile situation). The potential radiation doses from future groundwater contamination were based on the estimated groundwater concentrations discussed in Section 5.6.4.2 and Appendix I, Section I.4.

In a dry setting, the groundwater analysis indicated that measurable groundwater contamination would not occur until more than 1,000 years after failure of the disposal facility, even if the uranium were assumed to move rapidly through the soil. Groundwater contamination would not occur within 1,000 years because of the small amount of rainfall typical of a dry setting and the resulting small amount of water that would infiltrate the disposal facility. In addition, a large distance to the groundwater table would be expected in a dry environment. Therefore, no radiation or chemical exposures of members of the general public from contaminated groundwater would be expected within 1,000 years following failure of a disposal facility in a dry environment.

In a typical wet setting, groundwater contamination was estimated to occur within 1,000 years after failure of the disposal facility for shallow earthen structures, vaults, and mines. The maximum radiation dose to an individual assumed to use contaminated groundwater was estimated to be about 100 mrem/yr if the soil properties were such that the uranium moved rapidly through the soil. If the depleted uranium was classified as LLW, the radiation doses from using contaminated groundwater would exceed the dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices were calculated to range up to 10, indicating the potential for chemically induced adverse effects. However, impacts from using contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

In addition to possible exposures resulting from the use of contaminated groundwater, health impacts could result if a person inadvertently intruded or if the cover material (i.e., soil) above the disposal facility eroded away. The radiation dose was estimated to be as high as 10 rem/yr for a hypothetical future resident living on the disposal site in such a case (see Appendix I, Section I.4). Chemical health effects from uranium exposure could also be possible. Erosion of the cover material would probably not occur until several thousands of years after closure of a shallow earthen structure or vault disposal facility and would probably not occur at all for a mine disposal facility. If cover materials were to erode away, radiation exposures could be easily mitigated by adding new cover material. These considerations would be addressed in more detail during disposal facility design, site selection, licensing activities, and Phase II analyses and NEPA reviews if disposal were selected as the preferred alternative.

5.6.1.2 Facility Accidents

5.6.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the disposal as oxide alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater for the disposal as oxide alternative than the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and disposal facilities. The number of fatalities and injuries would depend on the specific cylinder preparation, conversion, and disposal options selected.

Considering all options, a range of 1 to 3 accidental worker fatalities from construction and operation of facilities were estimated over the 41-year period. The estimated number of accidental injuries (defined as injuries resulting in lost workdays) are shown in Figure 5.6. Approximately 700 to 1,800 injuries were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 100 to 450 worker injuries were estimated to occur at a disposal facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.6.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the disposal as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at an oxide conversion site, and at a disposal site. For each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix I, Section I.3.2, for disposal.

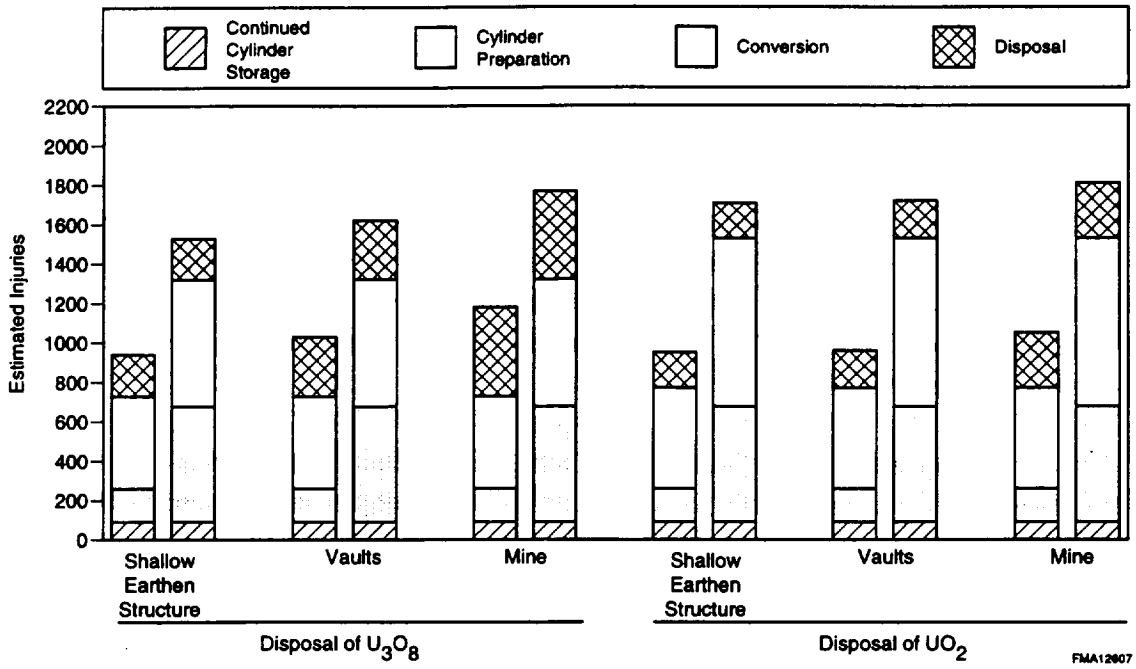

FIGURE 5.6 Total Estimated Number of On-the-Job Injuries (defined as injuries resulting in lost workdays) among All Workers from Construction and Operation of Facilities for the Disposal as Oxide Alternative, 1999 through 2039 (The two bars for each option represent the minimum and maximum impacts estimated.)

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are described in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. At a disposal facility, the potential consequences of all the accidents considered were estimated to be much less than potential conversion or cylinder accidents (see Appendix I). The disposal facility accident estimated to have the highest potential consequences was an earthquake accident during grouting operations that would release uranium oxide. This accident is considered unlikely. If such an accident occurred, potential chemical exposures of members of the general public were estimated to be much less than levels expected to cause adverse effects. Among noninvolved workers, up to 1 worker could experience adverse effects (mostly mild and transient effects) from chemical exposure to uranium, with no fatalities expected. This accident could also result in radiation exposures of workers and members of the general public. Among noninvolved workers, zero LCFs were estimated to be caused by radiation exposure if the accident did occur. Similarly, among members of the general public, zero radiation-induced LCFs were estimated if the accident occurred. The dose to any member of the general public was estimated to be considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

5.6.2 Transportation

The major materials assumed to be transported under the disposal as oxide alternative are summarized in Table 5.9. The transportation activities assumed to be required for the disposal as oxide alternative are the same as those described for long-term storage as oxide alternative in Section 5.3.2. The two alternatives differ only in the destination of the uranium oxide after conversion: it would either be shipped to a long-term storage facility or to a disposal facility. Because the locations of future storage or disposal sites will be evaluated in Phase II studies and NEPA reviews, in both cases the potential impacts from these shipments were estimated assuming a representative route of 620 miles (1,000 km). Therefore, the estimated impacts are the same for the two alternatives.

TABLE 5.9 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Disposal as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (U_3O_8 or UO_2)	Conversion site	Disposal site	25,500 – 26,800	8,480 – 8,960	1	1
Ammonia	Supplier	Conversion site	520 (U_3O_8 conversion)	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion sites	Treatment/disposal site	900 – 2,360	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

In summary, it was assumed that cylinders would be transported from the current storage sites to an oxide conversion facility and the uranium oxide would be transported to a disposal facility (rather than a long-term storage facility). Process chemicals (ammonia), products of conversion (anhydrous HF or CaF_2), and any waste generated was also assumed to be transported. The impacts of these shipments during both normal and accident conditions are described in detail in Section 5.3.2.

5.6.3 Air Quality

The analysis of potential impacts on air quality for the disposal alternative considered the potential for air pollutant emissions from continued cylinder storage through 2028, cylinder preparation activities, conversion, and disposal activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts for the disposal as oxide alternative would be the same as those discussed for the long-term storage as UF_6 alternative (Section 5.2.3). For conversion to oxide, air quality impacts would be the same as discussed for the long-term storage as oxide alternative (Section 5.3). Air quality impacts from construction and operation of a disposal facility would depend on the actual facility location. Based on analyses for a generic setting of typical size for this type of facility, the concentrations of criteria pollutants were estimated to be within applicable standards. The criteria pollutant with the highest potential emissions would be NO_x; concentrations of NO_x were estimated to be within standards and guidelines, even when combining the effects of construction and operational activities which would be conducted simultaneously.

For disposal options that include grouting the waste, operation of a waste form facility would emit about 0.6 lb/yr (0.3 kg/yr) or 1.1 lb/yr (0.5 kg/yr) of uranium for grouted U_3O_8 and grouted UO_2 options, respectively. No air quality standards exist for uranium compounds; however, potential health impacts of these emissions were evaluated in Section 5.3.1.1.

5.6.4 Water and Soil

Water use for continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.4. At a conversion facility, water use would be the same as discussed in Section 5.3.4. For disposal, construction and operations would be occurring concurrently over the 20-year disposal period. Water use for construction would range from 0.2 to 2.8 million gal/yr; water use for operations would range from 0.1 to 20 million gal/yr. The upper ends of the ranges correspond to options for disposing of grouted wasteforms because the grouting operations would require larger amounts of water. Wastewater generation would range from about 0.1 to 0.2 million gal/yr for construction and from 0.1 to 1.3 million gal/yr for operations.

5.6.4.1 Surface Water

Under the disposal alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a conversion facility, potential impacts to surface water would be the same as discussed for the long-term storage as oxide alternative (Section 5.3.4.1). At a disposal site, water use and wastewater generation would be approximately half or less than that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.6.4.2 Groundwater

5.6.4.2.1 Operational Phase

Potential impacts on groundwater quality at the current storage sites from continued cylinder storage and cylinder preparation activities would be the same as discussed in Section 5.2.4.2. At a conversion facility, the potential impacts would be the same as discussed in Section 5.3.4.2. Potential groundwater impacts at a disposal facility would depend on the size of the site in comparison with the facility, on the proximity of the site to a river with fairly large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the disposal facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for these facilities, there would be no direct impacts on groundwater quality. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction.

5.6.4.2.2 Post-Closure Phase (Long-Term Impacts)

For disposal, impacts on groundwater in the distant future would depend on the location of the facility. If the disposal facility were located in a dry environment typical of the western United States, groundwater impacts in the form of elevated uranium concentrations (i.e., concentrations greater than the proposed drinking water standard of 20 μg/L) would not occur for at least 1,000 years after failure of the facility. However, for a disposal facility in a wet environment, typical of the eastern United States, groundwater quality could be affected by contamination migrating from the disposal facility within 1,000 years after failure of the engineered barriers.

For purposes of analysis, if no sustained effort was made to maintain a disposal facility, failure of the facility (defined as the release of uranium material to the surrounding soil) was assumed to occur 100 years after closure (see Appendix I). This failure could be caused by natural

degradation of the disposal structures over time, primarily from physical processes such as the intrusion of water. With good engineering, disposal facilities would actually be unlikely to fail for several hundred years or more.

Following failure, the release of uranium from the facility would occur very slowly as water moved through the disposed material. The amount of groundwater contamination, as well as the length of time it would take for the groundwater to become contaminated, would depend on the integrity of the drums and the engineered barriers, whether or not the waste was grouted, and site-specific properties of the soil surrounding the disposal facility. Without more precise information concerning the expected duration of effectiveness for the containers and engineered barriers in the specific disposal facility environment, as well as site-specific soil and hydrological properties, the potential groundwater concentrations are subject to a large degree of uncertainty.

For a generic wet setting, if the soil properties were such that the uranium moved relatively rapidly through the soil, the uranium concentration in the groundwater beneath the facility 1,000 years after facility failure was estimated to range from about 230 to 425 pCi/L (910 to 1,700 μg/L) for disposal of U_3O_8 and from about 190 to 320 pCi/L (760 to 1,300 μg/L) for disposal of UO_2. These uranium concentrations would exceed the guideline of 20 μg/L used for comparison. If the uranium moved less rapidly through the soil surrounding the disposal facility, uranium concentrations in the groundwater beneath the facility after 1,000 years could be much less than the guideline value. However, the concentrations would increase with time, ultimately approaching the concentrations discussed for the mobile situation, and exceeding the guideline.

For both U_3O_8 and UO_2, larger groundwater concentrations were estimated over the long term for disposal of grouted waste compared with ungrouted waste because grouting would increase the waste volume, essentially exposing a larger cross section of material to infiltrating water. However, further studies using site-specific soil characteristics would be necessary to determine the effect of grouting on long-term waste mobility. Grouting might reduce the dissolution of the waste and subsequent leaching of uranium into the groundwater in the first several hundred years after failure. However, over longer periods, the grouted form would be expected to deteriorate and, because of the long half-life of uranium, the performance of grouted and ungrouted waste would be essentially the same. Depending on soil properties, it is also possible that grouting could increase the solubility of the uranium material, resulting in more rapid groundwater contamination.

The potential impacts on groundwater would be essentially similar for disposal in shallow earthen structures, vaults, and or a mine because of the long time periods considered and the fact that the calculations were performed for 1,000 years after each facility was assumed to fail. However, shallow earthen structures would be expected to contain the waste material for a period of several hundred years before failure, and vaults and a mine would be expected to last even longer. Therefore, vault and mine disposal would provide greater protection in a wet environment. In addition, a vault or a mine would be expected to provide additional protection against erosion of the cover material

(and possible exposure of the waste material) compared with shallow earthen structures. The exact time that any disposal facility would perform as designed would depend on the specific facility design and site characteristics.

5.6.4.3 Soil

Potential impacts on soil at the current storage sites and at a conversion site would be the same as discussed in Sections 5.2.4.3 and 5.3.4.3, respectively. Impacts at a disposal facility would depend on the actual location. Potential impacts, which would tend to be temporary, would generally result from the material excavated during construction that would be left on-site. The largest potential impacts on soil would occur from excavation for disposal. Construction for disposal could require excavating from about 300,000 to 2.6 million yd^3 (230,000 to 2.0 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return the soil to its former condition, and the impacts would be minor. If a previously existing mine were used for disposal, excavation requirements could be significantly reduced, and potential impacts on soil would be much less.

5.6.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities are discussed in Section 5.2.5. Socioeconomic impacts for an oxide conversion facility are summarized in Section 5.3.5. The potential socioeconomic impacts of construction and operation of a disposal facility (including the waste form facility) would depend on the facility location, facility type (i.e., shallow earthen structure, vault, or mine), and whether grouted or ungrouted oxide was disposed of. Construction would create from 65 to 770 direct jobs and from $3.5 to $42 million in direct income during the peak year of construction. Operation of the disposal facility would create from 60 to 180 direct jobs and produce from $6 to $18 million in direct income in each year of facility operation. For disposal, construction and operations would be occurring concurrently over the 20-year disposal period.

5.6.6 Ecology

5.6.6.1 Operational Phase

Potential impacts to ecological resources from continued storage through 2028 at the current storage sites are discussed in Section 5.2.6. Depending on the types of facilities, construction would disturb about 30 to 40 acres (12 to 16 ha) for conversion, 46 to 470 acres (18 to 190 ha) for disposal

as U_3O_8, and 30 to 150 acres (12 to 61 ha) for disposal as UO_2. Existing vegetation at a conversion or disposal site would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; in general, losses of 40 and 470 acres would constitute potential moderate and potential large adverse impacts in terms of habitat loss, respectively. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents, as discussed in Sections 5.6.1 and 5.6.2, could also result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of accident, season, and meteorological conditions.

5.6.6.2 Post-Closure Phase (Long-Term Impacts)

Potential impacts to aquatic biota could occur in the future if the disposal facility were to fail. Failure of facility integrity could result in contamination of groundwater at a wet setting within 1,000 years, as described in Section 5.6.4.2. Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium calculated for 1,000 years after facility failure would range up to about 425 pCi/L. Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range, although the resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d for aquatic organisms, as specified in DOE Order 5400.5. These potential ecological impacts, which correspond to the groundwater concentration estimated for 1,000 years after failure of the disposal facility, are highly uncertain and would depend on site-specific characteristics and on whether aquatic biota would actually contact contaminants.

5.6.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current sites are discussed in Section 5.2.7; waste management impacts of conversion at representative settings are discussed in Section 5.3.7. The maximum disposal volume of material would result from the disposal of grouted U_3O_8, approximately 312,000 m^3 over the duration of the program. This amount would represent approximately 7% of the projected DOE complexwide LLW disposal volume over the same approximate period (see Appendix C, Section C.10). If the U_3O_8 were not grouted, about 150,000 m^3 would be disposed of, representing about 3.5% of the projected DOE disposal volume. The volume of UO_2 disposed of would be approximately 72,000 m^3 if

grouted and 48,000 m^3 if ungrouted, representing less than 2% of the projected DOE disposal volume in either case. Although these amounts of waste would be appreciable, it is expected that disposal would have only a low impact on DOE's total LLW disposal capabilities.

5.6.8 Resource Requirements

Resource requirements for continued cylinder storage, cylinder preparation, and conversion to oxide are discussed in Section 5.3.8. Construction and operation of facilities under the disposal alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. Specialty materials would not be required for construction of disposal facilities. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique. However, for disposal in a mine, large quantities of electrical energy would be required during construction (up to 1,100 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would depend on the location of the facility and the existing infrastructure. If a previously existing mine were used for disposal, excavation and construction requirements would probably be reduced, depending on the characteristics and condition of the mine, and the electrical requirements would be subsequently reduced.

5.6.9 Land Use

Land-use impacts at the current cylinder storage sites from continued storage and cylinder preparation activities are discussed in Section 5.2.9. Impacts on land use for conversion and disposal would depend on the locations of the facilities. The amount of land required would range from about 30 to 40 acres (12 to 16 ha) for conversion, 46 to 470 acres (18 to 190 ha) for disposal of U_3O_8, and 30 to 150 acres (12 to 61 ha) for disposal of UO_2, constituting potential impacts to land use ranging from negligible to large. The large range for disposal results from two factors: (1) differences in the amounts of land required for shallow earthen structures, vaults, and mine disposal facilities; and (2) differences caused by whether the material is grouted (mixed with cement) or ungrouted prior to disposal. Grouting of the oxide would approximately double the amount of land required for disposal because the volume requiring disposal would increase. The smallest amount of land required for disposal would be for disposal of ungrouted UO_2 in shallow earthen structures, with the largest amount of land required for disposal of grouted U_3O_8 in a mine. For disposal in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. The potential for such impacts would be evaluated in site-specific NEPA documentation. Potential impacts to land use outside the boundaries of facilities would consist of temporary traffic impacts associated with project construction.

5.6.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the three existing sites are discussed in Section 5.2.10. The impacts to cultural resources for conversion and disposal facilities would depend on specific locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary.

5.6.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and disposal facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.7 PREFERRED ALTERNATIVE

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. The impacts of alternative strategies that would involve 100% use as oxide or 100% use as metal were analyzed and presented in Sections 5.4 and 5.5, respectively. Under the preferred alternative, conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The percentage of the depleted UF_6 inventory that would be used as oxide or converted and used as metal could vary. Additionally, most of the inventory would likely require interim storage as depleted uranium oxide pending use. Therefore, the impacts of the preferred alternative could involve a combination of the alternatives evaluated in the PEIS. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide (henceforth called the combination strategy) was also analyzed and is discussed in this section. DOE has no preference regarding the actual percentages of the inventory that would be used as oxide or as metal; the 25% values used in this analysis were chosen for purposes of analysis.

In this PEIS, the use as oxide alternative assumed that UO_2 oxide would be used as radiation shielding in storage casks for spent nuclear fuel or HLW. However, current technology research and development on the use of uranium oxide as shielding material shows that the U_3O_8

oxide form could also be used, although somewhat less efficiently because of its lower density. In the analyses of potential impacts of the combination strategy presented in the following sections (Sections 5.7.1 through 5.7.11), the impacts for the conversion to oxide alternative and long-term storage as oxide alternative are therefore given as a range of impacts for either U_3O_8 or UO_2. The impacts from the manufacture and use as oxide were calculated and are presented for the UO_2 form only; these impacts are considered to be representative of impacts for manufacture and use as oxide in general.

The impacts of the combination strategy would include impacts during continued cylinder storage; preparation of cylinders for shipment; conversion of UF_6 to uranium oxide (U_3O_8 or UO_2) and metal; treatment of empty cylinders; manufacture of uranium oxide and uranium metal casks; long-term storage of uranium oxide (U_3O_8 or UO_2); and transportation of cylinders, conversion products (oxide, metal, HF or CaF_2, ammonia, and waste), and casks. The potential impacts of this alternative were calculated by combining the impacts from each of the individual components, as appropriate. Certain impacts, such as the dose to an MEI, are not additive because the MEI at each site would be different, and the future facilities were assumed to be built at separate sites (except for the continued storage and cylinder preparation activities, which were both assumed to occur at the current storage sites; and the conversion and cylinder treatment activities, which would likely occur at the same site). The values for potential impacts estimated for the combination alternative (as discussed in the following sections) were obtained from Appendix D (Section D.4) for the continued cylinder storage component, Appendix E for the cylinder preparation component, and Appendix K (Sections K.1–K.6) for the other components.

5.7.1 Human Health and Safety — Normal Operations

5.7.1.1 Radiological Impacts

Involved Workers. The calculation of radiological impacts to involved workers is outlined below. The impacts are first presented for each of the individual components and then summed, as appropriate, to provide an estimate of the total radiological impact.

Continued Cylinder Storage. Potential radiological impacts during continued cylinder storage at the three current storage sites are the same as those previously estimated for the action alternatives (Section D.4.1.1); that is, 720 person-rem.

Cylinder Preparation. The total collective dose to involved workers would range from 835 person-rem for use of cylinder overcontainers for all cylinders from all three sites to 2,170 person-rem for transfer of all cylinders to new cylinders at the three sites (Section E. 3.1.1).

Conversion. The doses to workers from conversion for various throughput rates are provided in Figure K.5 for conversion to U_3O_8, Figure K.11 for conversion to UO_2, and in Figure K.17 for conversion to uranium metal. From these data, the estimated collective involved worker doses for conversion of 75% of the inventory to oxide and 25% to uranium metal are as follows:

Annual dose to workers from conversion of 75% of the inventory to U_3O_8
= 34 person-rem/yr

Total worker dose from conversion to U_3O_8 = 34 person–rem/yr
× 20 years = 680 person-rem

Annual dose to workers from conversion of 75% of the inventory to UO_2
= 40 to 46 person-rem/yr

Total worker dose from conversion to UO_2 = 40 to 46 person-rem/yr
× 20 years = 800 to 920 person-rem

Range for conversion of 75% of the inventory to oxide: 680–920 person-rem

Annual dose to workers from conversion of 25% of the inventory to metal
= 15 to 50 person-rem/yr

Total worker dose from conversion to metal = 5 to 50 person-rem/yr
× 20 years = 300 to 1,000 person-rem

Cylinder Treatment. The collective dose to workers from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Figure K.23. It was assumed that two treatment facilities would be required, one for a 75%-capacity oxide conversion facility and one for a 25%-capacity metal conversion facility. On this basis, the estimated doses to workers are as follows:

Annual dose to workers from treatment of 75% of the cylinder inventory
= 13 person-rem/yr

Annual dose to workers from treatment of 25% of the cylinder inventory
= 7 person-rem/yr

Total worker dose from cylinder treatment = 13 + 7 person-rem/yr
× 20 years = 400 person-rem

Long-Term Storage. The doses to workers for long-term storage as oxide at various throughput rates are provided in Section K.3.1.1. From these data, the estimated collective involved worker doses for long-term storage of 50% of the inventory as oxide are as follows:

Annual dose to workers from long-term storage of 50% of the inventory as U_3O_8
= 15 person-rem/yr (from Figure K.33)

Annual dose to workers from long-term storage of 50% of the inventory as UO_2
= 9 person-rem/yr (from Figure K.31)

Range for long-term storage of 50% of the inventory as oxide
= 9 to 15 person-rem/yr × 31 years = 280 to 465 person-rem

Manufacture and Use. The doses to workers from manufacture and use for various throughput rates are provided in Figure K.41 for manufacture of UO_2-shielded casks and in Figure K.47 for manufacture of uranium metal-shielded casks. From these data, the estimated worker doses for manufacture of 25% of the inventory to oxide shielded casks and 25% to metal-shielded casks are as follows:

Annual dose to workers from manufacture of 25% of the inventory to UO_2 casks
= 10 person-rem/yr

Total worker dose from manufacture of UO_2 casks
= 10 person-rem/yr × 20 years = 200 person-rem

Annual dose to workers from manufacture of 25% of the inventory to metal casks
= 2 person-rem/yr

Total worker dose from manufacture of metal casks
= 2 person-rem/yr × 20 years = 40 person-rem

Total Radiological Impacts to Workers. The total collective radiation dose to involved workers was calculated by summing the collective doses from the individual components. The individual contributions, as well as the total dose, are summarized in Table 5.10. In addition, the number of radiation-induced health effects was estimated by multiplying the collective dose by a health risk conversion factor of 4×10^{-4} LCF/person-rem for involved workers. The total LCFs among workers were estimated to range from one to two over the duration of the program. Similar to the 100% use as oxide, 100% use as metal, and 100% long-term storage as oxide alternatives, the radiological impacts to noninvolved workers were estimated to be negligible compared with those to involved workers.

TABLE 5.10 Range of Radiological Doses and Latent Cancer Fatalities among Involved Workers for the 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage Combination Strategy[a]

Component	Collective Dose (person-rem)
Continued cylinder storage	720
Cylinder preparation	840 – 2,200
Oxide conversion	680 – 920
Metal conversion	300 – 1,000
Cylinder treatment	400
Long-term storage	280 – 470
Manufacture of oxide casks	200
Manufacture of metal casks	40
Total dose	3,500 – 6,000
Latent cancer fatalities[b]	1 – 2

[a] Values rounded to 2 significant figures.

[b] The number of latent cancer fatalities was calculated using a health risk conversion factor of 4×10^{-4} LCF/person-rem for workers. Values rounded to one significant figure.

General Public. The collective radiation dose to members of the general public was calculated in a manner similar to that outlined above for involved workers, as follows:

Collective dose to public from continued cylinder storage (Table D.1)
= 1.1 person-rem

Collective dose to public from cylinder preparation (Tables E.1, E.2, and E.3)
= 0 to 0.006 person-rem

Collective dose to public from conversion to oxide (Figures K.1 and K.7)
= 0.6 to 9 person-rem

Collective dose to public from conversion to metal (Figure K.13)
= 0 to 3 person-rem

Collective dose to public from cylinder treatment (Figure K.19)
= 0.007 person-rem

Collective dose to public from long-term storage (Section K.3.1.2)
= approximately 0 because emissions are negligible

Collective dose to public from manufacture of oxide casks (Figure K.37)
= 0 to 0.02 person-rem

Collective dose to public from manufacture of metal casks (Figure K.43)
= 0.01 to 0.4 person-rem

The total collective dose to the public is estimated to range from approximately 1.8 to 14 person-rem. This dose would most likely result in no additional latent cancer fatalities among the public.

Because continued storage, conversion, long-term storage and manufacturing activities were assumed to occur at separate sites and the results of the parametric analyses indicate that impacts to individuals among the public would decrease with a decrease in the amount processed, the dose to general public MEIs from the combination strategy would be less than the estimates presented for the 100% use strategies in Sections 5.4 and 5.5. All doses to individual members of the general public would be well below applicable standards and regulatory limits.

5.7.1.2 Chemical Impacts

Chemical impacts to noninvolved workers and the general public from components constituting the combination strategy are generally nonadditive because these impacts were estimated for MEIs at each site and future facilities were assumed to be built at separate sites. The two exceptions are (1) continued storage and cylinder preparation activities, which would take place at the current storage sites; and (2) conversion and cylinder treatment activities, which would likely occur at the same site.

Estimated hazard indexes for MEIs for all management options are much less than 1 (a hazard index of greater than 1 indicates the potential for health impacts). The maximum hazard index for noninvolved workers and the general public for long-term storage activities is approximately 0 (Table G.5), and for manufacturing activities, it is 6.7×10^{-6} (Table H.4). To provide a conservative estimate of potential hazards from activities that would occur at the same sites, the maximum hazard index for both workers and the general public from continued cylinder storage activities for 1999 through 2039 (0.065; Tables D.5 and D.25) was added to the maximum hazard index from cylinder preparation activities (6.1×10^{-6}; Section E.3.1.2). Similarly, the maximum hazard index from conversion options (1.5×10^{-4}; Table F.6) was added to the maximum hazard index from cylinder treatment (7.1×10^{-8}; Table F.6). The results in all cases are still much lower than 1, so adverse chemical impacts from normal operations would not be associated with this combination strategy.

5.7.2 Human Health and Safety — Accident Conditions

5.7.2.1 Radiological and Chemical Impacts

For the combination strategy, the bounding impacts from accidents involving radiological or chemical releases would be the larger of the impacts estimated for the long-term storage as oxide, use as oxide, and use as metal strategies. (See Sections 5.3.1.2, 5.4.1.2, and 5.5.1.2 for detailed discussions of the impacts of these accidents.) The consequences of bounding accidents for the combination strategy would be the same as the consequences of accidents under these use strategies because about the same amount of material would be at risk of being released under accident conditions, regardless of the facility size or throughput. Although the frequencies of some accidents (for example, cylinder-handling accidents) would decrease somewhat as the facility throughput decreased, the overall frequency category for those accidents would remain the same despite these small changes in frequencies.

5.7.2.2 Physical Hazards

Physical hazards to involved and noninvolved workers were estimated by summing the injury and fatality hazards from each of the components constituting the combination strategy, similar to the method described for estimating involved worker collective radiation dose in Section 5.7.1.1. For the combination strategy, the calculations to estimate physical hazards are outlined below.

Continued Cylinder Storage. The numbers of fatalities and injuries during continued cylinder storage at the three current storage sites are the same as those previously estimated for the action alternatives (Section D.4.2.3); that is, 0.07 fatality and 90 injuries.

Cylinder Preparation. The total number of fatalities and injuries for workers would range from 0.14 fatality and 187 injuries for use of cylinder overcontainers for all cylinders from all three sites, to 0.86 fatality and 630 injuries for transfer of cylinders to new cylinders at all three sites (Section E.3.2.3). These values are estimates of the total fatalities and injuries over the entire 20-year period that cylinder preparation activities were assumed to be ongoing.

Conversion. The estimated numbers of fatalities and injuries for conversion of various throughput rates are provided in Section K.2.2.3. The estimated numbers of fatalities and injuries from conversion for the combination strategy are as follows:

Fatalities among workers from conversion of 75% of the inventory to U_3O_8
= 0.33 fatality

Fatalities among workers from conversion of 75% of the inventory to UO_2
= 0.39 to 0.57 fatality

Range for conversion of 75% of the inventory to oxide
= 0.33 to 0.57 fatality

Injuries among workers from conversion of 75% of the inventory to U_3O_8
= 270 injuries
Injuries among workers from conversion of 75% of the inventory to UO_2
= 320 to 490 injuries

Range for conversion of 75% of the inventory to oxide
= 270 to 490 injuries

Fatalities among workers from conversion of 25% of the inventory to metal
= 0.33 to 0.49 fatality

Injuries among workers from conversion of 25% of the inventory to metal
= 280 to 450 injuries

Cylinder Treatment. The estimated numbers of fatalities and injuries from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Section K.2.2.3. For the combination strategy, it was assumed that one 75%-capacity treatment facility and one 25%-capacity treatment facility would likely be constructed. The estimated numbers of fatalities and injuries from cylinder treatment are as follows:

Fatalities among workers from treatment of 75% of the cylinder inventory = 0.17 fatality

Fatalities among workers from treatment of 25% of the cylinder inventory = 0.13 fatality

Injuries among workers from treatment of 75% of the cylinder inventory = 150 injuries

Injuries among workers from treatment of 25% of the cylinder inventory = 120 injuries

Total fatalities = 0.30 fatality

Total injuries = 270 injuries

Long-Term Storage. The estimated numbers of fatalities and injuries for long-term storage at various throughput rates are provided in Section K.3.2.3. From these data, the estimated values for long-term storage of 50% of the inventory as oxide are as follows:

Fatalities among workers from long-term storage of 50% of the inventory as U_3O_8 = 0.17 to 0.36 fatality

Fatalities among workers from long-term storage of 50% of the inventory as UO_2 = 0.10 to 0.19 fatality

Range for storage of 50% of the inventory as oxide = 0.10 to 0.36 fatality

Injuries among workers from long-term storage of 50% of the inventory as U_3O_8 = 114 to 176 injuries

Injuries among workers from long-term storage of 50% of the inventory as UO_2 = 76 to 110 injuries

Range for storage of 50% of the inventory as oxide = 76 to 176 injuries

Manufacture and Use. Fatalities and injuries for manufacture of UO_2- or metal-shielded casks are presented in Section K.4.2.3. The estimated numbers of fatalities and injuries for the combination strategy are as follows:

Fatalities among workers from manufacture of 25% of the inventory to UO_2 casks = 0.60 fatality

Injuries among workers from manufacture of 25% of the inventory to UO_2 casks = 480 injuries

Fatalities among workers from manufacture of 25% of the inventory to metal casks = 0.70 fatality

Injuries among workers from manufacture of 25% of the inventory to metal casks = 510 injuries

Total Physical Hazards. The total fatalities and injuries were calculated by summing the values for the individual components. The individual contributions and total fatalities and injuries are summarized in Table 5.11.

TABLE 5.11 Range of On-the-Job Fatalities and Injuries among Workers for the 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage Combination Strategy[a]

Component	Fatalities	Injuries
Continued cylinder storage	0.07	90
Cylinder preparation	0.14 – 0.86	190 - 630
Oxide conversion	0.33 – 0.57	270 – 490
Metal conversion	0.33 – 0.49	280 – 450
Long-term storage	0.1 – 0.36	80 – 180
Cylinder treatment	0.30	270
Manufacture of oxide casks	0.60	480
Manufacture of metal casks	0.70	510
Total	3 – 4	2,200 – 3,100

[a] Represents impacts to involved and noninvolved workers from construction and operation of facilities. Values rounded to two significant figures.

5.7.3 Transportation

The transportation impacts for normal operations and traffic accident fatalities were determined by the number of shipments required for the combination strategy, assuming a travel distance of 620 miles (1,000 km) per shipment. These impacts would be the sum of the number of shipments if 25% of the inventory were converted for use as oxide, 25% of the inventory were converted for use as metal, and 50% were converted to oxide for long-term storage. As for the 100% use as oxide and 100% use as metal strategies, the impacts for exposures from normal operations (i.e., vehicular exhaust inhalation) would be no more than one fatality expected among workers and members of the general public combined. About four traffic accident fatalities would be expected for the combination strategy, about the same as expected for the 100% use as oxide or metal strategies

For the combination strategy, the bounding impacts for accidents involving releases from cylinders or releases of other materials would be the larger of the impacts estimated for the long-term storage as oxide, use as oxide, or use as metal alternative strategies. The consequences would be the same as the consequences of these strategies because the same amount of material (i.e., a single shipment) would be at risk under accident conditions, regardless of the number of shipments. The combination strategy would require approximately the same number of shipments as these strategies,

so the overall probability of accidents occurring under this strategy is about the same as that for the other strategies.

5.7.4 Air Quality

Air quality impacts from construction at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives examined, including the combination strategy. Impacts during operations at the current storage sites would be the same as those predicted under the 100% use as oxide strategy (because the rate of cylinder removal would be the same under the combination strategy).

Pollutant emissions during construction and operation of conversion, long-term storage, and manufacturing facilities designed to handle 25% to 75% of the inventory would remain within standards, and would be somewhat reduced for facilities with lower throughput rates.

5.7.5 Water and Soil

Similar to the situation for air quality impacts, groundwater impacts at the current storage sites for the combination strategy would be the same as those predicted for the 100% use as oxide strategy. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent, but, on the basis of evaluation of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels. The long-term storage component of the preferred alternative could require excavating between about 41,000 yd^3 to 1.1 million yd^3 of consolidated material.

5.7.6 Socioeconomics

5.7.6.1 Continued Cylinder Storage

Socioeconomic impacts from construction activities at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under the combination strategy. Impacts during operations at the current storage sites would be the same as those predicted under the 100% use as oxide strategy (because the rate of cylinder removal would be the same under the combination strategy).

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5.7.6.2 Cylinder Preparation, Conversion, Long-Term Storage, and Manufacturing

Parametric socioeconomic impacts for the cylinder preparation, conversion, long-term storage, and manufacturing options were assessed qualitatively in Sections E.3.5, K.2.5, K.3.5, and K.4.5 on the basis of the preliminary cost data for the 100% cases (LLNL 1996) and socioeconomic data for parametric cases provided in a cost analysis report (LLNL 1997b). For conversion activities, the maximum estimated direct jobs and direct income values for the combination strategy calculated using the above-described data are about 1.5 times greater than estimated for the 100% use as oxide and 100% use as metal strategies, respectively. Similarly, the maximum estimated direct jobs and income for manufacturing activities under the combination strategy are about 1.5 times greater than estimated for the 100% use strategies. These differences are mainly a result of the need to construct and operate two separate conversion facilities, two separate manufacturing facilities, and a separate long-term storage facility under the combination strategy.

5.7.7 Ecology

The principal differences in ecological impacts between the combination strategy and the 100% use strategies would be associated with habitat loss at conversion, long-term storage, and manufacturing facilities. Potential habitat loss at the current storage sites is the sum of habitat loss that would occur under the no action alternative (7 acres [2.8 ha]), which would be applicable for all alternatives because construction would occur prior to 2003, and loss that would occur from cylinder preparation activities. The use of overcontainers would avoid the loss of additional habitat. Transfer facilities would range in areal site requirements from about 12 acres (4.9 ha) for a facility to process the inventory at the K-25 site (10% of the entire inventory), to 14 acres (5.7 ha) for a facility to process the inventory at the Portsmouth site (30% of the entire inventory), to 21 acres (8.5 ha) for a facility to process the inventory at the Paducah site (60% of the entire inventory) (see Section E.3.6). For alternatives involving 100% use, the maximum habitat loss at any site would be 28 acres (21 + 7) (11 ha).

Potential habitat loss for conversion facilities was calculated on the basis of data provided in Section K.2.9. The habitat loss corresponding to a 75%-capacity U_3O_8 conversion facility would be about 18 acres (7.3 ha); the loss corresponding to a 75%-capacity UO_2 conversion facility would be about 22 acres (9.0 ha). The habitat loss corresponding to a 25% capacity metal conversion facility would be 17 acres (6.8 ha). For a 75%-capacity cylinder treatment facility, the habitat loss would be about 8 acres (3.3 ha); habitat loss for a 25%-capacity cylinder treatment facility would be about 7 acres (3 ha). Although these parametric values were calculated for specific conversion options (e.g., conversion to UO_2 by the dry process, with anhydrous HF production), the amount of land required for the other conversion technologies would be roughly similar. It was assumed that two cylinder treatment facilities would be required, one for each conversion facility. The total habitat

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loss for conversion for the combination strategy was therefore calculated as a maximum of from 26 to 30 acres for a 75%-capacity oxide conversion facility and about 24 acres for a separate 25%-capacity metal conversion facility (total of about 50 to 54 acres).

Potential habitat loss for long-term storage facilities was estimated from data provided in Section K.3.9. For a 50%-capacity storage as oxide facility, habitat loss would be approximately 49 acres (20 ha).

Potential habitat loss for manufacturing facilities was calculated on the basis of data given in Section K.4.9. For an oxide cask manufacturing facility, the land areas corresponding to a 25%-capacity facility would be 79 acres (32 ha); the land area for a 25%-capacity metal cask manufacturing facility would be the same. Therefore, the total habitat loss for manufacturing for the combination strategy would be about 79 acres at any single site (total of about 160 acres).

5.7.8 Waste Management

For waste management at the current storage sites, impacts for the combination strategy would be similar to those estimated for the 100% use as oxide and 100% use as metal strategies.

Conversion of 100% of the inventory to either oxide or metal could have potential moderate impacts to nationwide LLW generation on the basis of a possible requirement to dispose of CaF_2 and/or MgF_2 as LLW (see Sections 5.3.7 and 5.5.7). If such disposal were required and these wastes were considered DOE waste, these strategies could generate a volume of LLW equal to about 10% of the projected DOE complexwide disposal volume. Moderate impacts to nationwide waste management are defined as additional volumes in excess of 10% of the DOE complexwide disposal volume; negligible impacts generate less than 10%. Assuming a linear decrease in potential LLW production, the combination strategy involving 75% conversion to oxide and 25% conversion to metal could have low to moderate impacts on nationwide LLW management.

The potential waste management impacts for various throughput rates for long-term storage and manufacturing facilities are discussed in Sections K.3.7 and K.4.7, respectively. Since waste management impacts for the 100% throughput rates for these facilities are generally negligible, impacts would also be negligible for the lower throughput rates considered for the combination alternative.

5.7.9 Resource Requirements

Under the combination strategy, adverse effects on local, regional, or national availability of materials would not be expected.

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5.7.10 Land Use

Land use corresponds to habitat loss. See Section 5.7.7 for an explanation of the values calculated for the combination strategy.

5.7.11 Other Areas of Impact

Impacts to cultural resources at the current storage sites would depend on the selected locations for construction activities but are considered unlikely because construction would occur on land previously developed. Impacts to cultural resources at other facilities would depend on the locations and will be examined in detail at the next stage of the program when facilities are actually sited. Adverse environmental justice impacts for activities occurring under the combination strategy are not expected. The occurrence of severe transportation accidents involving a release are unlikely, and accidents occur randomly along transportation corridors; therefore, significant and disproportionate high and adverse impacts to minority or low-income populations are unlikely.

5.8 CUMULATIVE IMPACTS

Cumulative impacts are those impacts that result from the incremental impact of an action (in this case, depleted UF_6 management) when added to the impacts of other past, present, and reasonably foreseeable future actions. To conduct the cumulative impacts analysis, DOE examined those impacts associated with depleted UF_6 management activities certain to occur at the three current depleted UF_6 storage sites (Paducah, Portsmouth, and K-25 sites under all alternatives), which includes continued cylinder storage for some period for all alternatives and cylinder preparation for shipment for all alternatives except the no action alternative. To these impacts, DOE then added the impacts of other past, present, and reasonably foreseeable future actions in order to assess cumulative impacts. The USEC actions related to enrichment activities are included as a continuation of past DOE actions at the Paducah and Portsmouth sites. Non-DOE actions are considered when they will occur at one of the three depleted UF_6 storage sites, or when the nature of their impacts at locations near the three sites could increase impacts anticipated at the sites themselves.

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5.8.1 Cumulative Impact Issues and Assumptions

The cumulative impact analysis considered the following impact areas for existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions:

- ***Health Risk:***
  - Collective radiation dose and cancer risk for the general public over the 41-year period of depleted UF_6 operations,
  - Annual radiation dose for a hypothetical maximally exposed off-site individual,
  - Collective radiation dose and cancer risk for the worker population at a given site, and
  - Number of truck or rail shipments of radioactive materials to and from each site and the contributions to the dose to an MEI near the site gate;
- ***Environmental Quality:***
  - Potential emissions that affect air quality compared to air quality standards and
  - Potential contaminants that affect groundwater quality concentrations compared to drinking water standards or other guideline values;
- ***Resource and Infrastructure Requirements:***
  - Land requirements (presented as the percent of suitable land at each site occupied by existing facilities and needed for depleted UF_6 management activities and other future actions),
  - Percent of current water supply (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions),
  - Percent of current wastewater treatment capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions), and

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- Percent of current power capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions).

The health risks to the off-site population are reported as collective exposures and risks for the entire period of conducting a particular operation, while the dose to the maximally exposed individual is reported as an annual value. Annual exposures are used for the maximally exposed individual to allow a direct comparison to the DOE maximum dose limit of 100 mrem/yr exposure to an individual of the general public (MEI) from all radiation sources and exposure pathways (DOE Order 5400.5). A cumulative impacts table containing the impact categories and the major elements composing the cumulative impacts is presented for each of the three sites. These elements include the existing conditions at the site, the maximum impacts of depleted UF_6 management activities analyzed in this PEIS, and the impacts of other reasonably foreseeable future actions.

The impact categories addressed as part of the cumulative impact analysis for each of the sites are those associated with depleted UF_6 management that might generate noteworthy environmental effects when aggregated with the environmental consequences of other actions. Some impacts, such as impacts to ecological resources and cultural resources, were not included in the cumulative impact analysis because they are dependent on the specific facility location within the site boundary and location-specific environmental factors. Other impacts, such as impacts of accidents, were not included because it is highly improbable that accidents would occur together.

Cumulative impacts for the Paducah, Portsmouth, and K-25 sites were evaluated by adding the impacts of depleted UF_6 management options to the impacts of past, present, and reasonably foreseeable future actions at each site and in the region (primarily actions that DOE is considering for other programs). The latter include actions related to production and management of nuclear materials, management of nuclear fuel, research and development activities, and defense programs as described in various environmental assessments and EISs listed in Section 1.6. To assess the effects of cumulative impacts, the estimated cumulative impacts calculated for each site were compared to regulatory levels for MEI exposures, air quality standards, and drinking water standards or guidelines for these parameters. If regulatory levels or guidelines would be exceeded, then the impact could be considered significant. LCFs among the public would be considered significant if the cumulative impacts of activities at a site would yield more than 1 LCF over the 41-year period. Because radiological exposure of workers would be maintained at or below regulatory levels, resulting LCFs to those individuals would be those corresponding to acceptable radiation doses. Resources and infrastructure impacts would be considered significant if the land area required, water use, wastewater production, or power demand approached 100% of capacity for the site.

Cumulative impacts also included the consequences of recent and current environmental restoration actions. The impacts of future environmental restoration actions at the three sites were not included in the cumulative impact analysis because of insufficient characterization of the

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contamination and because proposals for particular actions are not yet final. Impacts of future environmental restoration activities at these sites would be analyzed in later site-specific CERCLA/RCRA program documents.

Past impacts included in the cumulative impact analysis consist of past construction, development, and environmental restoration activities that contributed to existing conditions at each site and any past activities that may have resulted in current groundwater contamination at each site; these are presented as impacts of existing operations. Although dose reconstruction studies were conducted at several DOE sites, including the Oak Ridge Reservation, these studies have not progressed to the point that would allow their incorporation in this PEIS.

No assumptions are made regarding future baseline conditions at each of the storage sites that could potentially reduce impacts, such as cessation of certain ongoing operations that would reduce current levels of radioactive releases. A number of other simplifying assumptions were made to estimate cumulative impacts regarding timing, site location, and consistency of analytical methods. Other existing or planned actions at each site were assumed to occur during the period of depleted UF_6 management operations. These other actions were assumed to be collocated with depleted UF_6 management facilities to the extent that they affect the same off-site population and MEI. These assumptions result in conservative analyses that overestimate actual cumulative impacts.

Some or most of the depleted UF_6 cylinder management activities currently occurring at the sites (and considered under existing operations) would persist during continued storage and are included in the impacts of continued storage. When estimating cumulative impacts over the 41-year assessment period, no adjustment was made for this overlap. This adds to the conservatism in the calculated cumulative collective population impacts for both the workers and members of the general public at each site.

The above simplifying assumptions could result in some differences in estimated impacts between the PEIS and site-specific documents. In addition, these simplifying assumptions and other assumptions used in performing calculations can result in some uncertainty regarding projected cumulative impacts. The cumulative impact analysis in the PEIS should be used only for evaluating the PEIS program; any site-specific analysis would supersede the PEIS cumulative analysis for that site.

5.8.2 Impacts of Continued Cylinder Storage and Preparation

This analysis focuses on potential cumulative impacts at the three sites where continued storage and cylinder preparation would occur — the Paducah, Portsmouth, and K-25 sites. For purposes of analysis, the maximum impacts estimated at each site for continued cylinder storage and cylinder preparation activities from any of the PEIS alternatives were used to provide an upper

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estimate of potential cumulative impacts. The three sites are discussed separately in Sections 5.8.2.1 through 5.8.2.3.

5.8.2.1 Paducah Site

Actions planned at the Paducah site include the continuation of uranium enrichment operations, waste management activities (including the Vortec vitrification system [DOE 1998b]), environmental restoration activities, and the depleted UF_6 management activities addressed in this PEIS. Actions occurring near the Paducah site that could contribute to the existing or future impacts on the site (because of their diffuse nature) include continued operation of the Tennessee Valley Authority's Shawnee power plant; the Joppa, Illinois, power plant (see DOE 1998b); and the Allied Signal uranium conversion plant in Metropolis, Illinois (NRC 1995). Table 5.12 identifies the projected cumulative impacts that could result from depleted UF_6 management activities and current activities at the Paducah site. As identified in the table, the maximum annual radioactive releases that would result from depleted UF_6 management would result in an increase in the dose to the off-site population. However, cumulative radioactive releases at the Paducah site would still be considerably below the maximum DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF_6 management options would be unlikely to result in additional land disturbance at Paducah because all activities are expected to occur on currently developed land. On-site infrastructure demands for water, wastewater treatment, and power would increase by at most very small amounts due to the depleted UF_6 management activities. Cumulative requirements would remain well within existing capacities.

The Paducah site is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. During construction activities at the site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

Data from 1996 annual groundwater monitoring showed 18 pollutants exceeding primary drinking water regulation levels in groundwater at the Paducah site: antimony, chromium, lead, nickel, nitrate, thallium, uranium, benzene, 1,2-dichloroethane, cis-1,2-dichloroethene, 1,1,-dichloroethene, ethyl benzene, tetrachloroethene, trichloroethylene, vinyl chloride, radon-222, radium-226, and technetium-99 (LMES 1997c). Fluoride has also exceeded its primary drinking water regulation level of 4 mg/L in two on-site wells (LMES 1996a).

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TABLE 5.12 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Paducah Site, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities		Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
		Continued Storage[b]	Cylinder Preparation		
Off-site population					
Collective dose, 41 years (person-rem)	4.8	0.34	0.0030	24.6	29.7
Number of LCFs[e]	0.002	0.0002	1.5×10^{-6}	1.2×10^{-2}	0.02
Annual dose to off-site MEI[f] (mrem)	3.03	0.10	2.0×10^{-5}	1.5	4.6
Worker population					
Collective dose, 41 years (person-rem)	213	900	1,000	4.1	2,117
Number of LCFs[g]	0.09	0.37	0.40	0.0016	0.85
Transportation[h]					
Number of truck shipments, 41 years	40,836	–	28,513	6,330	75,679
Number of rail shipments, 41 years	0	–	7,129	2,410	9,539
Annual dose to MEI from truck (mrem)	3.98	–	0.0077	0.010	4.0
Annual dose to MEI from rail (mrem)	0.0	–	0.0053	0.0041	0.0094
Resources and infrastructure					
Land area (% of site)	21.9	0.0	0.6	0.53	23.0
Water use (% capacity)	50.0	0.09	0.11	0.02	50.2
Wastewater production (% capacity)	22.9	0.0	0.0	0.13	23.0
Power demand (% capacity)	51.5	0.0	0.05	0.03	51.5
Air quality[i]	None	PM_{10}	None	None	PM_{10}
Groundwater quality[j]	19 parameters[k]	Uranium-238	None	None	19 parameters[l]

[a] Includes impacts of current UF_6 generation and management activities; waste management activities; conversion of uranium ore into UF_6 at the AlliedSignal, Inc., plant in Metropolis, Illinois (NRC 1995); electrical power generation at the Tennessee Valley Authority's Shawnee power plant and at the Joppa Electric Energy, Inc., power plant (DOE 1998b); and environmental restoration activities that have proceeded to a point where their consequences can be defined: Waste Area Groupings 1 and 7 (Solid Waste Management Units C-611, C-746-K, C-740), Grouping 6 (C-400, C-403, and C-400 to C-404 underground transfer line), Grouping 15 (24—C-750, 97—C-601, 139—C-746-A1, 140—C-746-A2, 72—C-200-A, 73—C-710-B), Grouping 17 (36 different concrete rubble piles), Grouping 22 (C-404, C-747-A, C-749), and Grouping 23 (C-340, C-540-A, C-541-A, C-611, C-728, C-747-C) (LMES 1997c).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] Includes impacts related to the preferred alternative for waste management at the Paducah site (DOE 1997a); continuation of conversion of uranium ore into UF_6 at the AlliedSignal, Inc., plant at Metropolis, Illinois (NRC 1995); and treatment of mixed wastes through the Vortec vitrification system (DOE 1998b). They also consider air quality impacts from the Tennessee Valley Authority's Shawnee power plant and from the Joppa Electric Energy, Inc., power plant (DOE 1998b).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] Based on LMES (1996a), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Impacts indicate which emissions would result in nonattainment. PM_{10} = particulate matter less than or equal to 10 μm in diameter.

[j] Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected in the future.

[k] Antimony, benzene, cis-1,2-dichloroethene, chromium, 1,2-dichloroethane, 1,1-dichloroethene, ethyl benzene, fluoride, lead, nickel, nitrate, radium-226, radon-222, technetium-99, tetrachloroethene, thallium, trichloroethylene, uranium, and vinyl chloride.

[l] Only 19 parameters are shown rather than 20 because uranium is included in more than one column (i.e., it is in existing operations as well as continued storage).

Sources: LMES (1996a; 1997c), DOE (1997a; 1998b), and NRC (1995).

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During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 6 µg/L, considerably below the 20 µg/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinder breaches occurring at Paducah before the year 2020 could result in groundwater concentrations of uranium exceeding 20 µg/L in the future.

5.8.2.2 Portsmouth Site

Actions planned at the Portsmouth site include the continuation of existing operations, waste management activities, environmental restoration activities, and the depleted UF_6 management activities addressed in this PEIS. Table 5.13 identifies the projected cumulative impacts that could result from future depleted UF_6 management activities and current activities at Portsmouth. As identified in the table, the maximum annual radioactive releases associated with depleted UF_6 management activities would result in a very slight increase in the radiation dose to the off-site population. However, cumulative radioactive releases would still be considerably below the DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF_6 management activities would be unlikely to result in any additional land disturbance at Portsmouth because all activities are expected to occur on currently developed land. On-site infrastructure demands for water, wastewater treatment, and power would increase by at most very small amounts due to depleted UF_6 management activities. Cumulative requirements would remain well within existing capacities.

The Portsmouth site is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. During construction activities at the site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

On the basis of data from 1996 annual groundwater monitoring, 11 pollutants have been found to exceed primary drinking water regulation levels in groundwater at the Portsmouth site: chromium, uranium, chloroform, cis-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1,-dichloroethene, Freon-113, 1,1,1-trichloroethane, trichloroethylene, and vinyl chloride (LMES 1997d). Elevated levels of technetium-99 have also been detected in groundwater.

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TABLE 5.13 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Portsmouth Site, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities		Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
		Continued Storage[b]	Cylinder Preparation		
Off-site population					
Collective dose, 41 years (person-rem)	1.2	0.05	0.001	0.0054	1.3
Number of LCFs[e]	0.001	0.00002	6.0×10^{-7}	2.7×10^{-6}	6.3×10^{-4}
Annual dose to off-site MEI[f] (mrem)	0.066	0.02	4.5×10^{-5}	6.8×10^{-5}	0.069
Worker population					
Collective dose, 41 years (person-rem)	7,000	380	690	14.6	8,085
Number of LCFs[g]	2.80	0.16	0.28	0.0058	3.2
Transportation[h]					
Number of truck shipments, 41 years	10,660	–	13,421	34,090	58,171
Number of rail shipments, 41 years	8,815	–	3,356	13,000	25,171
Annual dose to MEI from truck (mrem)	1.04	–	0.0036	0.055	1.10
Annual dose to MEI from rail (mrem)	0.86	–	0.0025	0.021	0.88
Resources and infrastructure					
Land area (% of site)	21.6	0.0	0.6	0.34	22.5
Water use (% capacity)	36.8	0.07	0.07	0.06	37.0
Wastewater production (% capacity)	81.1	0.0	0.0	0.65	81.8
Power demand (% capacity)	79.2	0.0	0.06	0.11	79.4
Air quality[i]	None	None	None	None	None
Groundwater quality[j]	12 parameters[k]	None	None	None	12 parameters[k]

[a] Includes impacts of current UF_6 generation and management activities, waste management activities, environmental restoration activities that have proceeded to a point where their consequences can be defined (Peter Kiewit landfill, X-611A lime salvage lagoons, X-749/X-120 interim action, X-705A/B soil removal action, sitewide drainage ditches), and the components of the experimental Technology Applications Program applied at the Portsmouth site (X-231B oil biodegradation plot technology demonstration field tests, X-701B in situ chemical oxidation, X-701B surfactant studies, X-623 inorganic photo catalytic membrane treatment study, X-231A soil fracturing demonstrations, X-625 passive groundwater treatment through reactive media, in situ radiological decontamination demonstration in X-326, TechXtract™ surface decontamination process) (Bechtel Jacobs Company LLC 1998b).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] Includes impacts related to the preferred alternative to waste management at the Portsmouth site (DOE 1997a).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] Based on LMES (1996b), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Impacts indicate which emissions would result in nonattainment.

[j] Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected in the future.

[k] Chloroform, chromium, cis-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, Freon-113, technetium-99, 1,1,1-trichloroethane, trichloroethylene, uranium, and vinyl chloride.

Sources: LMES (1996b, 1997d), DOE (1997a), and Bechtel Jacobs Company LLC (1998b).

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During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 5 µg/L, considerably below the guideline level used for comparison, 20 µg/L (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinders would have to undergo uncontrolled corrosion until about 2050 before groundwater concentrations of uranium would approach 20 µg/L in the future. The groundwater concentration would not actually reach 20 µg/L until later than the year 2100.

5.8.2.3 Oak Ridge Reservation: K-25 Site

This analysis considers all actions on the Oak Ridge Reservation and is not limited to the K-25 site alone, except where specified. Aside from the continuation of existing operations and depleted UF_6 management activities, reasonably foreseeable future actions at the Oak Ridge Reservation include waste management activities (DOE 1997a), stockpile stewardship and management activities (DOE 1996c), storage and disposition of weapons-usable fissile materials (DOE 1996i), the disposition of highly enriched uranium (DOE 1996a), interim storage of enriched uranium (DOE 1994c), the transfer of nonnuclear functions (DOE 1993), changes in the sanitary sludge land application program (DOE 1996i), proposed reindustrialization of the K-25 site as the East Tennessee Technology Park (DOE 1997b), and environmental restoration activities at the K-25 site (DOE 1997c). Many of these future actions would take place at the other two sites (Y-12 and ORNL) at the Oak Ridge Reservation. However, because of the overlapping region of influence, except for cases where available data preclude a reservationwide view, the cumulative impacts for K-25 generally include the impacts for the Oak Ridge Reservation as a whole.

Table 5.14 identifies the projected cumulative impacts that would result from the two depleted UF_6 management activities that would occur at the K-25 site, existing activities, and planned actions described in the aforementioned EISs. The off-site MEI is specific to K-25. As identified in the table, annual radioactive releases would increase as a result of releases from the depleted UF_6 management activities, depleted UF_6 transport, and other possible actions associated with the Oak Ridge Reservation. However, maximum cumulative radioactive releases would remain below the DOE dose limit of 100 mrem/yr to the off-site MEI.

Depleted UF_6 management activities would affect a maximum of about 7 additional acres (2.8 ha) at K-25, while other actions could affect another 975 acres (390 ha). This area is about 13.9% of the total suitable acreage at K-25. The demand for water, wastewater, and power at the Oak Ridge Reservation would not be greatly affected by depleted UF_6 activities that would occur at K-25. Cumulatively, water, wastewater, and power facilities at the Oak Ridge Reservation would not require major improvements (expansions or upgrades) because projected cumulative future demand is less than existing capacities.

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TABLE 5.14 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Oak Ridge Reservation, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities		Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
		Continued Storage[b]	Cylinder Preparation		
Off-site population					
Collective dose, 41 years (person-rem)	1,763	0.34	0.002	21.4	1,780
Number of LCFs[e]	0.88	0.0004	1.0×10^{-6}	0.011	0.89
Annual dose to off-site MEI[f] (mrem)	9.82	0.46	3.0×10^{-5}	0.62	10.8
Worker population					
Collective dose, 41 years (person-rem)	2,788	200	480	3,400	6,880
Number of LCFs[g]	1.12	0.08	0.19	1.36	2.75
Transportation[h]					
Number of truck shipments, 41 years	42,640	–	4,732	70,834	118,206
Number of rail shipments, 41 years	328	–	1,183	26,000	27,511
Annual dose to MEI from truck (mrem)	4.2	–	0.0013	0.20	4.4
Annual dose to MEI from rail (mrem)	0.032	–	0.0009	0.068	0.10
Resources and infrastructure					
Land area (% of site)[i]	26.0	0.14	0.4	13.9	40.5
Water use (% capacity)	45.5	0.01	0.05	0.5	46.1
Wastewater production (% capacity)[j]	69.6	0.0	0.0	17.2	86.8
Power demand (% capacity)[j]	10.9	0.0	0.09	21.8	32.8
Air quality[k]	None	PM_{10}, HF	None	None	PM_{10}, HF
Groundwater quality[l]	24 parameters[m]	Uranium-238	None	6 parameters[n]	27 parameters[o]

[a] Includes impacts of current UF_6 management activities, waste management activities, and environmental restoration activities (at K-25) that have proceeded to a point where their consequences can be defined: Watershed I, Watershed II, Watershed III, Watershed IV, Watershed V, Watershed VI, and non-Watershed Areas (individual projects listed in DOE 1997c).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] These include impacts from EISs related to (1) stockpile stewardship and management (DOE 1996c), (2) storage and disposition of weapons-usable fissile materials (DOE 1996d), (3) disposition of surplus highly enriched uranium (DOE 1996a), (4) transfer of nonnuclear functions (DOE 1993), (5) waste management (DOE 1997a), (6) proposed changes in the sanitary sludge land application program (DOE 1996i), and (7) potential reindustrialization of the K-25 site (DOE 1997b). Impacts of reasonably foreseeable future actions do not include the potential environmental impacts of constructing and operating a proposed CERCLA waste management facility or the potential impacts of constructing and operating a barge facility, both of which will be estimated in the future at a time closer to the development of those two facilities (see DOE 1997b).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] MEI at K-25. Based on LMES (1995a), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Land area impacts are determined on the basis of the K-25 site area of 4,845 acres (1,961 ha) (including undeveloped sections) rather than the total Oak Ridge Reservation area of 34,516 acres (13,974 ha), since Oak Ridge Reservation consists of three main areas of activity separated by large tracts of a National Environmental Research Park that will largely remain undeveloped.

[j] Considers K-25 only.

[k] Impacts indicate which emissions would result in nonattainment. PM_{10} = particulate matter less than or equal to 10 μm in diameter.

[l] Existing groundwater quality impacts are for the K-25 site only. Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected.

[m] Antimony, arsenic, barium, benzene, cadmium, carbon tetrachloride, chloroform, chromium, 1,1-dichloroethene, 1,2-dichloroethene, fluoride, lead, methylene chloride, nickel, technetium-99, tetrachloroethene, thallium, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, 1,1,2-trichloro-1,2,2-trifluoroethane, uranium, and vinyl chloride.

[n] 1,2-Dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

[o] Only 27 parameters would be exceeded instead of 31 because methylene chloride, technetium-99, and uranium could be exceeded under existing operations, continued storage, and as a result of other future actions (i.e., they are included in more than one column).

Sources: LMES (1996c, 1996d); DOE (1997a).

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The Oak Ridge Reservation is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. For construction activities at the K-25 site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

If current cylinder maintenance programs control continued cylinder corrosion, the air analysis indicates that the maximum HF concentration at the site boundary could reach a maximum of 23% of the standard. However, if no credit is taken for control of corrosion, the HF concentration could approach the primary standard concentration of 29 $\mu g/m^3$ (24-hour average) around the year 2020.

On the basis of data from 1994 and 1995 annual groundwater monitoring, 23 pollutants have been found to exceed primary drinking water regulation levels in groundwater at the K-25 site: antimony, arsenic, barium, cadmium, chromium, fluoride, lead, nickel, thallium, uranium (as estimated from gross alpha levels), benzene, carbon tetrachloride, chloroform, 1,1,-dichloroethene, 1,2-dichloroethene, methylene chloride, tetrachloroethene, toluene, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, and vinyl chloride (LMES 1995a; 1996d). Gross beta levels (possibly indicative of technetium-99) also exceeded the standard. Another six pollutants could affect groundwater quality as a result of reasonably foreseeable future actions; these are 1,2-dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 7 µg/L, considerably below the 20 µg/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinders would have to undergo uncontrolled corrosion until about 2025 before groundwater concentrations of uranium would approach 20 µg/L in the future. The groundwater concentration would not actually reach 20 µg/L until later than the year 2100.

5.8.3 Impacts of Facility Colocation

The cumulative impact analyses presented in Section 5.8.2 were based on the assumption that long-term storage, conversion, and disposal facilities would not be colocated with storage and cylinder preparation facilities and therefore would not be placed at any of the three current cylinder storage sites. However, colocation of facilities at these sites is a possibility for certain alternatives. Table 5.15 lists the most probable colocation scenarios for the alternatives considered in this PEIS,

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TABLE 5.15 Potential Colocation of Facilities and the Alternatives Affected

Facilities	Alternatives
Continued storage + Conversion	Long-term storage as oxide Disposal Use as oxide and metal Preferred alternative
Continued storage + Conversion + Long-term storage as oxide	Long-term storage as oxide Preferred alternative
Continued storage + Long-term storage as UF_6	Long-term storage as UF_6

scenarios that involve the addition of one or more facilities to the sites where current storage already is under way. A detailed analysis of potential impacts resulting from colocation would be the subject of site-specific Phase II NEPA reviews. One positive result of colocation would be the elimination of impacts associated with transporting material between sites that have been colocated. In this PEIS, effects associated with shipping depleted UF_6, either in original form or a converted form, can involve site-specific and non-site-specific issues. The former concerns activities associated with the preparation of material for shipping, most notably impacts considered under cylinder preparation activities that occur at the current storage site prior to transporting depleted UF_6 elsewhere. Non-site-specific issues, in contrast, primarily concern the shipment of material (depleted UF_6 in either original or a converted form) from one site to another. The reduction of impacts associated with the actual transport of material can yield advantages since these impacts are among the largest of the impacts associated with particular alternatives.

5.9 ISSUES RELATED TO POTENTIAL LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the PEIS. With the exception of potential long-term groundwater impacts from continued cylinder storage and disposal, the potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready for decision at this time. However, this section discusses issues related to the potential life-cycle impacts associated with depleted uranium management.

If a long-term storage alternative (no action, long-term storage as UF_6, or long-term storage as oxide) is selected in the Record of Decision for the PEIS, several actions could occur beyond

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2039: the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and used or disposed of.

The continued storage of depleted uranium beyond 2039 may require the replacement or refurbishment of storage containers and facilities as their design lifetimes are exceeded. The extent of such activities would depend heavily on the environmental storage conditions, maintenance performed, performance and condition of the containers and facilities over time, and applicable regulatory requirements at that time. With proper monitoring and maintenance and with replacement and refurbishment as needed, storage could, in theory, continue indefinitely with minimal impacts to workers and the environment.

If a decision is made in the future to use or dispose of the depleted uranium in storage, it is possible that conversion to a different chemical form may be required. For example, if the depleted uranium is stored as UF_6, conversion to uranium oxide or uranium metal may be necessary before use. Similarly, disposal may also require conversion to a suitable chemical form, such as uranium oxide. Such activities would depend on the nature of the uses identified in the future and the applicable regulatory requirements at the time of disposal.

If a use alternative is implemented (use as oxide, use as metal, or a combination such as in the preferred alternative), depleted uranium might also require management after use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or they could be treated (e.g., converted to another chemical form) and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time.

If the decision is made to dispose of depleted uranium products after use, treatment may be necessary. If the depleted uranium is used in the form of uranium oxide, treatment requirements would likely be minimal (e.g., volume reduction and packaging as needed) because uranium oxide is the current preferred chemical form for disposal. More extensive treatment may be required if the depleted uranium is used in the form of uranium metal. Current regulatory criteria restrict the chemical form for disposal. Reactive waste forms, such as depleted uranium metal, are specifically excluded from disposal at the two DOE LLW disposal sites at the Nevada Test Site and the Hanford Site. Current waste acceptance criteria would likely need to be relaxed before disposal of bulk quantities of uranium metal could occur. Conversely, uranium metal could be converted to uranium oxide before disposal, and a conversion facility would likely be required.

Some uses might also result indirectly in the permanent disposal of the material. For example, casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or HLW in a geologic repository. Pursuant to the Nuclear Waste Policy Act, DOE is currently characterizing the Yucca Mountain site in Nevada as a potential repository for spent nuclear fuel and HLW. Only casks that met the acceptance criteria of such a repository would be used for disposal. In addition, future uses may also consume the depleted uranium as fuel in advanced nuclear reactors, with the resulting spent nuclear fuel disposed of accordingly.

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5.10 MITIGATION

The impacts of the alternatives presented in this chapter are primarily the maximum impacts expected for the range of options included within each alternative. Factors such as flexibility in siting and collocation, technology selection, and facility design and construction could be used to reduce impacts from these maximum levels. This section identifies what impacts could be mitigated to reduce adverse impacts. The assessment of specific technologies, siting considerations, and facility design and construction are issues that will be addressed in Phase II NEPA reviews and future decisions related to siting, technology selection, or facility construction and operations. However, based on the analyses conducted for this PEIS, the following recommendations can be made:

- Temporary impacts on air quality from dust emissions during construction of any new facility should be controlled by the best available practice to avoid temporary exceedances of the PM_{10} standard.

- Eventual impacts on air and groundwater at the current storage sites should be avoided by cylinder inspection, cylinder maintenance (such as painting), and prompt cleanup of any releases from any breached depleted UF_6 cylinders. Additionally, collection and sampling of runoff from cylinder yards should allow detection of contaminant releases to avoid releases to surface water or groundwater.

- Future impacts on groundwater from failure of a disposal facility could be minimized by selection of a site in a dry environmental setting.

- If a new mine were to be used for long-term storage or disposal, tailings from the excavation would be disposed of at the surface. These tailings should be graded to be compatible with existing topography and surrounding land uses and revegetated with native species or species compatible with the surrounding environment.

Although the probability of transportation accidents involving hazardous chemicals such as HF and ammonia is very low, the consequences could be severe. The colocation of facilities could minimize the amount of transportation required and could reduce this risk. For this PEIS, the assessment of transportation accidents involving anhydrous HF assumed conservative conditions. Currently, a number of industry practices are commonly employed to minimize the potential for large HF releases, as discussed below.

Anhydrous HF is usually shipped in 100-ton, 23,000-gal (91-metric ton, 87,000-L) shell, full, noncoiled, noninsulated tank cars. Most HF railcars today meet the DOT classification 112S500W, which represents the current state-of-the-art. To minimize the potential for accidental releases, these railcars have head shields and employ shelf couplers, which assist in avoiding punctures during an accident. The use of these improved state-of-the-art tank cars has led

to an improved safety record with respect to HF accidents over the last several years. The HF transportation accident rate has steadily decreased since 1985. Industry recommendations for the new tank car guideline appear in *Recommended Practices for the Hydrogen Fluoride Industry* (Hydrogen Fluoride Industry Practices Institute 1995b).

Accidents involving anhydrous HF and ammonia at a conversion facility were estimated to have potentially serious consequences. A wide variety of good engineering and mitigative practices are available that affect siting, design, and accident mitigation for HF or ammonia storage tanks, such as might be present at a conversion facility. Many are summarized in *Guideline for the Bulk Storage of Anhydrous Hydrogen Fluoride* (Hydrogen Fluoride Industry Practices Institute 1995a). There is an advanced set of accident prevention and mitigative measures that are recommended by industry for HF storage tanks, including storage tank siting principles (e.g., evaluating seismic and high wind conditions or drainage conditions), design recommendations, and tank appurtenances, as well as spill detection, containment, and mitigation. Measures to mitigate the consequences of an accident include anhydrous HF detection systems, spill containment systems such as dikes, remote storage tank isolation valves, water spray systems, and rapid acid deinventory systems (removing acid rapidly from a leaking vessel). Details on these mitigative strategies are also provided in the Hydrogen Fluoride Industry Practices Institute (1995a) guidelines.

5.11 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts are those impacts that cannot be mitigated by strategy selection and future considerations of technology selection, siting, and facility construction. Some impacts would be unavoidable, no matter which strategy were selected.

The depleted UF_6 cylinders currently in storage would require continued monitoring and maintenance for all alternatives. These activities would result in exposures of workers to low levels of radiation in the vicinity of the cylinders. The radiation exposure of workers can be minimized, but some level of exposure is unavoidable. The radiation doses to workers were estimated to be well within public health standards for all alternatives. Radiation exposures of workers would be monitored at each facility and would be kept as low as reasonably achievable. Cylinder monitoring and maintenance activities would also produce emissions of air pollutants, such as vehicle exhaust and dust (PM_{10}), and produce small amounts of sanitary waste and LLW. Concentrations of air emissions during operations were estimated to be within applicable standards and guidelines, and waste generation would not appreciably affect waste management operations.

All alternatives would involve a potential for accidental on-the-job injuries and fatalities among workers, unrelated to radiation or chemical exposures. These impacts are a consequence of unanticipated events in the work environment, typical of all work places. Based on statistics in similar industries, from 1 to 4 accidental fatalities and up to several thousand worker injuries were estimated for the PEIS alternatives. The chance of fatalities and injuries occurring would be minimized by conducting all work activities in as safe a manner as possible, in accordance with

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occupational health and safety rules and regulations. However, the chance of these type of impacts cannot be completely avoided.

All alternatives other than the no action alternative might require the construction of new facilities, for purposes of cylinder preparation, conversion, long-term storage, or disposal. Up to several hundred acres could be required for some alternatives. Construction of new facilities could result in losses of terrestrial and aquatic habitats. Dispersal of wildlife and temporary elimination of habitats would result from land-clearing and construction activities involving movement of construction personnel and equipment. The construction of new facilities could cause both short-term and long-term disturbances of previously undisturbed biological habitats. Although some destruction would be inevitable during and after construction, these losses would be minimized by careful site selection and thorough environmental reviews at a site-specific level.

5.12 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The major irreversible and irretrievable commitments of natural and man-made resources related to the alternative management strategies for depleted UF_6 that can be identified at this programmatic level of analysis are discussed in Sections 5.12.1 through 5.12.3. A commitment of resources is irreversible when its primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources neither renewable nor recoverable for later use by future generations.

The programmatic decisions resulting from this PEIS would commit resources required for implementing the selected alternative. Three major resource categories would be committed irreversibly or irretrievably under the alternative management strategies considered in this PEIS: land, materials, and energy.

5.12.1 Land

Land that is currently occupied by or ultimately selected for UF_6 cylinder storage or potential conversion, manufacture, or long-term storage facilities could ultimately be returned to open space if the yards, buildings, roads, and other structures were removed, areas cleaned up, and the land revegetated. Future use of these tracts of land, although beyond the scope of this PEIS, could include restoring those areas for unrestricted use. Therefore, commitment of this land is not necessarily irreversible. However, land set aside for radioactive, hazardous, and chemical waste disposal represents an irretrievable commitment because wastes in belowground disposal areas could not be completely removed, the land could not be restored to its original condition or to minimum cleanup standards, nor could the site be feasibly used for any other purposes following closure of the disposal facility. The disposal facilities evaluated in this PEIS could require up to 470 acres (188 ha). This land would be permanently unusable because the ground would no longer be suitable for intrusive activities, such as mining or utilities. The surface area appearance and biological habitat

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potentially lost during construction and operation of the disposal facilities could, however, be restored to a large extent.

5.12.2 Materials

The irreversible and irretrievable commitment of material resources for the various PEIS alternatives includes construction materials that could not be recovered or recycled, materials rendered radioactive that could not be decontaminated, and materials consumed or reduced to unrecoverable forms of waste. Where construction was necessary, materials required would include wood, concrete, sand, gravel, steel, aluminum, and other metals. At this time, no unusual construction material requirements have been identified. The construction resources, except for those that could be recovered and recycled with current technology, would be irretrievably lost. None of the identified construction resources is in short supply, and all should be readily available. Consumption of operating supplies such as paper, miscellaneous chemicals such as sodium hydroxide, and gases such as argon and nitrogen, although irretrievable, would not constitute a permanent drain on local sources or involve any material in critically short supply in the United States as a whole. Strategic and critical materials (e.g., Monel and Inconel) would not be required in quantities that would seriously reduce the national or world supply.

Any decision to dispose of depleted uranium without prior application as a use option would represent an irretrievable commitment of a potential material resource. Disposal is by definition irreversible, and the depleted uranium would be lost forever as a material resource.

5.12.3 Energy

The irretrievable commitment of energy resources during construction and operations of the various facilities considered by the alternatives would include the consumption of fossil fuels used to generate heat and electricity for the facilities. Energy would also be expended in the form of diesel fuel, gasoline, and oil for construction equipment and transportation vehicles. Under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during construction (up to 1,100 MW-yr). The availability of this electricity would depend on site location.

Any decision to dispose of depleted uranium would represent an irretrievable commitment of a potential energy resource. Depleted uranium is a potential fuel for future nuclear breeder reactors. Disposal is by definition irreversible, and the depleted uranium would be lost forever as a potential energy resource.

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5.13 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

For this PEIS, short term was considered the period of construction activities for the alternative management strategies — the time when most short-term (or temporary) environmental impacts would occur. Most alternatives would require the use of additional land. Such use would remove this land from other beneficial uses until at least the year 2040 because of the presence of long-term hazards. Disposal of solid nonhazardous waste generated from new facility construction and operations would require additional land at a sanitary landfill site, which would be unavailable for other uses in the long term. Any LLW generated by the various alternatives would involve the commitment of associated land, transportation, processing facilities for waste management, and disposal resources.

For those alternatives involving the construction and operation of new facilities, the associated construction activities would result in both short-term and long-term losses of terrestrial and aquatic habitats from natural productivity. Dispersal of wildlife and temporary elimination of habitats would result from land clearing and construction activities involving movement and staging of construction personnel and equipment. The building of new facilities could cause long-term disturbances of previously undisturbed biological habitats, potentially causing long-term reductions in the biological activity of an area. Although some habitat loss would be inevitable during and after construction, these losses would be minimized by careful site selection and by thorough environmental reviews at a site-specific level. Short-term impacts would be reduced and mitigated as necessary. After closure of the new facilities (beyond 40 years), they would be decommissioned and could be reused, recycled, or remediated.

5.14 POLLUTION PREVENTION AND WASTE MINIMIZATION

Implementation of any of the PEIS alternatives would be conducted in accordance with all applicable pollution prevention and waste minimization guidelines. Pollution prevention utilizes source reduction techniques in order to reduce risk to public health, safety, welfare, and the environment, and environmentally-acceptable recycling to achieve these same goals. The *Pollution Prevention Act* of 1990 (42 USC 11001-11050) established a national policy that pollution should be prevented or reduced at the source, whenever feasible. Under the Act, pollution that cannot be prevented should be recycled in an environmentally safe manner. Disposal or other releases into the environment should only be employed as a last resort. Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements" (U.S. President 1993), and DOE Order 5400.1, "General Environmental Protection Program," implement the provisions of the *Pollution Prevention Act* of 1990. DOE has established goals for reducing the generation and release of toxic chemicals, all types of waste, and pollutants. These waste-reduction goals (to be achieved by December 31, 1999) use calendar year 1993 as the baseline year for measuring progress. *The 1996 Pollution Prevention Program Plan* (DOE 1996f) was issued by the Secretary of Energy on May 3, 1996, to serve as the principal crosscutting guidance to DOE Headquarters, DOE Operations Offices,

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the national laboratories, and contractors to fully implement pollution prevention programs within the DOE complex that would reduce DOE's routine generation of radioactive, mixed, and hazardous wastes, and total releases, and off-site transfers of toxic chemicals. Pollution prevention measures could include source reduction, recycling, treatment, and disposal. The emphasis is on source reduction and recycling to prevent the creation of wastes, i.e., waste minimization.

Waste minimization is the reduction, to the extent feasible, of the generation of radioactive and hazardous waste. Source reduction and waste minimization techniques include good operating practices, technology modifications, input material changes, and product changes. An example of facilitating waste minimization is to substitute nonhazardous materials, where possible, for those materials that contribute to the generation of hazardous or mixed waste.

Many of the facilities considered by the PEIS alternatives are still in the conceptual stages of the engineering and design process. Consideration of opportunities to reduce waste generation at the source, as well as for material recycle and reuse, will be incorporated to the extent possible into the engineering and design process for the selected alternative. Examples of pollution prevention and waste minimization concepts that have been incorporated into the PEIS alternatives include the following:

- A cylinder treatment facility (including removal of residual radioactive contamination [i.e., "heels"] from the cylinders) option was included to allow potential final disposition of empty UF_6 cylinders (after removal of the depleted UF_6 contained within them) to become part of the scrap metal inventory at the gaseous diffusion plant sites and to possibly avoid disposal of the empty UF_6 cylinders as LLW.

- The MgF_2 by-product from conversion of depleted UF_6 into uranium metal would be leached with nitric acid to reduce its level of uranium contamination, which might allow disposal of the MgF_2 in a sanitary landfill.

- Wastes such as paper, aluminum, and other items generated during facility operations were assumed to be collected for pickup by recycling organizations and not disposed of as sanitary waste.

Pollution prevention and waste minimization would be major factors in determining the final design of any facility constructed as part of the decision of a selected PEIS alternative. Specific pollution prevention and waste minimization considerations will be analyzed as part of the Phase II studies and NEPA reviews following the Record of Decision for the PEIS.

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6 IMPACTS ASSOCIATED WITH MANAGING CYLINDERS OF USEC-GENERATED DEPLETED UF_6*

After the draft PEIS was completed, management responsibility for approximately 11,400 cylinders of depleted UF_6 (about 137,000 metric tons) was transferred from USEC to DOE by the signing of two MOAs associated with the privatization of USEC. The *Memorandum of Agreement Relating to Depleted Uranium Generated Prior to the Privatization Date* (DOE and USEC 1998a), signed in May 1998, transferred management responsibility for approximately 9,400 cylinders from USEC to DOE, with about 6,600 of the cylinders stored at Paducah and about 2,800 stored at Portsmouth. The *Memorandum of Agreement Relating to Depleted Uranium* (DOE and USEC 1998b), signed in June 1998, transfers approximately 2,000 additional depleted UF_6 cylinders from USEC to DOE between 1999 and 2004. (The locations for these cylinders are not specified in this second agreement.)

This chapter provides a brief discussion of the USEC cylinders and the potential environmental impacts that would be associated with their management under each of the alternatives discussed in the PEIS. To account for uncertainties associated with the number of cylinders that would be transferred from USEC to DOE in the future and to provide a bounding analysis of environmental impacts for the purpose of analysis in this PEIS, it was assumed that the number of DOE-owned and DOE-managed cylinders would increase by 15,000 (approximately 180,000 metric tons), with 12,000 of those cylinders being managed at the Paducah site and 3,000 being managed at the Portsmouth site. This assumption is consistent with current operations, under which most or all of the newly generated depleted UF_6 cylinders are at the Paducah site.

6.1 DESCRIPTION OF THE USEC CYLINDER INVENTORY

The USEC-generated cylinders at the Paducah site are located in three storage yards: C-745-C, C-745-Q, and C-745-R (see Figure 3.2). A small number of cylinders are also located for short periods in the C-745-E yard, which is a staging area. The yards used for USEC cylinder storage at the Paducah site had not been paved when the MOAs were signed. Under the terms of the MOAs, yards C-745-Q and C-745-R will be reconstructed with concrete bases, and cylinders from yard C-745-C will then be moved there.

The approximately 2,800 USEC-generated cylinders stored at the Portsmouth site are located in yard X-745-G (see Figure 3.5). This yard has already been paved; however, the cylinders will be restacked onto concrete saddles.

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* Please note that this entire chapter has been added to the PEIS after the public comment period.

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6.2 APPROACH USED TO EVALUATE THE ENVIRONMENTAL IMPACTS ASSOCIATED WITH MANAGING USEC CYLINDERS

The results from detailed analyses on managing DOE-generated cylinders under various options (presented in Appendices D–J) were used to estimate the potential additional impacts that could result from managing the USEC-generated cylinders as well. In most cases, the impacts for specific management options were estimated by extrapolating from the results presented in Appendices D–J to account for the increase in the cylinder inventory. The activities were then combined to determine the overall impacts associated with each PEIS alternative when both DOE- and USEC-generated cylinders are considered. The specific assumptions that underlie the estimation of impacts for the various components of the alternatives are described here.

6.2.1 Continued Cylinder Storage and Preparation Activities

Management of the USEC-generated cylinders must conform with all requirements applicable to the DOE-generated cylinders. These requirements are described in the UF_6 cylinder project management plan (LMES 1997i). For the site-specific evaluation of continued storage of the USEC-generated cylinders, it was assumed that the USEC cylinders would be managed in the same way as were the DOE-generated cylinders. Management activities would include (1) refurbishment of cylinder yards and restacking as necessary, (2) routine and ultrasonic testing inspections of cylinders and valve monitoring and maintenance, (3) cylinder painting as necessary, and (4) repair and/or removal of the contents of any cylinders that might be breached during the storage period. These activities are described in more detail in Appendix D.

In general, the USEC-generated cylinders are newer than the DOE-generated cylinders and do not exhibit the heavy external corrosion that can result from long-term storage in substandard conditions. Moreover, since these cylinders would be regularly inspected and maintained while under DOE management, future external corrosion would be expected to be minimal. Nonetheless, for the purpose of analyzing continued cylinder storage impacts in this PEIS, the USEC-generated cylinders were assumed to be essentially the same as the DOE-generated cylinders; i.e., the rate of corrosion and the cylinder breach rate were assumed to be the same.

For this PEIS, under the no action alternative, potential environmental impacts were estimated from continued cylinder storage through the year 2039. Under the action alternatives (long-term storage as UF_6, long-term storage as oxide, use as oxide, use as metal, and disposal as oxide), it was assumed that continued cylinder storage would extend from 2009 through 2028 at the current storage sites. The inclusion of the USEC-generated cylinders would increase the length of some continued storage at the Paducah and Portsmouth sites from the year 2028 through about the year 2034. On the basis of the assumption that the rate of cylinder breaches would be the same for the USEC-generated cylinders as for the DOE-generated cylinders, it was estimated that the number of cylinder breaches would increase by 42% at the Paducah site and by 22% at the Portsmouth site. (This increase corresponds directly to the increase in the cylinder inventory at each site.) These

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assumptions were applied to estimate the number of breaches that would occur in two cases: (1) if painting the cylinders controlled future corrosion and (2) if corrosion continued at the historic rate. For corrosion-induced breaches, these are very conservative assumptions (i.e., are likely to result in overestimates of the number of breaches), because the USEC-generated cylinders are newer than the DOE cylinders.

The other site-specific management option addressed for the PEIS was preparation of cylinders for shipment. As detailed in Appendix E, the number of cylinders that would not meet U.S. Department of Transportation requirements at the time of shipment is unknown. A probable range of values determined by the current cylinder conditions was assumed for the analyses used for Appendix E. To assess the site-specific impacts from the addition of the USEC cylinders, it was assumed that the cylinder preparation options at the Paducah and Portsmouth sites (i.e., preparation of standard cylinders, use of overcontainers, or operation of a cylinder transfer facility) would be extended for about 6 years to accommodate the additional inventory.

Since no USEC-generated cylinders are located at the K-25 site, no impact on continued storage or cylinder preparation at the K-25 site would be associated with the management of the USEC-generated cylinders.

6.2.2 Other Management Options

The additional management options addressed by the PEIS were conversion (including empty cylinder treatment), long-term storage, manufacture and use, and disposal. To account for the management of USEC-generated cylinders for these options, the basic facility designs were assumed to remain the same, but the facilities were assumed to operate over a longer period of time. It was assumed that the period for operations would be extended by about 6 years to accommodate the additional USEC-generated cylinders (i.e., from 20 to 26 years). Under this assumption, annual impacts would generally remain the same as those reported on in Chapter 5 and the appendices, although the total impacts would generally increase by about 30%. Additionally, the land use requirements for the long-term storage and disposal options would be increased to accommodate the additional inventory.

The assumption that operations at these facilities would be extended by 6 years did not change the basic analytical time frame used for the PEIS (i.e., 41 years, from 1998 through 2039). As a result of including the USEC cylinders, the time frame for operations at conversion, long-term storage, manufacture, and disposal facilities was assumed to be from the year 2009 through 2034; monitoring operations at long-term storage facilities were assumed to occur from 2035 through 2039.[1]

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[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

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6.3 POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH MANAGEMENT OF USEC-GENERATED CYLINDERS

The following sections describe the potential environmental impacts associated with the management of USEC-generated cylinders under each of the PEIS alternatives. The potential impacts associated with the increase in the cylinder inventory are discussed relative to the impacts for the management of the DOE-generated inventory only, as presented in Sections 5.1 through 5.7. If the overall impacts would be the same as those presented in Chapter 5, they are generally not discussed in detail in this section; instead, the appropriate sections within Chapter 5 are referenced. If the inclusion of the USEC-generated cylinders would result in changes to the impacts discussed in Chapter 5, the differences are noted and the total impacts are discussed in this section.

6.3.1 No Action Alternative

The inclusion of USEC-generated cylinders under the no action alternative would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. The activities occurring at the K-25 site would be unaffected. The USEC-generated cylinders would be managed in the same manner as would the DOE-generated cylinders, as described in Appendix D.

6.3.1.1 Human Health and Safety

6.3.1.1.1 Normal Facility Operations

In general, the management of USEC-generated cylinders would result in increased levels of exposure to radiation and chemicals by workers and members of the public, when compared with the management of DOE-generated cylinders only as presented in Chapter 5. However, the increased exposure levels would not be large enough to cause appreciable increases in the potential health impacts under the no action alternative discussed in Chapter 5.

Workers. In general, the management of USEC-generated cylinders would increase the overall level of activity of involved workers by approximately 30%, resulting in a corresponding increase in the total radiation dose to the worker population over the duration of the program. It is estimated that the total dose to involved workers at all three sites would increase from about 1,500 to about 2,000 person-rem. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.) However, this increase in the radiation dose would not change the estimate of 1 LCF among workers under the no action alternative.

In addition, the average annual radiation dose to individual workers associated with management of the additional USEC-generated cylinders would be the same as that reported for the

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management of DOE-generated cylinders only, because additional cylinder yard workers would be used to perform the necessary activities instead of having the same individuals conduct extra activities. Thus, the number of involved workers at the Paducah site would increase from about 30 to 43 and the number at Portsmouth would increase from about 16 to 20. The average annual doses to involved workers would remain at about 740 mrem/yr at Paducah and 600 mrem/yr at Portsmouth, well within applicable standards.

General Public. The management of USEC-generated cylinders would result in a potential increase in the total radiation dose to the public from airborne releases that would be proportional to the increase in the total cylinder inventory and number of hypothetical cylinder breaches (i.e., by approximately 30%). Therefore, it is estimated that the total radiation dose to the general public within 50 mi (80 km) of the three current storage sites combined would increase by 0.11 person-rem, resulting in a total dose of 0.49 person-rem over the duration of the program. This level of exposure would remain well below levels expected to cause any adverse health effects.

The maximum radiation dose to an individual near the Paducah and Portsmouth sites would also increase because of the additional management of USEC-generated cylinders. However, this increase would be such that the dose to an individual near any one of the three storage sites would be less than 0.2 mrem/yr, the same as the dose for DOE-generated cylinders only reported on in Chapter 5. Similarly, the change in the potential for noncancer health effects from exposure to airborne uranium and HF releases would be such that the maximum hazard index for an individual would remain less than 0.1, as reported on in Section 5.1.1.1.2.

The estimated maximum uranium concentrations in groundwater and resulting health effects among members of the public from future cylinder breaches would be the same as those for the management of DOE-generated cylinders discussed in Chapter 5. The reason is that the estimated groundwater concentrations for the DOE-generated cylinders were calculated on the basis of hypothetical breaches occurring in the G-yard at the Paducah site and in both the C-yard and E-yard at the Portsmouth site. This assumption represents a worst-case scenario in terms of groundwater contamination; additional breaches from USEC cylinders stored in different yards would not increase the estimated groundwater concentrations. Therefore, the radiation dose and hazard index estimates given in Section 5.1.1.1.2 for the general public from use of contaminated groundwater under the no action alternative would not change as a result of the additional consideration of the USEC cylinders.

6.3.1.1.2 Facility Accidents

Physical Hazards (On-the-Job Injuries and Fatalities). The activities associated with managing and handling the USEC cylinders would be the same as those required for the DOE-generated cylinders. The number of additional accidental worker injuries and fatalities associated with maintenance and handling of the USEC-generated cylinders at the Paducah and Portsmouth sites would be about 40 injuries and 0.03 fatality through 2039.

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The total number of accidental worker fatalities and injuries at the three sites through 2039 under the no action alternative would increase by about 30%. The number of fatalities, when both DOE- and USEC-generated cylinders are considered, would be 0.14, well below 1. The estimated total number of accidental worker injuries would be 182.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the no action alternative discussed in Section 5.1.1.2.2, because the types of accidents assessed would involve only a limited amount of material that would be at risk under accident conditions, regardless of the number of cylinders in storage. (For example, a vehicle-induced fire would be estimated to involve three full cylinders, regardless of the number of cylinders at the sites.) Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC-generated cylinders (e.g., cylinder handling accidents), this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS (i.e., likely is defined as one time or more in 100 years; unlikely is one time between 100 years and 10,000 years; extremely unlikely is one time between 10,000 years and 1 million years; incredible is less than one time in 1 million years).

6.3.1.2 Transportation

The continued storage of the USEC-generated cylinders under the no action alternative would result in small, additional quantities of LLW and LLMW (from cylinder monitoring and maintenance activities) that would need to be shipped each year. This additional waste would result in less than one additional waste shipment each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would remain negligible.

6.3.1.3 Air Quality

Continued storage of the USEC-generated cylinders would require refurbishment of the storage yards used for these cylinders. The paving of these yards would result in particulate matter (PM_{10}) emissions (i.e., dust). For the continued storage of DOE-generated cylinders, as described in Section 5.1.3, potential PM_{10} emissions during construction activities would approach regulatory standards. This situation would also occur during refurbishment of the yards used for USEC cylinder storage. Emissions would be expected to be less than or equal to those estimated for the DOE-generated cylinders, because refurbishment of cylinder yards would be conducted sequentially and the yards being used to store USEC-generated cylinders and requiring refurbishment would be approximately the same size and in the same general location as the yards being used for DOE-generated cylinder storage. Mitigative measures, such as water spraying, might be required to reduce the PM_{10} emissions during refurbishment of cylinder yards for both the DOE- and USEC-generated cylinders.

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The overall site emissions of criteria pollutants would increase as a result of the continued storage of USEC cylinders; however, the resulting concentrations would remain well below regulatory standards. Painting the USEC-generated cylinders to protect them from external corrosion, as needed, would also not have a significant impact on regional ozone formation.

Under the no action alternative, potential emissions of HF due to hypothetical breaches of some USEC-generated cylinders were estimated to remain well within applicable standards and guidelines at the Paducah and Portsmouth sites, whether or not corrosion control was assumed.

6.3.1.4 Water and Soil

Construction activities associated with refurbishment of USEC storage yards would be limited and occur in previously developed areas; therefore, impacts in assessment areas, such as changes in runoff, recharge to underlying aquifers, and changes in soil permeability or erosion potential, would be expected to be very minimal. Additional water use for continued storage of USEC-generated cylinders was roughly estimated to be 0.8 million gal for construction at the Paducah site, 67,000 gal/yr for operations at the Paducah site, and 13,000 gal/yr for operations at the Portsmouth site. Total water use would be 3 million gal for construction, 230,000 gal/yr for operations at Paducah, and 73,000 gal/yr for operations at Portsmouth.

Releases from hypothetical breaches of the USEC cylinders would, in general, increase concentrations in groundwater in some areas of the sites (i.e., in the areas near or in USEC cylinder storage yards). However, maximum concentrations calculated for evaluating the worst-case impacts to groundwater at the Paducah site (G-yard) and the Portsmouth site (combined C- and E-yards) under the no action alternative would remain the same as those described in Section 5.1.4.2. These concentrations would not change because the number of cylinders at the G-yard and the combined C- and E-yards would be the same (USEC cylinders would be stored at other yards) and because, in the groundwater modeling method used, contaminant plumes emanating from the vicinity of the yards are assumed to be independent and to not interact because of the distance separating the yards, the short travel distance to the assumed receptor (i.e., 1,000 ft), and limited plume spreading caused by lateral dispersion. Therefore, although concentrations of uranium in groundwater beneath some cylinder storage yards would increase because of the addition of the USEC cylinders, the maximum concentrations for the entire site would still be represented by the values given in Section 5.1.4.2 (i.e., 6 and 5 µg/L for the Paducah and Portsmouth sites, respectively).

Maximum concentrations in surface water bodies adjacent to the two sites would also stay about the same (0.3 µg/L at Paducah and 0.7 µg/L at Portsmouth) because of dilution in these water bodies. For soil, worst-case concentrations would remain the same (about 1 µg/g at either site); runoff from the USEC yards would not mix with runoff from the G-yard at Paducah or combined C- and E-yards at Portsmouth to increase local soil contaminant concentrations.

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6.3.1.5 Socioeconomics

Additional construction activities that would result from the addition of USEC-generated cylinders at the Paducah site would generate approximately 8 additional direct jobs and about 34 additional total jobs. Operational activities at both the Paducah and Portsmouth sites would create 29 additional direct jobs and 45 additional total jobs per year. Direct additional income from construction at the Paducah site in the peak year would be $0.42 million, and total additional income would be $0.84 million. During operations, additional direct and total income at both the Paducah and Portsmouth sites would be $0.9 million and $1.2 million per year, respectively.

The additional employment and income created in the ROIs for the two sites would represent a very small change (estimated as less than 0.002%) in projected growth in these indicators of overall regional activity. The in-migration expected into each region with each activity would have only a low impact on regional population growth rates and would require less than 0.8% of vacant housing stock at either of the two sites. No significant impacts on local public finances would be expected.

The total socioeconomic impacts under the no action alternative (when both DOE- and USEC-generated cylinders are considered) would be 38 direct jobs and 174 total jobs in the peak construction year, 140 direct jobs and 255 total jobs per year during operations, $1.8 million direct income and $4.3 million total income from construction, and $6 million/yr direct income and $7.9 million/yr total income during operations. These values represent a total change of less than 0.007% of projected growth. A total of less than 3% of vacant housing stock at any of the sites would be required.

6.3.1.6 Ecology

Impacts to ecological resources from the continued storage of the additional USEC-generated cylinders would be minimal. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. (Benchmarks are given in Section C.3.3.) In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

6.3.1.7 Waste Management

Painting the USEC-generated cylinders at the Paducah site would add a maximum of an additional 8% to the site's total annual LLMW load (added to the 20% projected from painting the DOE-generated cylinders). Painting at the Portsmouth site would not significantly increase the 1% proportion of LLMW generation at the site that would be attributable to the DOE-generated cylinders only. The continued storage of the USEC-generated cylinders together with the DOE-generated cylinders would thus constitute a moderate potential impact on LLMW management at the Paducah

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site. The total impact on the projected annual DOE LLMW treatment volume, however, would be negligible to low.

6.3.1.8 Resource Requirements

Although the total resources required would increase by approximately 30% as a result of the inclusion of USEC-generated cylinders, continued storage activities would not be resource intensive, and no strategic or critical materials would be required. The continued storage of the DOE- and USEC-generated cylinders would have a negligible to low impact on resource requirements at the Paducah and Portsmouth sites.

6.3.1.9 Land Use

The cylinder yards that are or would be used to store USEC-generated cylinders have either already been used as cylinder yards or would be located in previously developed areas and thus would not impact land use at the Paducah or Portsmouth sites under the no action alternative.

6.3.1.10 Cultural Resources

The yards for USEC-generated cylinders at the Paducah and Portsmouth sites are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the National Register of Historic Places. Therefore, impacts to cultural resources would not be likely under the no action alternative.

6.3.1.11 Environmental Justice

No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah and Portsmouth sites in association with the continued storage of the USEC-generated cylinders.

6.3.2 Long-Term Storage as UF_6

Under the long-term storage as UF_6 alternative, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 to 2034. In addition, the number of cylinder shipments to a consolidated storage facility would increase by about 30%. The operational and construction (or emplacement) period for

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a consolidated long-term storage facility would be extended from 20 to 26 years, with approximately 30% more area being required for storage at the facility. At a long-term storage facility, surveillance and maintenance requirements would increase during the additional years of emplacement, for a total increase of 30% for the surveillance and maintenance period of 2035 through 2039.

6.3.2.1 Human Health and Safety

6.3.2.1.1 Normal Facility Operations

In general, the management of USEC-generated cylinders would increase the level of exposure of workers and members of the public to radiation and chemicals when compared with the management of DOE-generated cylinders only as presented in Section 5.2.1.1. For involved workers, the increased radiation exposure could result in 1 LCF in addition to the potential 1 LCF estimated for the management of DOE-generated cylinders. (The estimated number of LCFs increases by one because of rounding effects and the fact that estimates are presented as a single whole number.) For noninvolved workers and members of the public, the increased levels of exposure would not be large enough to cause appreciable increases in the potential health impacts over those under the long-term storage as UF_6 alternative discussed in Chapter 5.

Workers. Under the long-term storage as UF_6 alternative, the management of the additional USEC cylinders (including continued cylinder storage, cylinder treatment, and consolidated storage) was estimated to increase the total dose to involved workers by about 30%, resulting in 1 additional LCF under each of the three long-term storage options (yards, buildings, and mines). The total number of health effects among involved workers (including both DOE- and USEC-generated cylinders) would be about 1 to 2 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that reported on in Chapter 5 for DOE-generated cylinders (i.e., well within applicable standards) because additional workers would be used instead of having the same individuals conduct extra activities at both the current storage sites and a long-term storage facility.

Increased exposure to chemicals would not be expected to increase health impacts among involved or noninvolved workers. The total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three sites and at a consolidated storage facility.

General Public. The management of USEC-generated cylinders would result in a potential increase in the total radiation dose to the public around the three current storage sites from airborne releases. The increase would be proportional to the increase in the total cylinder inventory and

number of hypothetical cylinder breaches (i.e., approximately 30%). Therefore, it was estimated that the total radiation dose to the general public within 50 mi (80 km) of the three current storage sites combined would increase by about 0.3 person-rem, resulting in a total dose of 1.4 person-rem over the period 1999 through 2034. This level of exposure would remain well below levels expected to cause any adverse health effects.

The maximum radiation dose to an individual near the Paducah and Portsmouth sites would also increase because of the additional management of USEC-generated cylinders. However, this increase would be such that the dose to an individual near any one of the three storage sites would be less than 0.2 mrem/yr, the same as the dose reported on for DOE-generated cylinders only in Chapter 5. Similarly, the change in the potential for noncancer health effects from exposure to airborne uranium and HF releases would be such that the maximum hazard index for an individual would remain less than 0.1, as it would be for the long-term storage as UF_6 alternative reported on in Section 5.2.1.1.2.

Potential health impacts from surface and groundwater contamination associated with the management of the USEC-generated cylinders would be the same as those for DOE-generated cylinders discussed in Section 5.2.1.1.2. This result would occur because the modeling of releases to groundwater at the Paducah and Portsmouth sites for the DOE-generated cylinders represents a worst-case scenario; additional breaches from USEC cylinders stored in different yards would not increase the estimated groundwater concentrations under either cylinder corrosion assumption (controlled corrosion or uncontrolled cylinder corrosion).

For the reasons discussed for DOE-generated cylinders in Chapter 5, impacts to members of the general public near a consolidated storage facility would be less than or equal to those presented for the three current storage sites: no health effects would be expected.

6.3.2.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). For the long-term storage as UF_6 alternative, it was estimated that up to 1 additional worker fatality and up to 240 additional worker injuries could occur in association with management of the USEC-generated cylinders (including continued storage, cylinder preparation, and long-term storage as UF_6). The total physical hazards associated with management of the DOE- and USEC-generated cylinders would be about 2 worker fatalities and up to 1,200 worker injuries, an increase of roughly 30%.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the long-term storage as UF_6 alternative discussed in Section 5.2.1.2.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS.

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6.3.2.2 Transportation

The management of USEC-generated cylinders would result in an additional 15,000 truck shipments of UF_6 cylinders from the current storage sites to a consolidated long-term storage site, or an additional 3,750 rail shipments. (The annual number of shipments would be the same as that for DOE-generated cylinders described in Section 5.2.2 and Appendix J.) For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no adverse health effects would be expected among workers and the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders is considered.

Although the total number of shipments would increase by about 30%, the estimated number of fatalities from transportation accidents (not involving releases of radioactive or hazardous materials) would be the same as that for DOE-generated cylinders reported on in Section 5.2.2. (The estimated number of traffic fatalities would not change because of rounding effects and the fact that estimates are presented as a single whole number.) Thus, the total estimated number of traffic accident fatalities under the long-term storage as UF_6 alternative (including both DOE- and USEC-generated cylinders) would remain 2 for truck transport and 1 for rail transport.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders described in Section 5.2.2, because the shipment sizes would not change. The annual probability of severe accidents occurring would be the same as that discussed for DOE-generated cylinders, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.2.3 Air Quality

The continued storage of additional USEC cylinders at the Paducah and Portsmouth sites through the year 2034 would not result in significant impacts to air quality. The estimated concentrations of criteria pollutants at the current storage sites would remain approximately the same as those for the long-term storage as UF_6 alternative, when only DOE-generated cylinders are considered, as described in Section 5.2.3. The estimated maximum 24-hour average HF concentrations at the Paducah and Portsmouth sites would increase from about 0.22 $\mu g/m^3$ and 0.14 $\mu g/m^3$ to about 1.2 $\mu g/m^3$ and 0.44 $\mu g/m^3$, respectively. The overall concentration for the Paducah site would still be well below the Kentucky primary 24-hour standard for HF of 800 $\mu g/m^3$. The State of Ohio does not have air standards for HF.

At a consolidated long-term storage facility, impacts on criteria pollutant emissions from construction and operation would be the same as those for DOE-generated cylinders discussed in Section 5.2.3. The air quality impacts would be the same because, although the size of the long-term storage facility would increase by about 30% as a result of the addition of the USEC-generated

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cylinders, the annual level of operations (and emissions) would remain unchanged. No emission of uranium compounds was predicted in association with consolidated storage as UF_6.

6.3.2.4 Water and Soil

At the current storage sites, additional water use for continued storage of USEC-generated cylinders was roughly estimated to be 0.8 million gal for construction at the Paducah site, 67,000 gal/yr for operations at the Paducah site, and 13,000 gal/yr for operations at the Portsmouth site. The estimated total water use would be about 3 million gal for construction, 230,000 gal/yr during operations at Paducah, and 73,000 gal/yr for operations at Portsmouth.

The annual water requirements for a cylinder transfer facility would not change from those presented in Section 5.2.4 (i.e., between 6 and 9 million gal/yr), because the size of the facility would not change. However, the facility would be operated for an additional 6 years.

Because the duration of construction and operational activities at a long-term storage facility would be increased by 6 years, from 3.0 to 38 million gal of additional water would be required for construction, and about 7 million gal of additional water would be required for operations. About 6.6 million gal of additional wastewater would be generated. The total amount of water required during construction would be about 13 to 170 million gal; the total amount of water used during operations would be about 31 million gal; the total wastewater generated would be about 29 million gal.

As discussed in Section 6.3.1.4, the overall impacts to surface water, groundwater, and soil from the continued storage of USEC cylinders under this alternative would be the same as those estimated for the DOE-generated cylinders in Section 5.2.4. The estimated maximum groundwater uranium concentrations from continued storage at the Paducah and Portsmouth sites (i.e., 20 µg/L and 4 µg/L, respectively) would not change as a result of considering the USEC cylinders. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. The estimated maximum soil uranium concentration would remain 7 µg/g, well within the 230-µg/g guideline used for comparison.

Because total overall discharges would be extremely small, no impacts to groundwater quality would be expected from cylinder preparation activities or at a consolidated long-term storage facility.

The addition of USEC-generated cylinders would increase requirements for excavating a mine for a long-term storage facility. The additional excavation volume would be about 300,000 yd^3 (230,000 m^3). The total required excavation volume for the mine would be about 2.1 million yd^3 (1.6 million m^3).

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6.3.2.5 Socioeconomics

Under the long-term storage as UF_6 alternative, continued storage of the additional USEC-generated cylinders would result in about 8 additional direct construction jobs and about 34 additional total jobs at the Paducah site. Operational activities at both the Paducah and Portsmouth sites would create 29 additional direct jobs and 45 additional total jobs per year. Additional direct and total income from construction at the Paducah site in the peak year would be $0.42 million and $0.84 million, respectively. During operations, additional direct and total income at both the Paducah and Portsmouth sites would be $0.8 million/yr and $1 million/yr, respectively.

The total socioeconomic impacts for continued cylinder storage under the long-term storage as UF_6 alternative (including both DOE- and USEC-generated cylinders) would be 38 direct jobs and 174 total jobs in the peak construction year, 150 direct jobs and 275 total jobs per year during operations, $1.8 million direct income and $4.3 million total income from construction, and $6.8 million/yr direct income and $8.9 million/yr total income during operations.

The annual socioeconomic impacts from cylinder preparation activities would be the same as those for the DOE-generated cylinders only estimated in Section 5.2.5, but the period of operation would be extended by 6 years. Construction impacts would not change for the cylinder preparation options because facility sizes would remain the same.

Construction and operation of a long-term storage facility would be extended by 6 years as a result of the addition of the USEC-generated cylinders. The peak year construction costs would not change. For operations, the emplacement period, originally assumed to extend from the year 2009 through 2028, would be extended through 2034, with the surveillance and maintenance period being reduced to the years 2035 through 2039. The average annual income and number of jobs estimated for the surveillance and maintenance period would increase by about 30% as a result of the addition of the USEC-generated cylinders. To estimate the change in socioeconomic impacts associated with the additional USEC cylinders, 30% of the average annual number of jobs and income during the surveillance and maintenance period for each option were added to the average annual number of jobs and income during the emplacement period from 2009 through 2028 (Allison and Folga 1997). Adding this increased the range for the number of annual jobs by 11–14 for the long-term storage as UF_6 options, resulting in a total range of 60 to 70 jobs when both DOE- and USEC-generated cylinders are considered. Correspondingly, annual income would increase by about $1 million, to a total of $4 million.

6.3.2.6 Ecology

The continued storage and preparation of the USEC-generated cylinders at the current storage sites would not result in additional impacts to ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for

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toxic and radiological effects (see Section C.3.3). In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

The storage of the USEC-generated cylinders at consolidated long-term storage facilities would increase land use requirements by 11 to 26 acres (4 to 10 ha), which would result in additional habitat loss. The total land required would range from 107 to 170 acres (43 to 68 ha), which could have a large impact on vegetation and wildlife.

6.3.2.7 Waste Management

Continued storage of USEC-generated cylinders under the long-term storage as UF_6 alternative would increase waste impacts at the current storage sites. The maximum additional impacts from management of the USEC-generated cylinders at the Paducah site would be the same as those under the no action alternative discussed in Section 6.3.1.7. Because the annual treatment volumes would not change, operational impacts related to waste handling would not be impacted (see Section 5.2.7). However, the timeframe of operations would increase by 6 years, and the total amount of waste generated would increase by about 30%.

For the operation and construction of a consolidated long-term storage facility, the addition of the USEC cylinders would generate an additional 900 yd^3 (690 m^3) of LLW and 240 yd^3 (180 m^3) of LLMW for storage in yards and about 25 yd^3 (19 m^3) of LLW for storage in buildings or a mine. The total waste generated would be about 3,700 yd^3 (2,800 m^3) of LLW and 970 yd^3 (740 m^3) of LLMW for storage in yards and 100 yd^3 (80 m^3) of LLW for storage in buildings or a mine.

The generation of waste under the long-term storage as UF_6 alternative (when both DOE- and USEC-generated cylinders are considered) would have a negligible to low impact when considered in terms of national and regional waste management capabilities. That is, the required increase in capacity at the regional and national level would be less than 10%.

6.3.2.8 Resource Requirements

In general, the addition of the USEC cylinders would not change the assessment of impacts on resource requirements for DOE-generated cylinders presented in Chapter 5 (i.e., no significant impacts would result because construction and operational requirements would not be resource intensive, and the resources required would not be rare or unique). The electrical requirement for mine construction would increase by about 130 MW-yr to a total of 970 MW-yr. The impact of this high electrical requirement on use of local energy resources would depend on the location of the facility and the existing infrastructure.

6.3.2.9 Land Use

At the current storage sites, the impacts to land use from the addition of USEC-generated cylinders would be the same as that for management of DOE-generated cylinders described in Section 5.2.9. Storage space for the USEC cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 5.2.9, because the facility operational period would increase, not the facility size.

The increase in land use requirements at long-term storage facilities to accommodate the USEC-generated cylinders would range from 11 to 26 acres (4 to 10 ha). The total land use requirement for long-term storage of DOE- and USEC-generated cylinders would range from 107 to 170 acres (43 to 68 ha), constituting a moderate potential land use impact.

6.3.2.10 Cultural Resources

The potential impacts to cultural resources would be the same as those for the DOE-generated cylinders under the long-term storage as UF_6 alternative discussed in Section 5.2.10: impacts to cultural resources would be unlikely at the current storage sites because all activities would take place on previously developed land, and cultural impacts at a long-term storage facility would depend on the location of the facility.

6.3.2.11 Environmental Justice

The impacts to environmental justice would be the same as those for the DOE-generated cylinders under the long-term storage as UF_6 alternative discussed in Section 5.2.11. No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah and Portsmouth sites in association with the continued cylinder storage and/or cylinder preparation under the long-term storage as UF_6 alternative.

6.3.3 Long-Term Storage as Uranium Oxide

Under the long-term storage as oxide alternative, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities occurring at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 to 2034. In addition, the total number of shipments of cylinders, uranium oxide, HF, and associated materials would increase by about 30%, although the annual number of shipments would be unchanged. The operational period for a conversion facility would be extended from 20 to 26 years to accommodate the additional processing of USEC-generated

cylinders. Similarly, the operational and construction (or emplacement) period for a long-term storage facility would also be increased from 20 to 26 years, with approximately 30% more land area being required for storage at the facility. At a long-term storage facility, surveillance and maintenance requirements would increase during the additional 6 years of emplacement, for a total increase of 30% for the surveillance and maintenance period of 2035 through 2039.

6.3.3.1 Human Health and Safety

6.3.3.1.1 Normal Facility Operations

For the long-term storage as oxide alternative, the management of USEC-generated cylinders would increase the level of exposure of workers and members of the public to radiation and chemicals, when compared with the management of DOE-generated cylinders only as presented in Chapter 5. For involved workers, the increased radiation exposure could result in a maximum of 1 LCF in addition to the potential 1 to 2 LCFs estimated for the management of DOE-generated cylinders. (The estimated total, when both DOE- and USEC-generated cylinders are considered, would be 1 to 3 LCFs.) For noninvolved workers and members of the public, the increased levels of exposure would not be large enough to cause appreciable increases in the potential health impacts over those under the long-term storage as oxide alternative discussed in Chapter 5.

Workers. Under the long-term storage as oxide alternative, the management of the additional USEC cylinders (including continued cylinder storage, cylinder preparation, conversion, empty cylinder treatment, and consolidated storage of oxide) was estimated to increase the total dose to involved workers by about 30%, resulting in a maximum of 1 additional LCF under each of the three long-term storage options (buildings, vaults, and mines). The total number of health effects among involved workers (when both DOE- and USEC-generated cylinders are considered) would range from 1 to 3 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Chapter 5 (i.e., well within applicable standards) because (1) at the current storage sites and a long-term storage facility, additional workers would be used instead of having the same individuals conduct extra activities, and (2) at conversion facilities, the annual worker activities would be the same, but the facilities would operate over a longer period of time.

Increased exposure to chemicals would not be expected to increase health impacts on involved or noninvolved workers; the total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, or a consolidated long-term storage facility.

General Public. The overall potential impacts to members of the general public during normal operations would be the same as those for the management of DOE-generated cylinders described in Section 5.3.1.1.2: all exposures would be within applicable public health standards, and no LCFs from radiation exposures and no adverse effects from chemical exposures would be expected to occur among members of the general public near the three current storage sites, a conversion facility, or a consolidated long-term storage facility, when the management of additional USEC cylinders is considered.

At the current storage sites, potential public exposure to radiation and chemicals released from the sites would be exactly the same as that under the long-term storage as UF_6 alternative described in Section 6.3.2.1.1.

At conversion and long-term storage facilities, the annual impacts to members of the public would be the same as those for management of DOE-generated cylinders described in Section 5.3.1.1.2, because the annual operations would be the same. The total exposure of the public in the vicinity of these facilities to airborne radiation and chemicals would increase by approximately 30% as a result of the processing of USEC-generated cylinders. However, total exposure levels would remain well within standards and below levels expected to cause any adverse health effects among the public for all storage options.

6.3.3.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). For the long-term storage as oxide alternative, it was estimated that 1 additional worker fatality and up to 460 additional worker injuries could occur in association with management of the USEC-generated cylinders (including continued storage, cylinder preparation, empty cylinder treatment, conversion to oxide, and long-term storage as oxide activities). The total physical hazards associated with management of the DOE- and USEC-generated cylinders would range from about 1 to 3 worker fatalities and about 900 to 2,100 worker injuries.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the long-term storage as oxide alternative discussed in Section 5.3.1.2.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS.

6.3.3.2 Transportation

The management of the USEC-generated cylinders would result in an increase of approximately 30% in the total number of shipments of UF_6 cylinders, uranium oxide, ammonia,

anhydrous HF (if produced), CaF_2 (if produced), and waste materials. (The annual number of shipments would be the same as that for DOE-generated cylinders described in Section 5.3.2 and Appendix J.) For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no adverse health effects would be expected among workers and the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders and associated materials is considered.

Although the total number of shipments would increase by about 30%, the estimated number of fatalities from transportation accidents (not involving releases of radioactive or hazardous materials) would be the same as that for DOE-generated cylinders described in Section 5.3.2. As described under the long-term storage as UF_6 alternative in Section 6.3.2.2, the estimated number of traffic fatalities would not change because of rounding effects and the fact that estimates are presented as a single whole number. Thus, the total estimated number of traffic accident fatalities under the long-term storage as oxide alternative (when both DOE- and USEC-generated cylinders are considered) would remain 4 for truck transport and 2 for rail transport.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders and associated materials described in Section 5.3.2, because the shipment sizes would not change. The annual probability of severe accidents occurring also would be the same as that discussed in Section 5.3.2, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.3.3 Air Quality

At the current storage sites, air quality impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.3.

At a conversion to oxide facility, annual criteria pollutant emissions from construction and operation would be identical to those discussed for DOE-generated cylinders in Section 5.3.3, because conversion facilities would not increase in size, only in duration of operations. During an additional 6 years of operation, an additional 12 to 66 lb (5 to 30 kg) of uranium (as U_3O_8 or UO_2) would be emitted. The total uranium emissions that would result from conversion of both the DOE- and USEC-generated inventory could range from about 52 to 290 lb (24 to 132 kg). No air quality standards exist for uranium compounds. However, the potential health impacts from these emissions were evaluated in Section 6.3.3.1.1.

At a long-term storage facility, although the size of the facility would increase, annual average air concentrations of criteria pollutants and other emissions would remain the same as those predicted for the DOE-generated cylinders only in Section 5.3.3. No emission of uranium compounds is predicted in association with the long-term storage as oxide facility.

6.3.3.4 Water and Soil

At the current storage sites, impacts to surface water, groundwater, and soil would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.4.

The amount of water used to construct a conversion facility would be the same as that for DOE-generated cylinders described in Section 5.3.4. The duration of operational activities at a conversion facility would increase by 6 years, resulting in an additional water requirement of about 200 to 1,700 million gal. From about 90 to 840 million gal of additional wastewater would be generated over the additional 6 years of operation. The total water requirement at a conversion facility would range from about 880 to 7,400 million gal; the total wastewater generated would range from about 390 to 3,600 million gal.

The duration of both construction and operational activities at a long-term storage facility would increase by 6 years, so about 2 to 8 million gal of additional water would be required for construction, and about 8 million gal of additional water would be required for operations. Additional wastewater generation would range from about 0.6 to 8 million gal. The total water requirement for construction would range from 8 to 34 million gal; the total water requirement for operations would be about 36 million gal. Total wastewater generation would range from about 3 to 36 million gal.

Impacts to surface water and groundwater from an oxide conversion facility or a long-term storage facility would depend on the actual location of the facility. On the basis of an assessment of representative settings considered for this PEIS, impacts from the DOE cylinders only were expected to be negligible, as described in Section 5.3.4.1. Additional impacts to surface water and groundwater as a result of the additional USEC-generated cylinders during conversion to oxide and long-term storage would also probably be negligible because annual emissions would not change.

The conversion and storage of USEC-generated cylinders would increase requirements for excavating a mine for a long-term storage facility. The additional excavation volume would be about 400,000 yd^3 (306,000 m^3) for storage as U_3O_8 in a mine and 200,000 yd^3 (150,000 m^3) for storage as UO_2 in a mine. The maximum total required excavation volume for a mine would be about 2.6 million yd^3 (2.0 million m^3).

6.3.3.5 Socioeconomics

At the current storage sites, socioeconomic impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.5.

The annual socioeconomic impacts from operating a conversion to oxide facility would be the same as those estimated for the DOE-generated cylinders in Section 5.3.5, but the period of operation would be extended by 6 years. Annual socioeconomic impacts during construction would

also be the same as those for managing DOE-generated cylinders, but the period of construction activities for the long-term storage facility would also be extended by 6 years.

Construction and operation of a long-term storage as oxide facility would be extended by 6 years as a result of the addition of the USEC-generated cylinders. The peak year construction costs would not change. For operations, the emplacement period, originally assumed to extend from the year 2009 through 2028, would be extended through 2034, with the surveillance and maintenance period being reduced to the years 2035 through 2039. The average annual income and number of jobs estimated for the surveillance and maintenance period would increase by about 30% as a result of the addition of the USEC-generated cylinders. To estimate the change in socioeconomic impacts associated with the additional USEC cylinders, 30% of the average annual number of jobs and income during the surveillance and maintenance period for each option were added to the average annual number of jobs and income during the emplacement period from 2009 through 2028 (Allison and Folga 1997). Adding this increased the range for the number of annual jobs by 12–15 for the long-term storage as oxide options, resulting in a total range of 70 to 80 jobs when both DOE- and USEC-generated cylinders are considered. Correspondingly, annual income would increase by about $1 million, to a range of $4–5 million.

6.3.3.6 Ecology

The continued cylinder storage and preparation activities associated with management of the USEC-generated cylinders at the current storage sites would not result in additional impacts to ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects (see Section C.3.3). In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

At a conversion facility, treatment of USEC-generated cylinders would not result in any additional land use requirements or habitat loss, because the size of the conversion facility would not change. At a long-term storage facility, storage as U_3O_8 would increase land use from 14 to 52 acres (6 to 21 ha). Storage as UO_2 would increase land use from 7 to 22 acres (3 to 9 ha). These increases would result in additional habitat loss. The total land required for long-term storage would range from 135 to 264 acres (54 to 106 ha) for storage as U_3O_8, and from 81 to 135 acres (32 to 54 ha) for storage as UO_2. These total land requirements would have a moderate to large potential impact on vegetation and wildlife.

6.3.3.7 Waste Management

At the current storage sites, waste management impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.7.

The duration of operational activities at a U_3O_8 conversion facility would be increased by 6 years, resulting in the generation of about 1,100 to 4,700 yd^3 (840 to 3,600 m^3) of additional LLW, 8 yd^3 (6 m^3) of additional LLMW, and 55 yd^3 (42 m^3) of additional hazardous waste. For conversion to UO_2, about 1,300 to 5,800 yd^3 (1,000 to 4,400 m^3) of additional LLW, 0 to 1,400 yd^3 (0 to 1,100 m^3) of additional LLMW, and 55 to 130 yd^3 (42 to 100 m^3) of additional hazardous waste would be generated. The construction impacts would be the same as those presented for DOE-generated cylinders. For conversion to U_3O_8, the total waste generated during operations (USEC and DOE-generated material) would be about 4,700 to 21,000 yd^3 (3,600 to 16,000 m^3) of LLW, 34 yd^3 (26 m^3) of LLMW, and 240 yd^3 (180 m^3) of hazardous waste. For conversion to UO_2, the total waste generated during operations (USEC and DOE-generated material) would be about 5,800 to 25,000 yd^3 (4,400 to 19,000 m^3) of LLW, 0 to 620 yd^3 (0 to 470 m^3) of LLMW, and 240 to 580 yd^3 (180 to 440 m^3) of hazardous waste. (The ranges are the result of assessing different conversion technologies.)

If CaF_2 was produced in the conversion process, and if the CaF_2 was disposed of as nonradioactive, nonhazardous solid waste, an additional 3,000 to 87,000 yd^3 (2,300 to 66,000 m^3) of nonradioactive, nonhazardous solid waste would be generated over the additional 6 years of operation. The capacity for managing this annual volume of nonhazardous waste would already be in place. If the CaF_2 was disposed of as LLW, the addition of about 170,000 yd^3 (128,000 m^3) of LLW would be generated over the additional 6 years of operation. (The additional volume would be the result of grouting.) In total, about 720,000 yd^3 (550,000 m^3) of CaF_2 LLW could be generated as a result of conversion to oxide. This quantity would represent about 13% of the projected DOE complexwide disposal volume for approximately the same time period, an amount that would represent a moderate impact on waste management if the LLW was considered to be DOE waste.

The duration of operational activities at a cylinder treatment facility would increase by 6 years, resulting in a total of about 380 yd^3 (290 m^3) of additional LLW, 1.6 yd^3 (1.2 m^3) of additional LLMW, and 16 yd^3 (12 m^3) of additional hazardous waste generated as a result of the inclusion of the USEC-generated cylinders. The construction impacts would be the same as those described for management of DOE-generated material. The total waste generated during treatment operations for both DOE- and USEC-generated cylinders would be about 1,600 yd^3 (1,200 m^3) of LLW, 6.8 yd^3 (5.2 m^3) of LLMW, and 68 yd^3 (52 m^3) of hazardous waste. The crushed cylinders, totaling about 37,000 m^3, would add an additional 1% to the projected DOE complexwide LLW disposal volume (if a decision for disposal was made). The total inventory of crushed cylinders would add an additional 4% to the projected DOE complexwide LLW disposal volume.

For the operation and construction of a consolidated long-term storage facility, the addition of the USEC cylinders would generate a maximum of about 8 yd^3 (6 m^3) of additional LLW from the repackaging of failed storage containers; the maximum total volume of LLW generated as a result of both the DOE- and USEC-generated inventory would be 34 yd^3 (26 m^3).

The generation of waste for all components under the long-term storage as oxide alternative (when both DOE- and USEC-generated cylinders are considered) would have a negligible to moderate impact when considered in terms of national and regional waste management capabilities.

6.3.3.8 Resource Requirements

In general, the addition of the USEC cylinders under the long-term storage as oxide alternative would not change the assessment of impacts on resource requirements presented in Section 5.3.8. The electrical requirement for mine construction would increase by up to 150 MW-yr to a total of 1,150 MW-yr. The impact of this high electrical requirement on use of local energy resources would depend on the location of the facility and the existing infrastructure.

6.3.3.9 Land Use

At the current storage sites, the impacts to land use from the addition of USEC-generated cylinders would be the same as that for management of DOE-generated cylinders described in Section 5.2.9. Storage space for the USEC cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 5.2.9, because the facility operational period would increase, not the facility size. The land use required for a conversion facility would be the same as that for management of DOE-generated cylinders described in Section 5.3.9, because the size of the conversion facility would remain the same.

The increase in land use requirements at long-term storage facilities to accommodate the USEC-generated cylinders would range from 7 to 52 acres (3 to 21 ha). The total land use requirement for long-term storage as oxide for DOE- and USEC-generated cylinders combined would range from 81 to 264 acres (32 to 106 ha), constituting a moderate to large potential land use impact.

6.3.3.10 Cultural Resources

Potential impacts to cultural resources would be unlikely at the current storage sites because all activities would take place on previously developed land, and cultural impacts at a conversion or long-term storage facility would depend on the location of the facility.

6.3.3.11 Environmental Justice

No disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the Paducah and Portsmouth sites in association with the addition of the USEC-generated cylinders under the long-term storage as oxide alternative.

6.3.4 Use as Uranium Oxide

Under the use as uranium oxide alternative, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities occurring at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 to 2034. In addition, the total number of shipments of cylinders, uranium oxide, HF, uranium-oxide-shielded casks, and associated materials would increase by about 30%, although the annual number of shipments would be unchanged. The operational period for conversion and manufacturing facilities would be extended from 20 to 26 years to accommodate the additional processing of USEC-generated cylinders, but the sizes of these facilities would remain unchanged.

6.3.4.1 Human Health and Safety

6.3.4.1.1 Normal Facility Operations

For the use as uranium oxide alternative, the management of USEC-generated cylinders would increase the level of exposure of workers and members of the public to radiation and chemicals when compared with the management of DOE-generated cylinders only as presented in Chapter 5. However, the increased levels of exposure would not be large enough to cause appreciable increases in the potential health impacts over those under the use as uranium oxide alternative discussed in Chapter 5.

Workers. Under the use as uranium oxide alternative, the management of the additional USEC-generated cylinders (including continued cylinder storage, cylinder preparation, conversion, empty cylinder treatment, and manufacture and use) was estimated to increase the total dose to involved workers by about 30%. However, this increase would not result in additional health effects among workers when compared with the management of DOE-generated cylinders only. (The number of LCFs would not change because of rounding effects and the fact that estimates are presented as whole numbers.) The total number of health effects among involved workers (when both DOE- and USEC-generated cylinders are considered) would still range from 1 to 2 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Chapter 5 (i.e., well within applicable standards) because (1) at the current storage sites, additional cylinder yard workers would be used instead of having the same individuals conduct extra activities, and (2) at conversion and manufacturing facilities, the annual worker activities would be the same, but the facilities would operate over a longer period of time.

Increased exposure to chemicals would not be expected to increase health impacts on involved or noninvolved workers; the total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, or a manufacturing facility.

General Public. The overall potential impacts to members of the general public during normal operations would be the same as those for the management of DOE-generated cylinders described in Section 5.4.1.1.2: all exposures would be within applicable public health standards, and no LCFs from radiation exposures and no adverse effects from chemical exposures would be expected to occur among members of the general public near the three current storage sites, a conversion facility, or a manufacturing facility, when the management of additional USEC cylinders is considered.

At the current storage sites, potential public exposure to radiation and chemicals released from the sites would be exactly the same as that under the long-term storage as UF_6 alternative described in Section 6.3.2.1.1.

At conversion and manufacturing facilities, the annual impacts to members of the public would be the same as those for management of DOE-generated cylinders described in Section 5.4.1.1.2, because the annual operations would be the same. The total exposure of the public in the vicinity of these facilities to airborne radiation and chemicals would increase by approximately 30% as a result of the processing of USEC-generated cylinders. However, total exposure levels would remain well within standards and below levels expected to cause any adverse health effects among the public for all options.

6.3.4.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). For the use as uranium oxide alternative, it was estimated that no (zero) additional worker fatalities and up to 600 additional worker injuries could occur in association with management of the USEC-generated cylinders (including continued storage, cylinder preparation, cylinder treatment, conversion to oxide, and manufacture of uranium-oxide-shielded casks). The total physical hazards associated with management of the DOE- and USEC-generated cylinders would range from 2 to 3 worker fatalities and 1,600 to 2,600 worker injuries.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the use as uranium oxide alternative discussed in Section 5.4.1.2.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS.

6.3.4.2 Transportation

The management of the USEC-generated cylinders would result in an increase of approximately 30% in the total number of shipments of UF_6 cylinders, uranium oxide, ammonia, anhydrous HF (if produced), CaF_2 (if produced), uranium-oxide-shielded casks, and waste materials. (The annual number of shipments would be the same as that for DOE-generated cylinders described in Section 5.4.2 and Appendix J.) For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no adverse health effects would be expected among workers and the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders and associated materials is considered.

The 30% increase in the total number of shipments would not change the estimated number of fatalities from truck accidents (not involving releases of radioactive or hazardous materials) presented in Section 5.4.2: 4 fatalities from truck shipments (because of rounding). However, the estimated number of fatalities from rail shipment accidents would increase by 1, from 2 to 3, over the duration of the program.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders and associated materials described in Section 5.4.2, because the shipment sizes would not change. The annual probability of severe accidents occurring also would be the same as that discussed in Section 5.4.2, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.4.3 Air Quality

At the current storage sites, potential impacts to air quality would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.3. At an oxide conversion facility, the potential air quality impacts would be identical to those under the long-term storage as oxide alternative discussed in Section 6.3.3.3.

At a cask manufacturing facility, impacts on criteria pollutant emissions from construction and operation would be identical to those for DOE-generated cylinders only discussed in

Section 5.4.3, because manufacturing facilities would not increase in size, only in duration of operations. During an additional 6 years of operation, an additional 0.1 lb (0.048 kg) of uranium (as UO_2) would be emitted. The total uranium emissions from oxide cask manufacture of both the DOE- and USEC-generated inventory would be about 0.46 lb (0.21 kg). No air quality standards exist for uranium compounds. However, the additional radiological dose from these emissions was evaluated in Section 6.3.4.1.1.

6.3.4.4 Water and Soil

At the current storage sites, potential impacts to surface water, groundwater, and soil would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.4. At a conversion facility, impacts to water use and surface water, groundwater, and soil quality would be identical to those under the long-term storage as oxide alternative discussed in Section 6.3.3.4.

During construction of an oxide cask manufacturing facility, water use requirements would be the same as those for DOE-generated cylinders described in Section 5.4.4. The duration of operational activities at a cask manufacturing facility would increase by 6 years, so about 45 million gal of additional water would be required for operations. About 30 million gal of additional wastewater would be generated over the additional 6 years of operation. The total water requirement for oxide cask manufacturing facility operations would be about 200 million gal; the total operational wastewater generated would be about 130 million gal.

At a cask manufacturing facility, potential impacts to surface water, groundwater, and soil would depend on the actual location of the facility. Impacts from the DOE cylinders only were expected to be negligible, as discussed in Section 5.4.4. Impacts from the additional USEC-generated cylinders would also likely be negligible.

6.3.4.5 Socioeconomics

At the current storage sites, socioeconomic impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.5.

The annual socioeconomic impacts from operating a conversion to oxide facility and an oxide cask manufacturing facility would be the same as those for the DOE-generated cylinders only presented in Section 5.4.5. However, the period of operation would be extended by 6 years. Socioeconomic impacts during construction would also be the same as those described in Section 5.4.5.

6.3.4.6 Ecology

The continued cylinder storage and preparation activities associated with management of the USEC-generated cylinders at the current storage sites would not result in additional impacts to ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

At conversion and manufacturing facilities, treatment of USEC-generated cylinders would not result in any additional land use requirements or habitat loss, because the size of the facilities would not change when compared with those described in Section 5.4.6.

6.3.4.7 Waste Management

At the current storage sites, potential impacts to waste management would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.7.

Waste management impacts from conversion activities (including disposal of CaF_2, if necessary, and empty cylinder treatment) would be identical to those under the long-term storage as oxide alternative discussed in Section 6.3.3.7.

Waste generation during construction of a manufacturing facility would be the same as that for DOE-generated cylinders described in Section 5.4.7, because the design and size of the manufacturing facility would not change. During operation of a manufacturing facility, the addition of the USEC-generated cylinders would not change the amount of LLW generated annually; this amount would still be about 0.2% of the projected annual LLW treatment volume for all DOE facilities as described in Section 5.4.7. Operation of the manufacturing facility would generate about 1,000 yd^3 (780 m^3) of additional LLW, 2,200 yd^3 (1,700 m^3) of additional hazardous waste, and 1,500 metric tons of nonradioactive, nonhazardous solid waste. The total volume of LLW generated for processing of both the DOE- and USEC-generated cylinders would be about 4,400 yd^3 (3,400 m^3); the total volume of hazardous waste would be about 9,800 yd^3 (7,500 m^3); and the total volume of nonradioactive, nonhazardous solid waste would be about 6,500 metric tons.

The generation of waste for all components under the use as oxide alternative (when both DOE- and USEC-generated cylinders are considered) would have a low to moderate impact when considered in terms of national and regional waste management capabilities.

6.3.4.8 Resource Requirements

Addition of the USEC-generated cylinders under the use as uranium oxide alternative would not change the assessment of impacts on resource requirements presented in Section 5.4.8: no significant impacts would be expected because construction and operational requirements would not be resource intensive, and the resources required would not be rare or unique.

6.3.4.9 Land Use

At the current storage sites, the impacts to land use from the addition of USEC-generated cylinders would be the same as that for management of DOE-generated cylinders described in Section 5.2.9. Storage space for the USEC cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 5.2.9, because the facility operational period would increase, not the facility size. The land use required for conversion and manufacturing facilities would be the same as that for management of DOE-generated cylinders described in Section 5.4.9, because the facility sizes would remain the same.

6.3.4.10 Cultural Resources

The potential impacts to cultural resources would be the same as those for the DOE-generated cylinders under the use as uranium oxide alternative discussed in Section 5.4.10. Impacts to cultural resources would be unlikely at the current storage sites because all activities would take place on previously developed land, and cultural impacts at a conversion or manufacturing facility would depend on the location of the facility.

6.3.4.11 Environmental Justice

The potential impacts to environmental justice would be the same as those for the DOE-generated cylinders under the long-term storage as oxide alternative discussed in Section 5.4.11.

6.3.5 Use as Uranium Metal

Under the use as uranium metal alternative, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities occurring at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 to 2034. In addition, the total number of shipments of cylinders, uranium oxide, HF, uranium-metal-shielded casks, and associated materials would increase by about 30%, although

the annual number of shipments would be unchanged. The operational period for conversion and manufacturing facilities would be extended from 20 to 26 years to accommodate the additional processing of USEC-generated cylinders, but the sizes of these facilities would remain unchanged.

6.3.5.1 Human Health and Safety

6.3.5.1.1 Normal Facility Operations

For the use as metal alternative, the management of USEC-generated cylinders would increase the level of exposure of workers and members of the public to radiation and chemicals when compared with the management of DOE-generated cylinders only as presented in Chapter 5. However, the increased levels of exposure would not be large enough to cause appreciable increases in the potential health impacts over those under the use as metal alternative discussed in Chapter 5.

Workers. Under the use as metal alternative, the management of the additional USEC-generated cylinders (including continued cylinder storage, cylinder preparation, conversion, empty cylinder treatment, and manufacture and use) was estimated to increase the total dose to involved workers by about 30%. However, this increase would not result in additional health effects among workers when compared with the management of DOE-generated cylinders only. The total number of health effects among involved workers (when both DOE- and USEC-generated cylinders are considered) would still range from 1 to 2 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Chapter 5 (i.e., well within applicable standards) because (1) at the current storage sites, additional cylinder yard workers would be used instead of having the same individuals conduct extra activities, and (2) at conversion and manufacturing facilities, the annual worker activities would be the same, but the facilities would operate over a longer period of time.

Increased exposure to chemicals would not be expected to increase health impacts on involved or noninvolved workers. The total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, or a manufacturing facility.

General Public. The overall potential impacts to members of the general public during normal operations would be the same as those for the management of DOE-generated cylinders described in Section 5.5.1.1.2: all exposures would be within applicable public health standards, and no LCFs from radiation exposures and no adverse effects from chemical exposures would be expected to occur among members of the general public near the three current storage sites, a

conversion facility, or a manufacturing facility, when the management of additional USEC cylinders is considered.

At the current storage sites, potential public exposure to radiation and chemicals released from the sites would be exactly the same as that for the long-term storage as UF_6 alternative described in Section 6.3.2.1.1.

At conversion and manufacturing facilities, the annual impacts to members of the public would be the same as those for management of DOE-generated cylinders described in Section 5.5.1.1.2, because the annual operations would be the same. The total exposure of the public in the vicinity of these facilities to airborne radiation and chemicals would increase by approximately 30% as a result of the processing of USEC-generated cylinders. However, total exposure levels would remain well within standards and below levels expected to cause any adverse health effects among the public for all options.

6.3.5.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). For the use as metal alternative, it was estimated that no (zero) additional worker fatalities and up to 600 additional worker injuries could occur in association with the management of the USEC-generated cylinders (including continued storage, cylinder preparation, empty cylinder treatment, conversion to metal, and manufacture of metal casks). The total physical hazards associated with management of the DOE- and USEC-generated cylinders would range from 2 to 3 worker fatalities and 1,700 to 2,700 worker injuries.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the use as metal alternative discussed in Section 5.5.1.2.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS.

6.3.5.2 Transportation

The management of the USEC-generated cylinders would result in an increase of approximately 30% in the total number of shipments of UF_6 cylinders, uranium metal, ammonia, anhydrous HF (if produced), CaF_2 (if produced), MgF_2, uranium-metal-shielded casks, and waste materials. (The annual number of shipments would be the same as that for DOE-generated cylinders described in Section 5.5.2 and Appendix J). For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no adverse health effects would be expected among workers and

the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders and associated materials is considered.

The 30% increase in the total number of shipments would increase the estimated number of fatalities from truck and rail accidents (not involving releases of radioactive or hazardous materials) presented in Section 5.5.2. The estimated number of fatalities from truck shipments would increase from 3 to 4. The estimated number of fatalities from rail shipments would increase from 1 to 2 over the duration of the program.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders and associated materials described in Section 5.5.2, because the shipment sizes would not change. The annual probability of severe accidents occurring also would be the same as that discussed in Section 5.5.2, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.5.3 Air Quality

At the current storage sites, potential impacts to air quality would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.3.

At a metal conversion facility, impacts on criteria pollutant emissions from construction and operation would be identical to those for DOE-generated cylinders only under the use as metal alternative discussed in Section 5.5.3, because conversion facilities would not increase in size, only in duration of operations. During an additional 6 years of operation, an additional 24 to 66 lb (11 to 30 kg) of uranium (as U_3O_8 or UF_4) would be emitted. The total uranium emissions from conversion of both the DOE- and USEC-generated inventory would range from about 100 to 290 lb (45 to 130 kg). No air quality standards exist for uranium compounds. However, the potential health impacts from these emissions were evaluated in Section 6.3.5.1.1.

At a cask manufacturing facility, impacts on criteria pollutant emissions from construction and operation would be identical to those for DOE-generated cylinders only discussed in Section 5.5.3, because manufacturing facilities would not increase in size, only in duration of operations. During an additional 6 years of operation, an additional 0.66 lb (0.30 kg) of uranium (as U_3O_8) would be emitted. The total uranium emissions from metal cask manufacture of both the DOE- and USEC-generated inventory would be about 2.9 lb (1.3 kg). No air quality standards exist for uranium compounds. However, the additional radiological dose from these emissions was evaluated in Section 6.3.5.1.1.

6.3.5.4 Water and Soil

At the current storage sites, potential impacts to surface water, groundwater, and soil would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.4.

During construction of a metal conversion facility, water use requirements would be the same as those for DOE-generated cylinders described in Section 5.5.4. The duration of operational activities at a conversion to metal facility would increase by 6 years, so about 330 million gal of additional water would be required for operations. From about 150 to 180 million gal of additional wastewater would be generated over the additional 6 years of operation. The total water requirement for conversion to metal operations would be about 1,400 million gal; the total wastewater generated would range from about 650 to 780 million gal.

During construction of a cask manufacturing facility, water use requirements would be the same as those for DOE-generated cylinders described in Section 5.5.4. The duration of operational activities at a metal cask manufacturing facility would increase by 6 years, so about 42 million gal of additional water would be required for operations. About 30 million gal of additional wastewater would be generated over the additional 6 years of operation. The total water requirement for metal cask manufacturing facility operations would be about 180 million gal; the total operational wastewater generated would be about 130 million gal.

At a metal cask manufacturing facility, potential impacts to surface water, groundwater, and soil would depend on the actual location of the facility. Impacts for the DOE-cylinders only were expected to be negligible, as described in Section 5.5.4. Impacts from the additional USEC-generated cylinders would also likely be negligible.

6.3.5.5 Socioeconomics

At the current storage sites, socioeconomic impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.5.

The annual socioeconomic impacts from operating a conversion to metal facility and metal cask manufacturing facility would be the same as those for the DOE-generated cylinders only presented in Section 5.5.5. However, the period of operations would be extended by 6 years. Socioeconomic impacts during construction would also be the same as those described in Section 5.5.5.

6.3.5.6 Ecology

The continued cylinder storage and preparation activities associated with management of the USEC-generated cylinders at the current storage sites would not result in additional impacts to

ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

At conversion and manufacturing facilities, treatment of USEC-generated cylinders would not result in any additional land use requirements or habitat loss, because the sizes of the facilities would not change when compared with those described in Section 5.5.6.

6.3.5.7 Waste Management

At the current storage sites, potential impacts to waste management would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.7.

At a metal conversion facility, the impacts during construction would be the same as those for DOE-generated cylinders described in Section 5.5.7. Operation of the metal conversion facility would increase by 6 years, so about 1,400 to 14,000 yd^3 (1,100 to 11,000 m^3) of additional LLW, 8 yd^3 (6 m^3) of additional LLMW, and 55 to 78 yd^3 (42 to 60 m^3) of additional hazardous waste would be generated as a result of including the USEC-generated cylinders. The total waste generated during operations for conversion of both DOE- and USEC-generated cylinders would be about 6,400 to 64,000 yd^3 (4,900 to 49,000 m^3) of LLW, 34 yd^3 (26 m^3) of LLMW, and 230 to 340 yd^3 (180 to 260 m^3) of hazardous waste. (The ranges are the result of assessing different conversion technologies.)

If MgF_2 produced in the conversion process was disposed of as nonradioactive, nonhazardous solid waste, an additional 48,000 yd^3 (37,000 m^3) of nonradioactive, nonhazardous solid waste would be generated. This additional waste would be disposed of annually (about 7,900 yd^3 [6,100 m^3] per year) over the additional 6 years of operation of the conversion facility. The capacity for managing this annual volume of nonhazardous waste would already be in place. If the MgF_2 needed to be disposed of as LLW, an additional 96,000 yd^3 (74,000 m^3) of LLW would be generated over the additional 6 years of operation. This additional volume would be a result of grouting. In total, about 420,000 yd^3 (320,000 m^3) of MgF_2 LLW could be generated through conversion to metal. This amount of LLW would represent less than 8% of the projected DOE complexwide disposal volume for approximately the same time period, which would be considered a low impact for waste management if the LLW was considered DOE waste. If HF was neutralized to produce CaF_2, and if the CaF_2 needed to be disposed of as LLW, an additional 27,000 yd^3 (21,000 m^3) of CaF_2 would be produced, yielding a total of 120,000 yd^3 (91,000 m^3) of grouted CaF_2 LLW. This additional volume of LLW would constitute approximately 4% of the projected DOE complexwide LLW disposal volume.

Waste generation during construction of a metal cask manufacturing facility would be the same as that for DOE-generated cylinders described in Section 5.5.7, because the design and size of

the manufacturing facility would not change. During operation of a manufacturing facility, the addition of the USEC-generated cylinders would not change the amount of LLW generated annually; this amount would still be about 0.3% of the projected annual LLW treatment volume for all DOE facilities, as described in Section 5.4.7. Operation of the manufacturing facility would generate about 5,100 yd^3 (3,900 m^3) of additional LLW, 2,500 yd^3 (1,900 m^3) of additional hazardous waste, and 1,800 metric tons of nonradioactive, nonhazardous solid waste. The total volume of LLW generated for processing of both the DOE- and USEC-generated cylinders would be about 22,000 yd^3 (17,000 m^3); the total volume of hazardous waste would be about 1,100 yd^3 (8,300 m^3); and the total volume of nonradioactive, nonhazardous solid waste would be about 7,800 metric tons.

The generation of waste for all components of the use as metal alternative (when both DOE- and USEC-generated cylinders are considered) would have a low to moderate impact when considered in terms of national and regional waste management capabilities.

6.3.5.8 Resource Requirements

The addition of the USEC-generated cylinders under the use as uranium metal alternative would not change the assessment of impacts on resource requirements presented in Section 5.5.8: no significant impacts would be expected, because construction and operational requirements would not be resource intensive, and the resources required would not be rare or unique.

6.3.5.9 Land Use

At the current storage sites, the impacts to land use from the addition of USEC-generated cylinders would be the same as that for management of DOE-generated cylinders described in Section 5.2.9. Storage space for the USEC cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those given for the DOE-generated cylinders only described in Section 5.2.9, because the facility operational period would increase, not the facility size. The land use required for conversion and manufacturing facilities would be the same as that for management of DOE-generated cylinders described in Section 5.5.9, because the facility sizes would remain the same.

6.3.5.10 Cultural Resources

For the use as uranium metal alternative, impacts to cultural resources would be unlikely at the current storage sites, because all activities would take place on previously developed land, and cultural impacts at a conversion or manufacturing facility would depend on the location of the facility.

6.3.5.11 Environmental Justice

The impacts to environmental justice would be the same as those for the DOE-generated cylinders under the use as metal alternative discussed in Section 5.5.11.

6.3.6 Disposal as Uranium Oxide

Under the disposal as uranium oxide alternative, the inclusion of USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities occurring at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 to 2034. In addition, the total number of shipments of cylinders, uranium oxide, HF, and associated materials would increase by about 30%, although the annual number of shipments would be unchanged. The operational period for a conversion facility would be extended from 20 to 26 years to accommodate the additional processing of USEC-generated cylinders. Similarly, the operational period of a disposal facility would also be increased from 20 to 26 years, with approximately 30% more land area being required for disposal.

6.3.6.1 Human Health and Safety

6.3.6.1.1 Normal Facility Operations

For the disposal as uranium oxide alternative, the management of USEC-generated cylinders would increase the level of exposure of workers and members of the public to radiation and chemicals when compared with the management of DOE-generated cylinders only, as presented in Chapter 5. For involved workers, the increased radiation exposure could result in a maximum of 1 LCF in addition to the potential 1 to 2 LCFs estimated for the management of DOE-generated cylinders. (The estimated total including DOE- and USEC-generated cylinders would be 1 to 3 LCFs.) For noninvolved workers and members of the public, the increased levels of exposure would not appreciably increase the potential health impacts over those under the disposal as oxide alternative discussed in Chapter 5. For a disposal facility in a wet environment, potential long-term exposure of members of the public to radiation and chemicals from groundwater could exceed standards and levels expected to cause adverse health effects. For a disposal facility in a dry environment, no long-term impacts would be expected.

Workers. Under the disposal as oxide alternative, the management of the additional USEC cylinders (including continued cylinder storage, cylinder preparation, conversion, empty cylinder treatment, and disposal of oxide) was estimated to increase the total dose to involved workers by about 30%, resulting in a maximum of 1 additional LCF for each disposal option (shallow-earthen structures, vaults, and mines). The total number of health effects among involved workers (when

both DOE- and USEC-generated cylinders are considered) would range from 1 to 3 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same as that for DOE-generated cylinders reported on in Chapter 5 (i.e., well within applicable standards) because (1) at the current storage sites, additional cylinder yard workers would be used instead of having the same individuals conduct extra activities, and (2) at conversion and disposal facilities, the annual worker activities would be the same, but the facilities would operate over a longer period of time.

Increased exposure to chemicals would not be expected to increase health impacts on involved or noninvolved workers; the total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, or a disposal facility.

General Public. During the operational phase of the disposal facility, the overall potential impacts to members of the general public during normal operations would be the same as those for the management of DOE-generated cylinders described in Section 5.6.1.1.2: all exposures would be within applicable public health standards, and no LCFs from radiation exposures and no adverse effects from chemical exposures would be expected to occur among members of the general public near the three current storage sites, a conversion facility, or a disposal facility, when the management of additional USEC cylinders is considered.

At the current storage sites, potential public exposure to radiation and chemicals released from the sites would be exactly the same as that for the long-term storage as UF_6 alternative described in Section 6.3.2.1.1.

At a conversion facility or a disposal facility during the operational phase, the annual impacts to members of the public would be the same as those for management of DOE-generated cylinders described in Section 5.6.1.1.2, because the annual operations would be the same. The total exposure of the public to airborne radiation and chemicals in the vicinity of these facilities would increase by approximately 30% as a result of the processing of USEC-generated cylinders. However, total exposure levels during the operational phase would remain well within standards and below levels expected to cause any adverse health effects among the public for all disposal options.

For a disposal facility located in a wet environment, during the postclosure phase (long-term), potential exposures of members of the public to radiation and chemicals in groundwater could increase as a result of the additional management of USEC-generated cylinders. (For a disposal facility in a dry environment, groundwater contamination would not occur until well after the 1,000-year assessment period considered in the PEIS.) As described in the groundwater analysis in Section 6.3.6.4, in a wet environment, the addition of the USEC-generated cylinders would increase the uranium concentration in groundwater by 20% 1,000 years after facility failure (Tomasko 1998).

The potential radiation dose and chemical intakes for a maximally exposed individual would increase proportionally. The maximum radiation dose to an individual assumed to use contaminated groundwater would be expected to increase to about 120 mrem/yr, a level that is greater than the dose limit of 25 mrem/yr specified in 10 CFR Part 61. The chemical hazard indices were calculated to increase to 12, indicating the potential for chemically induced adverse effects.

6.3.6.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). Under the disposal as uranium oxide alternative, it was estimated that no (zero) additional worker fatalities and up to 600 additional worker injuries could occur in association with the management of the USEC-generated cylinders (including continued cylinder storage, cylinder preparation, cylinder treatment, conversion, and disposal). The total physical hazards associated with management of the DOE- and USEC-generated cylinders would range from 1 to 3 worker fatalities and 900 to 2,400 worker injuries.

Accidents Involving Releases of Radiation or Chemicals. For accident consequences, impacts would be the same as those for the DOE-generated cylinders under the disposal as uranium oxide alternative discussed in Section 5.6.1.2.2. Although the estimated frequencies of some accidents would increase somewhat in association with the management of the additional USEC cylinders, this increase would not be expected to be enough to change the overall expected frequency of specific accidents from the broad ranges used for this PEIS.

6.3.6.2 Transportation

The management of the USEC-generated cylinders would result in an increase of approximately 30% in the total number of shipments of UF_6 cylinders, uranium oxide, ammonia, anhydrous HF (if produced), CaF_2 (if produced), and waste materials. (The annual number of shipments would be the same as that for DOE-generated cylinders described in Section 5.6.2 and Appendix J.) For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no adverse health effects would be expected among workers and the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders and associated materials is considered.

Although the total number of shipments would increase by about 30%, the estimated number of fatalities from transportation accidents (not involving releases of radioactive or hazardous materials) would be the same as that for DOE-generated cylinders reported on in Section 5.6.2. The number would be the same because of rounding and the fact that estimates were presented as a single whole number. Thus, the total estimated number of traffic accident fatalities under the disposal as oxide alternative (including both DOE- and USEC-generated cylinders) would remain at 4 for truck transport and 2 for rail transport.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders and associated materials described in Section 5.6.2, because the shipment sizes would not change. The annual probability of severe accidents occurring also would be the same as that discussed in Section 5.6.2, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.6.3 Air Quality

At the current storage sites, potential impacts to air quality would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.3. At a conversion facility, potential impacts to air quality would be identical to those for conversion under the long-term storage as oxide alternative discussed in Section 6.3.3.3.

At a disposal facility, although the size of the facility would increase, annual average air concentrations of criteria pollutants would remain the same as those predicted for the DOE-generated cylinders only in Section 5.6.3, because the annual level of operations would stay the same. For disposal options that involve the grouting of waste, during an additional 6 years of operation, an additional 3.6 to 6.6 lb (1.6 to 3 kg) of uranium (as U_3O_8 or UO_2) would be emitted. The total uranium emissions from disposal of grouted U_3O_8 or UO_2 for both the DOE- and USEC-generated inventory would range from about 16 to 29 lb (7 to 13 kg). No air quality standards exist for uranium compounds. However, the potential health impacts from these emissions were evaluated in Section 6.3.6.1.1.

6.3.6.4 Water and Soil

At the current storage sites, potential impacts to water and soil would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.4. At an oxide conversion facility, potential impacts to water and soil would be identical to those for conversion under the long-term storage as oxide alternative discussed in Section 6.3.3.4.

At a disposal facility, the addition of the USEC-generated cylinders would require that construction and operational activities be increased by 6 years. Therefore, about 1.2 to 17 million gal of additional water would be required for construction, and about 0.6 to 120 million gal of additional water would be required for operations. Additional wastewater generation would range from about 0.6 to 1.2 million gal for construction and 0.6 to 8 million gal for operations. The total water requirement for construction would range from 5 to 73 million gal; the total water requirement for operations would range from about 3 to 520 million gal. Total wastewater generation would range from about 3 to 5 million gal for construction and 3 to 34 million gal for operations.

As stated in Section 5.6.4.1, impacts to surface water from a disposal facility would be negligible, because no process water effluents would be expected and because wastewater generation rates would be half or less than half of those from a conversion facility. Additional impacts of disposal to surface water as a result of the additional USEC-generated cylinders would also be negligible.

Potential impacts to groundwater during the operational phase of disposal when the USEC cylinders are considered would be the same as the impacts for the DOE-generated cylinders only described in Section 5.6.4.2.1.

Potential long-term impacts to groundwater from disposal of DOE-generated cylinders only were discussed in Section 5.6.4.2.2. The addition of the USEC cylinders to the disposal inventory would increase the total subsurface disposal area, which ultimately would increase the estimated concentration of uranium in groundwater by 20% 1,000 years after failure of the facility (Tomasko 1998). This increase would not impact the assessment for disposal in a dry environment (i.e., concentrations greater than the guideline level of 20 µg/L would not occur for at least 1,000 years after failure of the facility). For disposal in a wet environment, the inclusion of the USEC cylinders in the disposal calculations would result in estimated concentrations of uranium in groundwater at 1,000 years after facility failure that would range from about 280 to 510 pCi/L (1,100 to 2,000 µg/L) for disposal of U_3O_8 and about 230 to 380 pCi/L (910 to 1,600 µg/L) for disposal of UO_2.

The additional excavation volume that would result from the addition of the USEC cylinders under the disposal as uranium oxide alternative would range from 70,000 yd^3 (54,000 m^3) for disposal as ungrouted UO_2 in a vault to 1 million yd^3 (770,000 m^3) for disposal as grouted U_3O_8 in a mine. The total required excavation volumes would range from 400,000 yd^3 (310,000 m^3) to 3.6 million yd^3 (230,000 to 2.8 million m^3).

6.3.6.5 Socioeconomics

At the current storage sites, socioeconomic impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.5.

The annual socioeconomic impacts from operating a conversion to oxide facility and a disposal facility would be the same as those for the DOE-generated cylinders only presented in Section 5.6.5. However, the period of operation would be extended by 6 years. Socioeconomic impacts during construction would not change for the conversion facility. However, the period of construction activities for the disposal facility would increase by 6 years.

6.3.6.6 Ecology

The continued cylinder storage and preparation activities associated with management of the USEC-generated cylinders at the current storage sites would not result in additional impacts to ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts.

At a conversion facility, treatment of USEC-generated cylinders would not result in any additional land use requirements or habitat loss, because the size of the facilities would not change when compared with those described in Section 5.6.6.

For the operational phase of the disposal facility, addition of the USEC-generated cylinders would increase land use requirements by 8 to 116 acres (3 to 46 ha), which would result in additional habitat loss. The total land required for a disposal facility would range from 36 to 587 acres (14 to 230 ha), which would have a moderate to large potential impact on vegetation and wildlife.

Although the postclosure groundwater uranium concentrations at disposal facilities might increase somewhat (i.e., by about 20%) as a result of the addition of the USEC-generated cylinders, the overall ecological impacts during the postclosure phase would remain the same as those discussed in Section 5.6.6.2.

6.3.6.7 Waste Management

At the current storage sites, potential impacts on waste management would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.7. At an oxide conversion facility, impacts would be identical to those under the long-term storage as oxide alternative discussed in Section 6.3.3.7.

At a disposal facility, the inclusion of the USEC-generated cylinders would increase disposal volumes by approximately 30%. Thus, the maximum volume of grouted U_3O_8 for disposal would increase by approximately 130,000 yd^3 (100,000 m^3), to a total of 540,000 yd^3 (412,000 m^3). This amount would represent approximately 10% of the projected DOE complexwide LLW disposal volume over the same approximate period. If the U_3O_8 was not grouted, an additional 65,000 yd^3 (50,000 m^3) would be disposed of, for a total of about 260,000 yd^3 (200,000 m^3), representing about 5% of the projected DOE disposal volume. The volumes of UO_2 disposed of would increase by approximately 30,000 yd^3 (23,000 m^3) if grouted and 20,000 yd^3 (15,000 m^3) if ungrouted, for totals of about 120,000 yd^3 (95,000 m^3) grouted and 82,000 yd^3 (63,000 m^3) ungrouted. These volumes represent less than about 2.2% of the projected DOE disposal volume. Overall, the additional volumes represent a range of potential waste management impacts from low to moderate.

The generation of waste for all components under the disposal alternative (when both DOE- and USEC-generated cylinders are considered) would have a low to moderate impact when considered in terms of national and regional waste management capabilities.

6.3.6.8 Resource Requirements

In general, addition of the USEC cylinders would not change the assessment of impacts on resource requirements from those under the disposal alternative presented in Section 5.6.8; no significant impacts would be expected because construction and operational requirements would not be resource intensive, and the resources required would not be considered rare or unique. The maximum electrical requirement for mine construction would increase by approximately 200 MW-yr, to a total of 1,300 MW-yr. The impact of this high electrical requirement on use of local energy resources would depend on the location of the facility and the existing infrastructure.

6.3.6.9 Land Use

At the current storage sites, the impacts to land use from the addition of USEC-generated cylinders would be the same as that for management of DOE-generated cylinders described in Section 5.2.9. Storage space for the USEC cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 5.2.9, because the facility operational period would increase, not the facility size. The land use required for a conversion facility would be the same as that for management of DOE-generated cylinders described in Section 5.6.9, because the facility size would remain the same.

The increase in land use requirements for disposal facilities to accommodate the USEC-generated cylinders would range from 8 to 116 acres (3 to 46 ha). The total land use requirement for disposal of DOE- and USEC-generated cylinders combined would range from 36 to 587 acres (14 to 230 ha), constituting a moderate to large potential land use impact.

6.3.6.10 Cultural Resources

For the disposal alternative, impacts to cultural resources would be unlikely at the current storage sites, because all activities would take place on previously developed land, and cultural impacts at a conversion or disposal facility would depend on the location of the facility.

6.3.6.11 Environmental Justice

The impacts to environmental justice would be the same as those for the DOE-generated cylinders only under the disposal alternative discussed in Section 5.6.11.

6.3.7 Preferred Alternative

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory, including USEC-generated cylinders, as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. As explained in Section 5.7, some portion of the inventory would probably require long-term storage as oxide, and for use, it could be in the form of either uranium oxide or uranium metal. To analyze the impacts of the preferred alternative as detailed in Section 5.7, a representative combination strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was evaluated. Estimates of the impacts taken from parametric analyses of facilities with capacities ranging from 25% to 100% (presented in Appendix K) were added as appropriate to estimate the total impacts.

In practice, the addition of the USEC cylinders could be managed in a variety of ways. For example, facilities could be increased in size or operated longer to accommodate the additional inventory (as was assumed for the assessment of the potential impacts from the management of USEC-generated cylinders detailed in Sections 6.3.1 through 6.3.6). To remain consistent with the assumptions for the USEC-generated cylinders used in Sections 6.3.1 through 6.3.6, the analysis conducted for this section assumed that the facilities would operate longer to process the additional inventory. (For example, a 75%-capacity conversion to oxide facility would operate about 6 years longer, for a total of 26 years, to process 75% of the USEC-generated cylinders; a 25%-capacity conversion to metal facility would operate about 6 years longer, to process 25% of the USEC-generated cylinders.) The results of the analyses detailed in Sections 6.3.1 through 6.3.6 were incorporated and modified when possible to estimate the combined impacts when both the DOE- and USEC-generated cylinders are considered under the preferred alternative. For example, the impacts that would result from continued storage would be the same as those presented under the long-term storage as UF_6 alternative that considers USEC cylinders (Section 6.3.2).

6.3.7.1 Human Health and Safety

6.3.7.1.1 Normal Facility Operations

Under the preferred alternative, the management of USEC-generated cylinders would increase the levels of exposure of workers and members of the public to radiation and chemicals when compared with the management of DOE-generated cylinders only presented in Chapter 5. For involved workers, the increased radiation exposure could result in a maximum of 1 LCF in addition

to the potential 1 to 2 LCFs estimated for the management of DOE-generated cylinders. Thus, the estimated total, when both DOE- and USEC-generated cylinders are considered, would range from 2 to 3 LCFs. For noninvolved workers and members of the public, the increased levels of exposure would not be large enough to cause appreciable increases in the potential health impacts under the preferred alternative discussed in Chapter 5.

Workers. Under the preferred alternative, the management of the additional USEC cylinders (including continued cylinder storage, cylinder preparation, conversion to both uranium oxide and uranium metal, empty cylinder treatment, manufacture of oxide- and metal-shielded casks, and long-term storage of oxide) was estimated to increase the total dose to involved workers by about 30%, resulting in a maximum of 1 additional LCF. The total number of health effects among involved workers (when both DOE- and USEC-generated cylinders are considered) would range from 2 to 3 LCFs over the duration of the program. (The dose to noninvolved workers would remain negligible when compared with the involved worker dose.)

In general, the average annual radiation dose to individual workers associated with management of the additional USEC cylinders would be the same or less than that for DOE-generated cylinders reported on in Chapter 5 (i.e., well within applicable standards) because (1) at the current storage sites and a long-term storage facility, additional cylinder yard workers would be used instead of having the same individuals conduct extra activities and (2) conversion and manufacturing facilities would be smaller than the full-scale facilities and would thus require fewer worker activities.

Increased exposure to chemicals would not be expected to increase health impacts on involved or noninvolved workers; the total estimated hazard indices (when both DOE- and USEC-generated cylinders are considered) would be less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, a manufacturing facility, or a consolidated storage facility.

General Public. Although the exposure of the public to radiation and chemicals would increase by about 30%, the overall potential impacts to members of the general public during normal operations would be the same as those for the management of DOE-generated cylinders only described in Section 5.7.1.1: all exposures would be within applicable public health standards, and no LCFs from radiation exposures and no adverse effects from chemical exposures would be expected to occur among members of the general public near the three current storage sites, a conversion facility, a manufacturing facility, or a consolidated long-term storage facility, when the management of additional USEC cylinders is considered.

At the current storage sites, potential public exposure to radiation and chemicals released from the sites would be exactly the same as that under the long-term storage as UF_6 alternative described in Section 6.3.2.1.1.

At conversion, manufacturing, and long-term storage facilities, the total exposure of the public in the vicinity of these facilities to airborne radiation and chemicals would increase by

approximately 30% as a result of the processing of USEC-generated cylinders. However, total exposure levels would remain well within standards and below levels expected to cause any adverse health effects among the public.

6.3.7.1.2 Facility Accidents

Physical Hazards (On-the Job Injuries and Fatalities). Overall, on-the-job injuries and fatalities under the preferred alternative as presented in Section 5.7.2.2 and Table 5.11 would be expected to increase by about 30%. This percentage would represent an increase of about 700 to 990 injuries, for a total range of 2,900 to 4,100 injuries under the preferred alternative. The estimated fatalities would increase by about 1, to a total range of 4 to 5.

Accidents Involving Releases of Radiation or Chemicals. The assessment of impacts from these accidents would remain the same as previously that under the preferred alternative discussed in Section 5.7.2.1.

6.3.7.2 Transportation

The management of the USEC-generated cylinders would result in an increase of approximately 30% in the total number of shipments of UF_6 cylinders, uranium oxide, uranium metal, ammonia, anhydrous HF (if produced), CaF_2 (if produced), oxide- and metal-shielded casks, and waste materials. For normal (incident-free) transportation operations, these additional shipments would increase exposure to overall external radiation and vehicle exhaust emissions by about 30%. However, no additional adverse health effects would be expected among workers and the public during normal transportation activities when shipment of both DOE- and USEC-generated cylinders and associated materials is considered.

The 30% increase in the total number of shipments would increase the estimated numbers of fatalities due to truck and rail accidents (not involving releases of radioactive or hazardous materials) from the numbers presented in Section 5.7.3. The estimated number of fatalities from truck shipments would increase from 4 to 5. The estimated number of fatalities from rail shipments would increase from 1 to 2 over the duration of the program.

The consequences of severe traffic accidents involving releases of radiation or chemicals would be the same as those for the shipment of DOE-generated cylinders and associated materials described in Section 5.7.3, because the shipment sizes would not change. The annual probability of severe accidents occurring also would be the same as that discussed in Section 5.7.3, although the total probability of a severe accident would increase by about 30% as shipments continued for an additional 6 years.

6.3.7.3 Air Quality

At the current storage sites, potential impacts to air quality would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.3.

As stated in Section 5.7.4, under the preferred alternative, during the construction and operation of conversion, long-term storage, and manufacturing facilities designed to handle less than 100% of the inventory, pollutant emissions would remain within standards.

6.3.7.4 Water and Soil

At the current storage sites, potential impacts to water and soil would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.4.

Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent. On the basis of an evaluation of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels.

The consideration of long-term storage of USEC-generated cylinders would result in increased excavation requirements. Additional excavation volumes would range from 10,000 to 200,000 yd^3 (7,600 to 150,000 m^3). The total required excavation volume would range from 51,000 to 1.3 million yd^3 (39,000 to 1.0 million m^3).

6.3.7.5 Socioeconomics

At the current storage sites, socioeconomic impacts would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.5.

The annual socioeconomic impacts from operating conversion to oxide and conversion to metal facilities under the preferred alternative would be the same as those estimated for the DOE-generated cylinders only in Section 5.7.5, but the period of operation would be extended by about 6 years. Socioeconomic impacts during construction would not change for the conversion facilities.

For the long-term storage as oxide component of the preferred alternative, construction and operations would be extended by 6 years as a result of the addition of the USEC-generated cylinders. The peak year construction jobs and income would not change from those stated in Table 2.4 for the preferred alternative (that is, 60–210 direct jobs, $3–10 million direct income). It is estimated that additional operational activities due to the USEC-generated cylinders would create from 9 to 11 direct jobs per year and up to $1 million in additional direct income. Thus, the total operational socioeconomic impacts from the DOE- and USEC-generated cylinders combined would be expected

to range from 39 to 46 direct jobs per year and from $3 to $4 million in direct income per year. The values are in ranges to allow for the form of the oxide and the location used for storage (buildings, vaults, or a mine).

6.3.7.6 Ecology

The continued cylinder storage and preparation activities associated with management of the USEC-generated cylinders at the current storage sites would not result in additional impacts to ecological resources. Concentrations of uranium in soil, groundwater, and surface water would remain well below benchmark values for toxic and radiological effects. In addition, construction activities would take place on previously disturbed areas (i.e., existing yards) and would have no ecological impacts. Habitat losses due to conversion and manufacturing facilities would not change from those presented in Section 5.7.7.

At a long-term storage facility, the addition of the USEC-generated cylinders would increase the land use requirement by up to about 25% (see Section 5.7.7), from about 49 acres (20 ha) to 61 acres (25 ha). The result would be additional habitat loss, but this loss would still represent only a moderate potential impact to vegetation and wildlife.

6.3.7.7 Waste Management

At the current storage sites, potential impacts on waste management would be identical to those under the long-term storage as UF_6 alternative discussed in Section 6.3.2.7.

At uranium oxide and uranium metal conversion facilities, inclusion of the USEC-generated cylinders could increase the amount of CaF_2 and MgF_2 requiring disposal as LLW by about 30%. However, this increase would not change the overall assessment of impacts on waste management; disposal of the LLW would still have a moderate impact on nationwide LLW management (assuming these wastes would be considered DOE wastes).

At long-term storage and manufacturing facilities, impacts to waste management would generally be negligible, as described in Section 5.7.8. The operation of these facilities for an additional 6 years to process USEC-generated cylinders would not appreciably change waste management impacts.

The generation of waste for all components under the preferred alternative (when both DOE- and USEC-generated cylinders are considered) would have negligible to moderate impacts when considered in terms of national and regional waste management capabilities.

6.3.7.8 Resource Requirements

Under the preferred alternative, when the USEC cylinders are considered, adverse effects on local, regional, or national availability of materials would not be expected.

6.3.7.9 Land Use

No change in land use would occur at the current storage sites under the preferred alternative described in Section 5.7.7 when the USEC cylinders are considered. Storage space for the cylinders is already present at the sites. If transfer facilities were built for cylinder preparation, the land use requirements would be the same as those for the DOE-generated cylinders only described in Section 5.7.7, because the facility operational period would increase, not the facility size.

Land use requirements at conversion and manufacturing facilities would not change from those presented in Section 5.7.6, because the length of operations at these facilities would be increased to accommodate the USEC cylinders; sizes of the facilities would not be increased.

For the long-term storage component of the preferred alternative, the addition of the USEC-generated cylinders would increase the land use requirement by about 25% (Section 5.7.7), from about 49 acres (20 ha) to 61 acres (25 ha). This increase would still represent only a moderate potential land use impact.

6.3.7.10 Cultural Resources

The impacts to cultural resources would be the same as those for the DOE-generated cylinders under the preferred alternative discussed in Section 5.7.11.

6.3.7.11 Environmental Justice

The impacts to environmental justice would be the same as those for the DOE-generated cylinders under the preferred alternative discussed in Section 5.7.11.

6.3.8 Cumulative Impacts

This section addresses whether the consideration of the additional USEC-generated cylinders would increase the impacts of depleted UF_6 management activities sufficiently to change the cumulative impacts evaluation presented in Section 5.8.

Inclusion of the USEC-generated cylinders would increase the number of cylinders managed by DOE at the Paducah site by 42% and at the Portsmouth site by 22%. Activities at the K-25 site would be unaffected. Consequently, the duration of continued cylinder storage and preparation activities at the Paducah and Portsmouth sites would be extended by about 6 years, from 2028 through 2034.

At the Paducah site, the increased inventory would generally result in a 42% increase in the collective population dose to the involved workers and to the public from continued cylinder storage and preparation activities, as reported on in Table 5.12. However, this increase in radiological exposure would not significantly affect the estimated number of cumulative health effects at the Paducah site. The overall cumulative impacts to workers and the public would be unaffected by the increase in the inventory because of rounding effects and the fact that estimated health effects (e.g., LCFs) are presented as whole numbers. Similarly, although transportation requirements and resource and infrastructure requirements would increase, this increase would not significantly change the cumulative impacts from those presented in Table 5.12. Air quality standards at the Paducah site would not be exceeded, nor would groundwater quality impacts change from those estimated for the DOE-generated cylinders alone. (See Sections 6.3.1.3, 6.3.1.4, 6.3.2.3, and 6.3.2.4.)

At the Portsmouth site, the increased inventory would generally result in a 22% increase in the collective population dose to the involved workers and to the public from continued cylinder storage and preparation activities, as reported on in Table 5.13. However, this increase in radiological exposure would not significantly affect the estimated number of cumulative health effects at the Portsmouth site. The overall cumulative impacts to workers and the public would be unaffected by the increase in the inventory because of rounding effects and the fact that estimated health effects (e.g., LCFs) are presented as whole numbers. Although transportation requirements and resource and infrastructure requirements would increase, this increase would not significantly change the cumulative impacts from those presented in Table 5.13. Air quality standards at the Portsmouth site would not be exceeded, nor would groundwater quality impacts change from those estimated for the DOE-generated cylinders alone. (See Sections 6.3.1.3, 6.3.1.4, 6.3.2.3, and 6.3.2.4.)

7 ENVIRONMENTAL, OCCUPATIONAL SAFETY, AND HEALTH PERMITS AND COMPLIANCE REQUIREMENTS

The major laws, regulations, executive orders, and compliance instruments that would apply to activities of the Depleted Uranium Hexafluoride Management Program under the no action and other alternatives are identified below. Various federal environmental statutes impose environmental protection and compliance requirements upon DOE. Further, those authorities have been assessed to determine which state and local environmental authorities are also applicable because they are delegated to the states for enforcement or implementation under federal law. It is DOE policy to conduct its operations in an environmentally safe manner in compliance with all applicable statutes, regulations, and standards. Although this chapter does not address pending legislation or regulations that may become effective in the future, DOE recognizes that the regulatory environment is rapidly changing and that the construction and operation of any future depleted UF_6 management alternative must be conducted in compliance with the applicable statutes, regulations, and standards in effect at the time.

The *Atomic Energy Act* of 1954 (42 *United States Code* [USC] 2011 et seq.) authorizes the DOE to establish standards to protect health or minimize dangers to life or property for its facilities and operations. The DOE has established an extensive system of standards and requirements through DOE Orders to ensure safe operation of its facilities. Executive Order 12088, "Federal Compliance with Pollution Control Standards," requires federal agencies — including DOE — to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the *Clean Air Act, Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act*, and *Toxic Substances Control Act*.

In addition to those in Executive Order 12088, other environmental, occupational safety, and health permit and compliance requirements might also apply to activities under the PEIS alternatives. Depending on the locale chosen for the new activity, particularly the siting, construction, and operation of new facilities, these potential requirements might include the following:

- *Clean Air Act Amendments* (CAAA) of 1990 (Public Law 101-549, 104 Statute 2684, November 15, 1990);
- *Federal Facilities Compliance Act* (FFCA) of 1992 (Public Law 120-386, 106 Statute 1505, October 6, 1992);
- *Atomic Energy Act* of 1954;
- *Low-Level Radioactive Waste Policy Act*;

- *Emergency Planning and Community Right-to-Know Act* of 1986 (as extended to federal facilities by Executive Order 12856, August 3, 1993);
- *Endangered Species Act*, as amended;
- *Migratory Bird Treaty Act*, as amended;
- *Bald and Golden Eagle Protection Act*, as amended;
- *National Historic Preservation Act* of 1966, as amended;
- *Archaeological and Historic Preservation Act*;
- *American Indian Religious Freedom Act* of 1978;
- *Wild and Scenic Rivers Act;*
- *Farmland Protection Policy Act;*
- *Soil and Water Conservation Act* of 1977; and
- Executive Order 12898 — "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations."

DOE also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the depleted UF_6 stored at the K-25 site. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from K-25 or complete the conversion of their contents by December 31, 2009.

DOE has entered into an agreement with the Ohio EPA for the management of the depleted uranium stored at the Portsmouth site. This agreement, dated February 24, 1998, is entitled "Ohio EPA Director's Final Findings and Orders" (DFF&O) and is the result of the State's Notice of Violation issued against DOE. The DFF&O outlines the management, surveillance and maintenance activities, inspection requirements, and other requirements for the depleted UF_6 storage yards and cylinders owned by DOE at the Portsmouth site.

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9 GLOSSARY

accident: An unplanned sequence of events resulting in undesirable consequences, such as the release of radioactive or hazardous material to the environment.

accident consequence assessment: An assessment of the impacts following the occurrence of an accident, independent of the probability of that accident. The PEIS provides estimates of the consequences of a large number of possible accidents, ranging from those with low probability (rare) to those with relatively high probability (frequent).

accident frequency: The likelihood that a specific accident will occur, that is, the probability of occurrence. If an accident is estimated to happen once every 50 years, the accident frequency is generally reported as 0.02 per year (1 occurrence divided by 50 years = 0.02 occurrences per year). For the PEIS, accident frequencies were grouped as follows:

- I, likely (L) — The average frequency of occurrence is estimated to be greater than or equal to 1 in 100 years.
- II, unlikely (U) — The average frequency of occurrence is estimated to be 1 in 100 to 1 in 10,000 years.
- III, extremely unlikely (EU) — The average frequency of occurrence is estimated to be 1 in 10,000 to 1 in 1 million years.
- IV, incredible (I) — The average frequency of occurrence is estimated to be less than 1 in 1 million years.

accident risk: Risk based on both the severity of an accident (consequence) and the probability that the accident will occur. High-consequence accidents that are unlikely to occur (low probability) may pose a low overall risk. For purposes of comparison, accident risk is typically calculated by multiplying the accident consequence (e.g., dose or expected fatalities) by the accident probability.

accident risk assessment: An assessment that considers the probabilities and consequences of a range of possible accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences. The overall *risk* associated with an accident is generally estimated by multiplying the accident consequence by the probability of occurrence.

accident source term: The amount of radioactive or hazardous material released to the environment in dispersible form following an accident.

adsorption: Process in which solid surfaces attract and retain a layer of ions from a water solution.

advection: The process by which material is transported by the bulk motion of flowing water.

air quality: Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances. Air quality standards are the prescribed level of constituents in the outside air that cannot be exceeded during a specific time in a specified area.

Air Quality Control Region (AQCR): An interstate or intrastate area designated by the U.S. Environmental Protection Agency for the attainment and maintenance of National Ambient Air Quality Standards.

ALARA: see *as low as reasonably achievable.*

alpha particle (α): A positively charged particle consisting of two protons and two neutrons that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

ambient air: The surrounding atmosphere as it exists around people, plants, and structures.

***American Indian Religious Freedom Act* of 1978:** The Act that established national policy to protect and preserve for Native Americans their inherent right of freedom to believe, express, and exercise their traditional religions, including the rights of access to religious sites, use and possession of sacred objects, and freedom to worship through traditional ceremonies and rites.

AQCR: see *Air Quality Control Region.*

aquifer: A saturated subsurface geologic formation that can transmit significant quantities of water.

***Archaeological and Historic Preservation Act*:** Act directed at the preservation of historic and archaeological data that would otherwise be lost as a result of federal construction. It authorizes the U.S. Department of the Interior to undertake recovery, protection, and preservation of archaeological and historic data.

as low as reasonably achievable (ALARA): An approach to control or manage radiation exposures (both individual and collective to the workforce and the public) and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit; it is a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

***Atomic Energy Act* of 1954:** The Act that, along with other related legislation, provided the Atomic Energy Commission (a predecessor of the U.S. Department of Energy) with authority to develop generally applicable standards for protecting the environment from radioactive materials.

attainment area: An area considered to have air quality as good as or better than the National Ambient Air Quality standards as defined in the *Clean Air Act.* An area may be an attainment area for one pollutant and a nonattainment area for others (see also *nonattainment area*).

***Bald and Golden Eagle Protection Act*, as amended:** The Act making it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States.

beta particle (β): An elementary particle emitted from a nucleus during radioactive decay; it is negatively or positively charged, identical in mass to an electron, and in most cases easily stopped, as by a thin sheet of metal or plastic.

biota: The plant and animal life of a region.

blending: The mixing of two quantities of uranium with different levels of enrichment to produce uranium enriched to a level suitable for manufacture into a fuel. Depleted uranium can be blended with highly enriched uranium to produce nuclear reactor fuel.

bounding: In the case of accident analysis, bounding is a condition, consequence, or risk that provides an upper limit that is not exceeded by other conditions, consequences, or risks. This term is also used to identify conservative assumptions that will likely overestimate actual risks or consequences.

breach: A general term referring to a hole in a cylinder or container. A breach may be caused by corrosion or by mechanical forces, such as those caused by a drop or contact with handling equipment.

cancer: A group of diseases characterized by uncontrolled cellular growth. Increased incidence of cancer can be caused by exposure to radiation.

candidate species: Plant or animal species that are not yet officially listed as threatened or endangered but are undergoing status review by the U.S. Fish and Wildlife Service. These species are candidates for possible addition to the list of threatened and endangered species.

carbon monoxide (CO): A colorless, odorless gas that is toxic if breathed in high concentration over a period of time. Carbon monoxide is one of six criteria air pollutants specified under Title I of the *Clean Air Act*.

cascade: The process system that is used to separate the isotopic streams of uranium-235 and uranium-238 in gaseous diffusion plants.

cask: A heavily shielded, typically robust container for shipping or storing spent nuclear fuel. Spent nuclear fuel casks are usually cylindrical containers with radiation shielding provided by steel, lead, concrete, or depleted uranium.

census tract: An area usually containing between 2,500 and 8,000 persons that is used for organizing and monitoring census data. The geographic dimensions of census tracts vary widely, depending on population settlement density. Census tracts do not cross county borders.

***Clean Air Act*:** The Act that mandates the issuance and enforcement of air pollution control standards for stationary sources and motor vehicles.

***Clean Air Act Amendments* of 1990:** An Act that expanded the enforcement powers of the U.S. Environmental Protection Agency and added restrictions on air toxins, ozone-depleting chemicals, stationary and mobile emissions sources, and emissions implicated in acid rain and global warming.

***Clean Water Act* of 1972, 1987:** The Act that regulates the discharge of pollutants from a point source into navigable waters of the United States in compliance with a National Pollution Discharge Elimination System permit. Also regulates discharges to or dredging of wetlands.

***Code of Federal Regulations* (CFR):** The codified form in which all federal regulations in force are published.

collective dose: Summation of individual radiation doses received by all those exposed to the source or event being considered. The collective radiation dose received by a population group is usually measured in units of person-rem.

collective population risk: A measure of possible loss in a group of people that takes into account the probability that the hazard will cause harm and the consequences of that event. The collecti . population risk does not express the risk to specific individual members of the population.

committed effective dose equivalent: The sum of the committed dose equivalents to various tissues of the body, each multiplied by its weighting factor. It does not include contributions from external doses. Committed effective dose equivalent is expressed in units of rem and provides an estimate of the lifetime radiation dose to an individual from radioactive material taken into the body through either inhalation or ingestion.

convection: Process by which heat is transferred between a surface and a moving fluid when they are at different temperatures.

cost analysis: The life-cycle cost estimates, including estimates of labor and capital, for each of the strategy alternatives considered in the PEIS.

criteria pollutants: Six air pollutants for which national ambient air quality standards are established by the U.S. Environmental Protection Agency under Title I of the *Clean Air Act*. The six pollutants are sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10}, particles with a mean diameter of less than 10 microns [μm]), and lead (Pb).

critical habitat: Air, land, or water area and constituent elements, the loss of which would appreciably decrease the likelihood of survival and recovery of a species listed as threatened or endangered or a distinct segment of the population of that species.

cultural resources: Archaeological sites, architectural structures or features, traditional use areas, and Native American sacred sites or special use areas.

cumulative impacts: The impacts assessed in an environmental impact statement that could potentially result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal), private industry, or individual undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

curie (Ci): A measure of the radioactivity of a material, equal to 3.7×10^{10} disintegrations per second.

cylinder: As defined for this PEIS, a large steel container used to store depleted UF_6. Cylinders are typically about 12 ft long by 4 ft in diameter and weigh about 10 to 14 tons when full of depleted UF_6.

cylinder preparation: The activities required to prepare depleted UF_6 cylinders for transportation. Cylinder preparation would be required for alternatives that involve transport of cylinders to a conversion facility or a long-term storage site.

decay: Natural process by which a radioactive atom is physically transformed into another form by the release of energy in the form of subatomic particles such as alpha or beta particles, or electromagnetic radiation such as gamma rays.

decay products, radioactive: The isotopes produced when another isotope undergoes radioactive decay. The decay products are also typically radioactive.

decommissioning: The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

defluorination: The conversion of uranium hexafluoride to U_3O_8 accomplished by using

steam. UF_6 is chemically decomposed with steam and heat to produce U_3O_8 and HF, with concentrated HF as the direct by-product.

depleted UF_6: see *depleted uranium hexafluoride.*

depleted uranium hexafluoride (depleted UF_6): A compound of uranium and fluorine from which most of the uranium-235 isotope has been removed. Isotope separation results in two product "streams." The stream containing the additional uranium-235 is said to be enriched and is collected for further processing into other forms of enriched uranium. The remaining UF_6 stream is said to be "depleted" and is now stored at the Paducah, Portsmouth, and K-25 sites.

disposal: The emplacement of material in a manner designed to ensure isolation for the foreseeable future. Disposal is considered to be permanent, with no intent to retrieve the material for future use.

disposal facility: A facility or part of a facility into which hazardous, radioactive, or solid waste is intentionally placed and at which waste is intended to permanently remain after closure of the facility.

disproportionately high and adverse environmental impact: An adverse environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an environmental hazard with a risk or rate of exposure for a low-income or minority population that exceeds the risk or rate of exposure for the general population.

disproportionately high and adverse human health effect: Any effect on human health from exposure to environmental hazards that exceeds generally accepted levels of risk and affects low-income and minority populations at a rate that appreciably exceeds the rate for the general population. Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts to human health.

dose: The amount of energy deposited in body tissue due to radiation exposure. Various technical terms — such as dose equivalent, effective dose equivalent, and collective dose — are used to evaluate the amount of radiation received by an exposed individual or population.

dose rate: Radiation dose delivered per unit of time and measured in rem per hour.

drain: A device (e.g., a channel or pipe) used to carry away or to empty liquid from a liquid source.

drifts: Lateral extensions of belowground tunnels that are used for storage or disposal of material.

DUCRETE™: A composite material produced by combining dense UO_2 and concrete.

effective dose equivalent: The sum of the products of the dose equivalent to various organs or tissues and the weighting factors applicable to each of the body organs or tissues that are irradiated. The effective dose equivalent includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem.

EIS: see *environmental impact statement.*

***Emergency Planning and Community Right-to-Know Act* of 1986:** The Act that established programs to provide the public with important information on the hazardous and toxic chemicals in their communities and established

emergency planning and notification requirements to protect the public in the event of a release of hazardous substances.

Emergency Response Planning Guideline (ERPG): A hazardous-material personnel exposure level or range which, when exceeded by a short-term or acute exposure, will cause adverse reproductive, developmental, or carcinogenic effects in humans. ERPGs are approved by a committee of the American Industrial Hygiene Association.

endangered species: Any species that is in danger of extinction throughout all or a significant portion of its geographic range.

***Endangered Species Act*, as amended:** The Act intended to prevent the further decline of endangered and threatened species and to restore these species and their habitats. Consultation with the U.S. Fish and Wildlife Service is necessary to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed action.

engineering analysis: A comprehensive technical analysis of depleted UF_6 technology options, including conversion, use, transportation, storage, and disposal.

enrichment: An isotopic separation process that increases the portion of the uranium-235 isotope in relation to uranium-238 in natural uranium. In addition to the enriched uranium, this process also produces uranium depleted in uranium-235. Enrichment is accomplished in the United States through a process called gaseous diffusion.

environmental impact statement (EIS): A document prepared in accordance with the requirements of the *National Environmental Policy Act*. A programmatic EIS (PEIS) is a broad-scope EIS that identifies and assesses the environmental impacts of a program or policy.

environmental justice: The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic strength.

ERPG: see *Emergency Response Planning Guideline*.

evapotranspiration: Loss of water from the soil by both evaporation and transpiration from plants growing in the soil.

exposure: The condition of being made subject to the action of radiation, chemicals, or physical hazards. Exposure is sometimes used as a generic term to refer to the dose of radiation or chemicals absorbed by an individual or population.

external exposure: Exposure to radiation, principally gamma radiation, that originates from sources outside of the body.

failure: For this PEIS, defined as the release of disposed uranium material from the bottom of the disposal facility to the surrounding soil. Failure of a disposal facility would generally occur hundreds to thousands of years after facility closure due to the ultimate penetration of water and natural degradation of engineered barriers.

***Farmland Protection Policy Act* of 1981:** An Act that requires federal agencies to take steps to ensure that federal actions do not contribute to the unnecessary and irreversible conversion

of farmland to nonagricultural uses in cases in which other national interests do not override the importance of protecting the farmland resources.

fault: A fracture in the earth's crust accompanied by displacement of one side of the fracture with respect to the other and in a direction parallel to the fracture.

***Federal Facilities Compliance Act* of 1992:** An Act that amended the *Resource Conservation and Recovery Act*, with the objectives of bringing all federal facilities into compliance with applicable federal and state hazardous waste laws, of waiving federal sovereign immunity under those laws, and of allowing the imposition of fines and penalties. The law also requires the U.S. Department of Energy to submit an inventory of all its mixed waste and to develop a treatment plan for mixed waste.

federal-listed species: see *threatened, endangered,* and *candidate* species.

fission: The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.

floodplain: The lowlands adjoining inland and coastal waters and relatively flat areas, including at a minimum that area inundated by a 1% or greater chance flood in any given year. The base floodplain is defined as the 100-year (1%) floodplain. The critical action floodplain is defined as the 500-year (0.2%) floodplain.

food chain: The scheme of feeding relationships between trophic levels that unites the member species of a biological community.

fugitive dust: The dust released from activities associated with construction, manufacturing, or transportation.

fugitive emissions: Uncontrolled emissions to the atmosphere from pumps, valves, flanges, seals, and other process points not vented through a stack. Also includes emissions from area sources such as ponds, lagoons, landfills, and piles of stored material.

gamma radiation (γ): High-energy, short-wavelength electromagnetic radiation (a packet of energy) emitted from a radioactive nucleus during decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials such as lead or uranium. Gamma rays are similar to X-rays, but are usually more energetic.

gaseous diffusion: The uranium enrichment process first developed in the 1940s as part of the Manhattan Project. In gaseous diffusion, gaseous UF_6 is allowed to flow irreversibly through a membrane or diffusion barrier. With holes just large enough to allow the passage of individual molecules without passage of the bulk gas through the membrane or diffusion barrier, more of the lighter molecules (i.e., those containing uranium-235 atoms) will flow through the barrier than the heavier molecules (i.e., those containing uranium-238 atoms), thus effecting partial separation. Gaseous diffusion results in two streams of UF_6: one enriched in the uranium-235 isotope and one depleted in the uranium-235 isotope.

gelation: A process for conversion of UF_6 to UO_2, where the solid uranium is separated from an aqueous solution through chemical reaction.

general public: For purposes of analyses in this PEIS, anyone outside the boundary of a site

at the time of an accident or during normal facility operations, as well as people along transportation routes used to ship hazardous chemicals or radioactive materials.

generic sites: For this PEIS, sites broadly defined with very generalized environmental characteristics for the purpose of evaluating the impacts of manufacturing, disposal, and long-term storage in mines. For example, disposal of uranium oxide was analyzed for a wet (or eastern) location and a dry (or western) location. Such a broad characterization is useful for evaluating an activity that is very generalized in nature and for which one environmental variable (such as groundwater) is of most importance.

geologic repository (mined geologic repository): An underground facility for the disposal of nuclear waste. The waste is isolated by placing it in mined cavities in a continuous, stable geologic formation at depths typically greater than 300 meters. A surface facility is used to prepare the waste material for placement in the underground portions of the repository.

glove box: An airtight box used to work with hazardous material, vented to a closed filtering system, having gloves attached inside the box to protect the worker.

greater-than-Class-C waste: Low-level radioactive waste generated by the commercial sector that exceeds U.S. Nuclear Regulatory Commission concentration limits for Class-C low-level waste, as specified in 10 CFR Part 61.

green salt: see *uranium tetrafluoride*.

groundshine: Gamma radiation emitted from radioactive materials deposited on the ground.

groundwater: Generally, all water contained in the ground; water held below the water table available to freely enter wells.

grout: A cementing or sealing mixture of cement and water to which sand, sawdust, or other fillers (additives — e.g., waste) may be added.

grouted waste: Refers to the solid material obtained by mixing waste material with cement and repackaging it in drums. Grouting is intended to reduce the mobility of the waste material.

habitat: Area where a plant or animal lives.

hazard index: A summation of the hazard quotients for all chemicals to which an individual is exposed. A hazard index value of 1.0 or less than 1.0 indicates that no adverse human health effects (noncancer) are expected to occur.

hazard quotient: A comparison of an estimated chemical intake (dose) with a reference dose level below which adverse health effects are unlikely. The hazard quotient is expressed as the ratio of the estimated intake to the reference dose. The value is used to evaluate the potential for noncancer health effects, such as organ damage, from chemical exposures.

hazardous air pollutants: The 189 chemicals and chemical classes — such as asbestos, beryllium, mercury, benzene, and radionuclides — whose emissions are specially regulated by the *Clean Air Act*.

hazardous material: A material that poses a potential risk to health, safety, and property when transported or handled.

hazardous waste: Under the *Resource Conservation and Recovery Act*, a solid waste, or

combination of solid waste, which — because of its quantity, concentration, or physical, chemical or infectious characteristics — may (a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed. Source material (including UF_6), special nuclear material, and by-product material, as defined by the *Atomic Energy Act*, are specifically excluded from the definition of solid waste.

health risk conversion factors: Estimates of the expected number of health effects (i.e., cancer cases, cancer fatalities, or genetic effects) caused by exposure to a given amount of radiation. Health risk conversion factors are multiplied by the estimated radiation dose received by a given population (such as workers or members of the public) in order to estimate the number of health effects expected to occur as a result of the exposure. Health risk conversion factors are derived from data collected from Japanese atomic bomb survivors, historical medical and industrial exposures, and animal experimentation.

heels: Residual amounts of nonvolatile material left in a cylinder following the removal of the depleted UF_6.

HEU: see *highly enriched uranium.*

HF: see *hydrogen fluoride.*

high-efficiency particulate air (HEPA) filter: A filter with an efficiency of at least 99.95% used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level radioactive waste (HLW): The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid. High-level waste contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

highly enriched uranium (HEU): Uranium that contains the isotope uranium-235 in concentration of 20% or more. Naturally occurring uranium has a uranium-235 content of about 0.7%.

hydrocarbons (HC): Chemical compounds containing carbon and hydrogen as the principal elements.

hydrogen fluoride (HF): A colorless, toxic, fuming, corrosive liquid or gas; miscible with cold water and very soluble in hot water. HF is produced when UF_6 comes in contact with water, such as humidity in the air, and is often a by-product produced when UF_6 is converted to another chemical form.

hygroscopic: A chemical substance with an affinity for water; one that will absorb moisture, usually from the air.

Inconel: A metal alloy containing nickel, chromium, and iron, which exhibits good resistance to corrosion in aqueous environments.

internal exposure: The ingestion or inhalation of radioactive contaminants in air, water, food, or soil, and the subsequent radiation dose to internal organs and tissues of the body.

involved worker: A worker directly involved in the handling or processing of radioactive or hazardous materials.

ion: An atom, molecule, or molecular fragment carrying a positive or negative electrical charge.

ionizing radiation: Radiation that has enough energy to remove electrons from substances that it passes through, forming ions.

isotope: One of two or more species of an element that have the same atomic number but different masses. The difference in mass is due to the presence of one or more extra neutrons in the nucleus. The number of protons for different isotopes of the same element is the same. Uranium-235 and uranium-238 are examples of isotopes of the element uranium.

land disposal restrictions: Restrictions on the disposal of waste that is hazardous under the *Resource Conservation and Recovery Act*. The land disposal restrictions include technology-based or performance-based treatment standards that must be met before hazardous waste can be disposed of on land.

latent cancer fatality (LCF): Term used to indicate the estimated number of cancer fatalities that may result from exposure to a cancer-causing element. Latent cancer fatalities are similar to naturally occurring cancers and may be expressed at any time after the initial exposure.

lead (Pb): A toxic metal in air, food, water, and soil. Overexposure to this metal can cause damage to the circulatory, digestive, and central nervous systems. Lead is one of six criteria air pollutants specified under Title I of the *Clean Air Act*.

LEU: see *low-enriched uranium*.

long-term storage: The containment of material on a temporary basis or for a period of years, in such a manner as not to constitute disposal of such material. Long-term storage would preserve access to the material until a future use is identified or until a decision is made to dispose of the material.

low-enriched uranium (LEU): Uranium that contains the isotope uranium-235 in a concentration of less than 20% and greater than 0.7%. Most commercial reactor fuel is enriched to 5% or less uranium-235.

low-income population: Persons of low-income status. This status is based on U.S. Bureau of the Census definitions of individuals living below the poverty line, as defined by a statistical threshold that considers family size and income. For 1990, the poverty line threshold for a family unit of four individuals was $12,674 (based on 1989 income). In this PEIS, low-income population was defined as consisting of any census tract located within a 50-mile (80-km) radius of a storage site that has a proportion of low-income population that is greater than the respective state average.

low-level mixed waste (LLMW): Waste that contains both hazardous waste under the *Resource Conservation and Recovery Act* and radioactive material, including source, special nuclear, or by-product material subject to the *Atomic Energy Act* of 1954. Such waste has to be handled, processed, and disposed of in a manner that considers its chemical as well as its radioactive components.

low-level radioactive waste (LLW): Waste that contains radioactivity but is not classified as high-level waste, transuranic waste, spent nuclear fuel, or "11e(2) by-product material" as defined by U.S. Department of Energy Order

5820.2A. Low-level waste is typically disposed of using shallow land burial.

***Low-Level Radioactive Waste Policy Act*:** The Act, as amended, that established procedures for the implementation of compacts providing for the establishment and operation of regional disposal facilities for low-level radioactive waste and that made the federal government responsible for ultimate disposal of commercially generated waste with a classification of greater-than-Class-C (see also *greater-than-Class-C waste*).

maximally exposed individual (MEI): A hypothetical individual who — because of proximity, activities, or living habits — could potentially receive the maximum possible dose of radiation or of a hazardous chemical from a given event or process.

***Migratory Bird Treaty Act*, as amended:** Act intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia.

millirem: A unit of radiation exposure equal to one-thousandth of a rem.

minority population: Persons classified by the U.S. Bureau of the Census as Negro/Black/ African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, or other nonwhite; based on self-classification by individuals according to the race with which they most closely identify. For this PEIS, a minority population was defined as any census tract located within a 50-mile (80-km) radius of a storage site that has a proportion of minority population that is greater than the respective state average.

mixed waste: see *low-level mixed waste*.

model: A conceptual, mathematical, or physical system obeying certain specified conditions, whose behavior is used to understand the physical system to which it is analogous. Models are often used to predict the behavior or outcome of future events.

Modified Mercalli Intensity: A level on the modified Mercalli scale. A measure of the perceived intensity of earthquake ground-shaking with 12 divisions, from I (not felt by people) to XII (damage nearly total).

Monel: Trade name for a white copper-nickel alloy that is acid- and corrosion-resistant.

multi-purpose unit: A heavily shielded cask that can be used for storage, transportation, and disposal of spent nuclear fuel.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the *Clean Air Act*, as amended. The primary NAAQS are intended to protect the public health with an adequate margin of safety, and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Emission Standards for Hazardous Air Pollutants (NESHAPS): A set of national emission standards for listed hazardous pollutants emitted from specific classes or categories of new and existing sources. These standards were implemented in the *Clean Air Act Amendments* of 1977.

***National Environmental Policy Act* (NEPA) of 1969:** The Act that established the national policy to protect humans and the environment, requiring environmental reviews of federal actions that have the potential for significant impact on the environment. Also established the Council on Environmental Quality.

***National Historic Preservation Act* of 1966, as amended:** The Act directing federal agencies to consider the effects of their programs and projects on properties listed on or eligible for the *National Register of Historic Places*. It does not require any permits, but pursuant to federal code, if a proposed action might impact any archaeological, historical, or architectural resource, it mandates consultation with the proper agencies.

National Pollutant Discharge Elimination System (NPDES): Federal permitting system required for hazardous effluents regulated through the *Clean Water Act*, as amended.

***National Register of Historic Places*:** A list maintained by the Secretary of the Interior as the official list of historic properties (districts, sites, buildings, structures, and objects) deserving preservation because of their local, state, or national significance in American history, architecture, archaeology, engineering, and culture. Properties listed on or eligible for the *National Register* are protected by the *National Historic Preservation Act* of 1966, as amended.

NEPA document: A document prepared pursuant to requirements of the *National Environmental Policy Act* or the Council on Environmental Quality regulations, including the following: environmental assessment, environmental impact statement, Notice of Intent, Record of Decision, and Finding of No Significant Impact.

nitrogen oxides (NO_x): The oxides of nitrogen, primarily nitrogen oxide (NO) and nitrogen dioxide (NO_2), that are produced in the combustion of fossil fuels and can constitute an air pollution problem. When NO_2 combines with volatile organic compounds in sunlight, ozone is produced. Nitrogen oxides are one of six criteria air pollutants specified under Title I of the *Clean Air Act*.

nonattainment area: An Air Quality Control Region (or a portion thereof) for which the U.S. Environmental Protection Agency has determined that ambient air concentrations exceed National Ambient Air Quality Standards for one or more criteria pollutants (see also *attainment area* and *criteria pollutants*).

nonhazardous waste: Routinely generated waste, including general facility refuse such as paper, cardboard, glass, wood, plastics, scrap, metal containers, dirt, and rubble. Nonhazardous waste is segregated and recycled whenever possible.

noninvolved worker: A worker employed at a site who is not directly involved in the handling of radioactive or hazardous materials.

normal operations: Conditions during which facilities and processes operate as expected or designed. In general, the evaluation of normal operations includes the occurrence of some infrequent events that, although not considered routine, are not classified as accidents. For example, the identification and repair of breached cylinders, expected to occur infrequently, was considered to be normal operations.

***Nuclear Waste Policy Act* of 1982, as amended:** The Act that authorized federal agencies to develop a geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste. The Act specified the process for selecting a repository site and constructing, operating, closing, and decommissioning the repository. The Act also established programmatic guidance for these activities.

nuclear weapon: The general name given to any weapon in which the explosion results from energy released by reactions involving atomic nuclei — either fission, fusion, or both.

Occupational Safety and Health Administration (OSHA): The agency that oversees and regulates workplace health and safety, created by the *Occupational Safety and Health Act* of 1970.

Options, Continued Cylinder Storage: An option for all alternative management strategies considered in the PEIS that would involve the continued storage of depleted UF_6 cylinders at the Paducah, Portsmouth, and K-25 sites for some period of time. Continued cylinder storage was assumed to occur at these three sites through 2028 for all alternatives and to extend through 2039 for the no action alternative.

Options, Conversion: Conversion of depleted UF_6 to another chemical form. The conversion options considered in the PEIS were conversion to U_3O_8, conversion to UO_2, and conversion to metal. Several representative technologies were considered within each option.

Options, Cylinder Preparation: The activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Depleted UF_6 cylinders were designed, built, tested, and certified to meet requirements of the U.S. Department of Transportation (DOT) for shipment by truck and rail. However, after several decades in storage, some cylinders no longer meet these requirements. Two options for preparing these cylinders for shipment were considered in the PEIS:

- ***Cylinder Overcontainers*** — Protective metal "overcontainers" in which cylinders not meeting DOT requirements could be placed for shipment. These reusable overcontainers would be slightly larger than a cylinder and would be designed to meet all DOT requirements.
- ***Cylinder Transfer*** — New cylinders into which the depleted UF_6 in cylinders not meeting DOT requirements would be transferred for shipment.

Options, Disposal: Options for disposal of depleted uranium material as low-level radioactive waste. The disposal options in the PEIS are defined by the chemical form of the uranium and the type of disposal facility. Two disposal options were considered in the PEIS:

- ***Disposal of U_3O_8*** — Depleted uranium could be disposed of as U_3O_8 following conversion. Disposal of both ungrouted and grouted U_3O_8 was considered. Potential disposal facilities included shallow earthen structures, belowground vaults, and an underground mine.
- ***Disposal of UO_2*** — Similarly to disposal of U_3O_8, depleted uranium could be disposed of as UO_2 following conversion, in either grouted or ungrouted form. The disposal facilities considered were the same as those considered for U_3O_8: shallow earthen structures, belowground vaults, and an underground mine.

Options, Manufacture and Use: Options that involve the manufacture and use of depleted uranium as radiation shielding material, as follows:

- ***Use as Uranium Oxide Shielding*** — The manufacture and use of uranium oxide-shielded storage casks for spent nuclear fuel.
- ***Use as Uranium Metal Shielding*** — The manufacture and use of uranium metal-shielded casks for spent nuclear fuel.

Options, Storage: Storage of depleted uranium until use at a later date. Storage options were defined by the chemical form of the uranium

and the type of storage facility. Three storage options were considered in the PEIS:

- ***Storage as UF_6*** — Storage of UF_6 in cylinders similar to those currently used. Storage facilities considered included yards, buildings, and an underground mine.
- ***Storage as U_3O_8*** — Storage of depleted uranium in drums as U_3O_8 following conversion. Storage facilities considered included buildings, belowground vaults, and an underground mine.
- ***Storage as UO_2*** — Similar to options for U_3O_8, storage of depleted uranium as UO_2 in drums in buildings, belowground vaults, or an underground mine.

OSHA: see *Occupational Safety and Health Administration.*

overcontainer: Container used for transporting cylinders not meeting U.S. Department of Transportation (DOT) requirements. An overcontainer is a container into which a cylinder would be placed for shipment. The metal overcontainer would be designed, tested, and certified to meet all DOT shipping requirements and would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. The type of overcontainer evaluated in the PEIS was a "clamshell" vessel.

ozone (O_3): The triatomic form of oxygen. In the stratosphere, ozone protects the Earth from the sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant and can cause irritation of the eyes and respiratory tract. Ozone is one of six criteria air pollutants specified under Title I of the *Clean Air Act.*

palustrine: Nontidal wetlands dominated by trees, shrubs, or persistent emergent vegetation or small shallow wetlands.

particulates: Particles in an aerosol stream, the larger of which usually can be removed by filtration.

Pasquill stability categories: Classification scheme that describes the degree of atmospheric turbulence. Categories range from extremely unstable (A) to extremely stable (F). Unstable conditions promote the rapid dispersion of atmospheric contaminants and result in lower air concentrations compared with stable conditions.

pathway: A route or sequence of processes by which radioactive or hazardous material may move through the environment to humans or other organisms. For example, one potential exposure pathway involves the contamination and subsequent use of surface water or groundwater.

PCBs: see *polychlorinated biphenyls.*

PEIS: see *programmatic environmental impact statement.*

PELs: see *permissible exposure limits.*

permeability: In hydrology, the capacity of a medium (rock, sediment, or soil) to transmit groundwater. Permeability depends on the size and shape of the pores in the medium and how they are interconnected.

permissible exposure limits (PELs): Occupational exposure limits established for worker exposures to various chemicals, endorsed by the Occupational Safety and Health Administration. Permissible exposure limits are defined so as to protect worker health and may be for short-term or 8-hour duration exposure.

plume: The spatial distribution of a release of airborne or waterborne material as it disperses in the environment.

plutonium (Pu): A heavy, radioactive, metallic element with the atomic number 94. Plutonium is produced artificially in a reactor by bombardment of uranium with neutrons and is used primarily in the production of nuclear weapons.

PM_{10}: Particulate matter with a mean aerodynamic diameter equal to or less than 10 microns (μm). PM_{10} is one of six criteria air pollutants specified under Title I of the *Clean Air Act*.

***Pollution Prevention Act* of 1990:** The Act establishing the national policy that pollution should be prevented or reduced at the source or recycled in an environmentally safe manner and that pollution that cannot be prevented or recycled should be, as a last resort, treated and disposed of in an environmentally safe manner.

polychlorinated biphenyls (PCBs): A class of chemical substances formerly manufactured as an insulating fluid in electrical equipment. PCBs are highly toxic to aquatic life and, in the environment, exhibit many of the characteristics of dichloro diphenyl trichloroethane (DDT). PCBs persist in the environment for a long time and accumulate in animals.

polycyclic aromatic hydrocarbons (PAHs): A group of organic compounds, some of which are known to be potent human carcinogens.

population dose: see *collective dose*.

programmatic environmental impact statement (PEIS): A type of EIS that deals with broad strategies and decisions, such as those that are regional or national in scope.

proposed action: The term used in an EIS to refer to the activity planned by a federal agency that generates the need to prepare an EIS. The proposed action for this PEIS is to select a strategy for the long-term management of depleted UF_6. The PEIS considers six alternative approaches to accomplish that action.

public: see *general public*.

rad: see *radiation absorbed dose*.

radiation: The particles (alpha and beta particles) or photons (gamma rays) emitted from the nuclei of radioactive atoms. Some elements are naturally radioactive; others are induced to become radioactive by bombardment in a reactor. Naturally occurring radiation, such as that from uranium, is indistinguishable from induced radiation.

radiation absorbed dose (rad): The basic unit of absorbed dose equal to the absorption of 0.01 joule per kilogram of absorbing material.

radioactivity: The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

radionuclide: An atom that exhibits radioactive properties. Standard practice for naming a radionuclide is to use the name or atomic symbol of the element followed by its atomic weight (e.g., cobalt-60 [Co-60], a radionuclide of cobalt with an atomic weight of 60).

recharge: Replenishment of water to an aquifer.

Record of Decision (ROD): A document prepared in accordance with the requirements of 40 CFR 1505.2 that provides a concise public record of the U.S. Department of Energy's decision on a proposed action for which an EIS was prepared. A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), and the factors balanced by the U.S. Department of Energy in making the decision. The ROD also

identifies whether all practicable means to avoid or minimize environmental harm have been adopted and, if not, why they were not.

region of influence (ROI): The physical area that bounds the environmental, sociological, economic, or cultural feature of interest for the purpose of analysis.

rem: The dosage of an ionizing radiation that will cause the same biological effect as one roentgen of X-ray or gamma-ray exposure.

repository: see *geologic repository*.

representative sites: For this PEIS, sites defined with data for actual conditions at sites that, although not proposed for that activity, might be somewhat similar to an eventual site. Representative sites were used for analysis of conversion and long-term storage in yards, buildings, and vaults. This more narrow characterization of potential future sites was used when the activity was technically better defined. Use of representative sites results in a more realistic assessment and comparison of options and alternatives than generic sites. In this PEIS, the conditions at the current storage sites were used to define the range of conditions at the representative sites.

***Resource Conservation and Recovery Act* (RCRA), as amended:** An Act that provides a "cradle-to-grave" regulatory program for hazardous waste that established, among other things, a system for managing hazardous waste from its generation until its ultimate disposal.

retardation: The process by which dissolved material moves more slowly through the soil than the velocity of the bulk fluid (i.e., water).

risk: A quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event.

***Safe Drinking Water Act*, as amended:** An Act that protects the quality of the public water supplies and all sources of drinking water.

sanitary waste: Waste generated by normal housekeeping activities, liquid or solid (includes sludge), that is not hazardous or radioactive.

schoepite: A yellow secondary uranium mineral that has the chemical formula $UO_3 \cdot 2H_2O$.

scope: The range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the *National Environmental Policy Act* of 1969.

scoping: The process of inviting public comment on what should be considered prior to preparation of an environmental impact statement.

severe accident: An accident with a frequency of less than 1 in 1 million (10^{-6}) per year that would have more severe consequences than a design-basis accident in terms of damage to the facility, off-site consequences, or both.

shielding: Any material that is placed between a source of radiation and people, equipment, or other objects, in order to absorb the radiation and thereby reduce radiation exposure. Common shielding materials include concrete, steel, water, and lead. In general, for shielding gamma radiation sources, the denser a material is, the more effective it is as a shield.

shielding manufacturing facility: A plant where depleted uranium shielding is generated and assembled with nonradioactive shielding components to produce casks.

sinter: To form a homogenous mass by heating without melting.

socioeconomic analysis: Analysis of those parts of the human environment in a particular location that are related to existing and potential future economic and social conditions.

socioeconomic impacts: For this PEIS, impacts expressed in terms of regional economic impacts (notably changes in local employment, income, and economic output [sales]), impacts to public services and finance in local jurisdictions, and impacts to local housing markets.

***Soil and Water Conservation Act* of 1977:** An act to establish a program administered by the Secretary of Agriculture to further the conservation of soil, water, and related resources consistent with the roles and responsibilities of other federal agencies and state and local governments.

***Solid Waste Disposal Act*:** An Act that regulates the treatment, storage, or disposal of solid, both nonhazardous and hazardous, waste, as amended by the *Resource Conservation and Recovery Act* and the *Hazardous and Solid Waste Amendments* of 1984.

source: Any physical entity that may cause radiation exposure, for example, by emitting ionizing radiation or releasing radioactive material. Examples of radiation sources include X-ray machines and radionuclides such as uranium.

source term: The amount of radioactive or hazardous material released to the environment following an accident.

spent nuclear fuel: Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

stability class: see *Pasquill stability categories*.

stakeholder: Any person or organization interested in or potentially affected by activities and decisions of the U.S. Department of Energy.

storage: The temporary holding of material in a controlled and monitored facility.

strategy: For this PEIS, a set of actions for handling depleted UF_6, from its current storage condition at three U.S. Department of Energy sites — Portsmouth, Ohio; Paducah, Kentucky, and Oak Ridge, Tennessee — to ultimate disposition. These broad strategies focus on material use, storage, and disposal.

sulfur dioxide (SO_2): A compound of sulfur produced by the burning of sulfur-containing compounds and considered to be a major air pollutant. Sulfur dioxide is one of six criteria air pollutants specified under Title I of the *Clean Air Act*.

sulfur oxides (SO_x): A general term used to describe the oxides of sulfur — pungent, colorless gases formed primarily by the combustion of fossil fuels. Sulfur oxides, which are considered major air pollutants, may damage the respiratory tract as well as vegetation.

technology assessment report: A document (Lawrence Livermore National Laboratory 1995) that identified and assessed the recommendations received in response to the "Request for Recommendations" for uses and management technologies for depleted UF_6.

terrestrial: Pertaining to plants or animals living on land rather than in the water.

threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

throughput: A general term that refers to the amount of material handled or processed by a facility in a year.

tiering: The process of first addressing general (programmatic) matters in a broad PEIS, followed by more narrowly focused (project-level) environmental documentation that incorporates by reference the more general document. For the Depleted Uranium Hexafluoride Management Program, the PEIS addresses the potential impacts of broad strategy alternatives. At the second level, documents will address specific siting issues, construction and operation decisions, and the impacts of transport between identified origins and destinations.

topography: Physical shape of the ground surface.

total effective dose equivalent: The sum of the effective dose equivalent from external exposure and the 50-year committed effective dose equivalent from internal exposure.

***Toxic Substances Control Act* of 1976 (TSCA):** The Act authorizing the U.S. Environmental Protection Agency (EPA) to secure information on all new and existing chemical substances and to control any of these substances determined to cause an unreasonable risk to public health or the environment. This law requires that the health and environmental effects of all new chemicals be reviewed by the EPA before they are manufactured for commercial purposes.

transuranic waste: Waste contaminated by alpha-emitting transuranic radionuclides (i.e., radionuclides with atomic numbers greater than 92) with half-lives of more than 20 years and concentrations higher than 100 nanocuries per gram (nCi/g) at the time of assay.

triuranium octaoxide (U_3O_8): An oxide form of uranium that is the most common chemical form found in nature. U_3O_8 is very stable and has a low solubility in water.

UF_4: see *uranium tetrafluoride*.

UF_6: see *uranium hexafluoride*.

UO_2: see *uranium dioxide*.

U_3O_8: see *triuranium octaoxide*.

ungrouted waste: For this PEIS, defined as U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process.

uranium: A heavy, silvery-white, naturally radioactive, metallic element (atomic number 92). Its two principally occurring isotopes are uranium-235 and uranium-238. Uranium-235 is indispensable to the nuclear industry because it is the only isotope existing in nature to any appreciable extent that is fissionable by thermal neutrons. Uranium-238 is also important because it absorbs neutrons to produce a radioactive isotope that subsequently decays to plutonium-239, an isotope that also is fissionable by thermal neutrons.

uranium dioxide (UO_2): A black crystalline powder that is widely used in the manufacture of fuel pellets for nuclear reactors. Pressed and sintered, it is stable when exposed to water or air below 300°C.

uranium hexafluoride (UF_6): A chemical composed of one atom of uranium combined with 6 atoms of fluorine. UF_6 is a volatile white crystalline solid at ambient conditions. This form of uranium is used as feed for gaseous diffusion enrichment plants.

uranium metal: A heavy, silvery-white, malleable, ductile, softer-than-steel metallic element. One of the densest materials known, it is 1.6 times more dense than lead and slightly

less toxic. Uranium metal is not as stable as U_3O_8 or UF_4 because it is subject to surface oxidation. It tarnishes in air, with the oxide film preventing further oxidation of massive metal at room temperature.

uranium tetrafluoride (UF_4): A green crystalline solid that melts at about 960°C and has an insignificant vapor pressure. It is very slightly soluble in water; generally an intermediate in the conversion of UF_6 to either uranium oxide (U_3O_8 or UO_2) or uranium metal. It is formed by the reaction of UF_6 with hydrogen gas in a vertical tube-type reactor or by the action of hydrogen fluoride on uranium dioxide. Also known as green salt.

uranyl fluoride (UO_2F_2): A yellow hygroscopic (i.e., moisture-retaining) solid that is very soluble in water. In accidental releases of UF_6, UO_2F_2 is a solid particulate compound that may deposit on the ground over a large area.

vacuum: A pressure less than atmospheric. Depleted uranium hexafluoride is stored in a vacuum in cylinders.

volatile organic compounds (VOCs): A broad range of organic compounds (such as benzene, chloroform, and methyl alcohol), often halogenated, that vaporize at ambient or relatively low temperatures.

waste management: The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated pollution prevention and surveillance and maintenance activities.

waste minimization: An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling.

wastewater: Water that typically contains less than a 1% concentration of organic hazardous waste materials.

***Water Quality Act* of 1987:** An act amending the *Federal Water Pollution Control Act* to make National Pollutant Discharge Elimination System requirements applicable to storm-water discharges.

wetlands: Lands or areas exhibiting hydric soils, saturated or inundated soil during some portion of the plant growing season, and plant species tolerant of such conditions (includes swamps, marshes, and bogs).

***Wild and Scenic Rivers Act*:** An Act providing for protection of the free-flowing, scenic, and natural values of rivers designated as components or potential components of the National Wild and Scenic Rivers System.

World Wide Web site: A collection of information — possibly including text, figures, pictures, audio, and video — that can be accessed by computer through the Internet computer network. These sites are intended to communicate and distribute information to anyone having access to the Internet.

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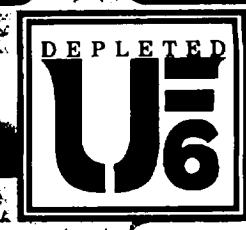

Final

Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride

Volume 2 Appendices

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, Maryland 20874

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DOE/EIS-0269

DOE/EIS-0269

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

Volume 2: Appendices

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology

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COVER SHEET

RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE)

TITLE: Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269)

CONTACT: For further information on this Programmatic Environmental Impact Statement (PEIS), call or contact:

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ABSTRACT: This PEIS assesses the potential impacts of alternative management strategies for depleted uranium hexafluoride (UF_6) currently stored at three DOE sites: Paducah site near Paducah, Kentucky; Portsmouth site near Portsmouth, Ohio; and K-25 site on the Oak Ridge Reservation, Oak Ridge, Tennessee. The alternatives analyzed in the PEIS include no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

* Vertical lines in the right margin of this cover sheet and the appendixes indicate changes that have been added after the public comment period.

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ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS

In this document, units of measure are presented with the English unit first, followed in most cases by the metric equivalent in parentheses; if the measurement was originally made in metric units, the values were not converted back to English units. In tables, the data are expressed in one unit only. The following table lists the appropriate equivalents for English and metric units.

Multiply	By	To Obtain
English/Metric Equivalents		
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) -32	0.5555	degrees Celsius (°C)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) +17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

APPENDIX A:

CHEMICAL FORMS AND PROPERTIES OF URANIUM

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NOTATION (APPENDIX A)

The following is a list of acronyms and abbreviations, including units of measure, used in this appendix.

ACRONYMS AND ABBREVIATIONS

General

DOE	U.S. Department of Energy
PEIS	programmatic environmental impact statement

Chemicals

BrF_3	bromine fluoride
Cl_2	chlorine
F_2	fluorine
HF	hydrogen fluoride; hydrofluoric acid
HNO_3	nitric acid
H_2O	water
NH_3	ammonia
O_2	oxygen
S	sulfur
Se	selenium
TCE	trichloroethylene
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UH_3	uranium hydride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
UO_3	uranium trioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

atm	atmosphere(s)	g	gram(s)
°C	degrees Celsius	mPa	millipascal(s)
°F	degrees Fahrenheit	psia	pounds per square inch absolute
cm^3	cubic centimeter(s)		

APPENDIX A:

CHEMICAL FORMS AND PROPERTIES OF URANIUM

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix describes the properties of the chemical forms of uranium that are relevant to the analysis in the PEIS.

Most depleted uranium in the United States is currently stored as solid UF_6 in steel cylinders that have a wall thickness of at least 5/16 in. and are located outdoors. Although UF_6 can be handled and stored safely in a well-managed industrial environment, other uranium compounds or uranium metal may be more appropriate for long-term storage, use, or permanent disposal. Potential compounds other than UF_6 include triuranium octaoxide (U_3O_8) and uranium dioxide (UO_2).

A.1 PHYSICAL PROPERTIES

The physical properties of the pertinent chemical forms of uranium are shown in Table A.1.

A.1.1 Uranium Hexafluoride

Uranium hexafluoride (UF_6) at ambient conditions is a volatile, white, crystalline solid. Solid UF_6 is readily transformed into the gaseous or liquid states by the application of heat. All three phases — solid, liquid, and gas — coexist at 147°F (64°C) (the triple point). Only the gaseous phase exists above 446°F (230°C), the critical temperature, at which the critical pressure is 45.5 atm (4.61 mPa). The vapor pressure above the solid reaches 1 atm (0.1 mPa) at 133°F (56°C), the sublimation temperature.

Figure A.1 is the phase diagram covering the range of conditions usually encountered in working with UF_6. It shows the correlation of pressure and temperature with the physical state of UF_6. The triple point occurs at 22 pounds per square inch, absolute (psia) and 147°F (64°C). These are the only conditions at which all three states — liquid, solid, and gas — can exist in equilibrium. If the temperature or pressure is greater than at the triple point, there will only be gas or liquid.

A large decrease in UF_6 density occurs when UF_6 changes from the solid to the liquid state, which results in a large increase in volume. The thermal expansion of the liquid with increasing

TABLE A.1 Physical Properties of Pertinent Uranium Compounds

Compound	Melting Point (°C)	Density (g/cm^3) Crystal/ Particle	Density (g/cm^3) Bulk[a]	Solubility in Water at Ambient Temperature
UF_6	64.1	5.1	5.1	Decomposes to UO_2F_2
UF_4	960 ± 5	6.7	2.0 – 4.5	Very slightly soluble
U_3O_8	Decomposes to UO_2 at 1,300	8.30	1.5 – 4.0	Insoluble
UO_2	2,878 ± 20	10.96	2.0 – 5.0	Insoluble
Uranium metal	1,132	19.05	19	Insoluble

[a] Bulk densities of UF_4, U_3O_8, and UO_2 are highly variable, depending on the production process and the properties of the starting uranium compounds.

Notation: UF_4 = uranium tetrafluoride; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; UO_2F_2 = uranyl fluoride; U_3O_8 = triuranium octaoxide.

temperature is also high. Therefore, it is important to maintain control of the total mass and physical state of UF_6 throughout an operational cycle. To avoid hydraulic rupture, when items with restricted volumes, such as traps and containers, are filled with UF_6, full allowance must be made for the volume changes that will arise over the working temperature range to which the vessels will be subjected.

For UF_6 to be handled as a liquid, the pressure must be in excess of 0.15 mPa (1.5 atm) and the temperature above 147°F (64°C) because the sublimation temperature lies below the triple point. Thus, any process using liquid UF_6 is above atmospheric pressure and is subject to a potential leakage of UF_6 to the environment, with vapor loss and cooling occurring simultaneously. Solidification occurs exothermically when the pressure falls below 1.5 atm (0.15 mPa). Thus, if a cylinder heated above the triple point is breached, a rapid outflow of the UF_6 occurs until the pressure drops sufficiently to start the solidification process. The rate of outflow then decreases but continues until the contents cool to about 133°F (56°C), which is the atmospheric sublimation temperature. Some release of material may continue, depending on the type and location of the breach.

UF_6 is hygroscopic (i.e., moisture-retaining) and, in contact with water (H_2O), will decompose immediately to uranyl fluoride (UO_2F_2). When heated to decomposition, UF_6 emits toxic fluoride fumes.

A.1.2 Uranyl Fluoride (Uranium Oxyfluoride)

Uranyl fluoride (UO_2F_2) is an intermediate in the conversion of UF_6 to an uranium oxide or metal form and is a direct product of the reaction of UF_6 with moisture in the air. It is very soluble

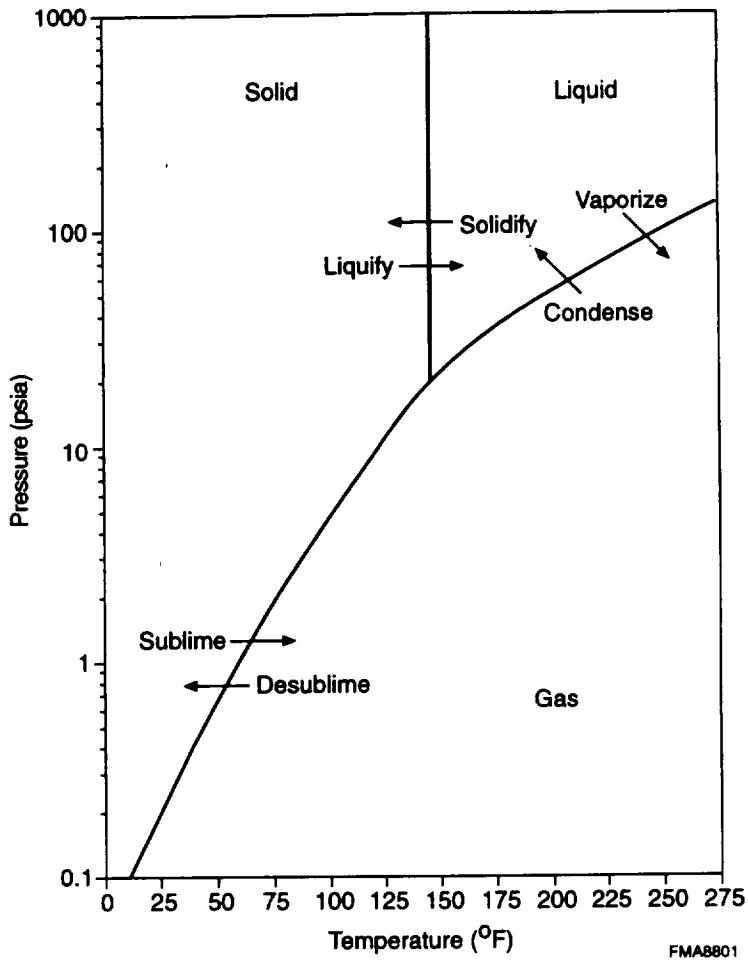

FIGURE A.1 Uranium Hexafluoride Phase Diagram

in water. Uranyl fluoride also is hygroscopic and changes in color from brilliant orange to yellow after reacting with water. Uranyl fluoride is reported to be stable in air to 570°F (300°C), above which slow decomposition to U_3O_8 occurs. When heated to decomposition, UO_2F_2 emits toxic fluoride fumes.

A.1.3 Uranium Tetrafluoride

Uranium tetrafluoride (UF_4) is a green crystalline solid that melts at about 1,760°F (960°C) and has an insignificant vapor pressure. It is very slightly soluble in water. It is generally an intermediate in the conversion of UF_6 to either uranium oxide (U_3O_8 or UO_2) or uranium metal. It is formed by the reaction of UF_6 with hydrogen gas in a vertical tube-type reactor or by the action of hydrogen fluoride (HF) on uranium dioxide. UF_4 can be readily converted to either uranium metal or uranium oxide. UF_4 is less stable than the uranium oxides and produces hydrofluoric acid in reaction with water; it is thus a less favorable form for long-term disposal.

A.1.4 Triuranium Octaoxide

Triuranium octaoxide (U_3O_8) occurs naturally as the olive-green-colored mineral pitchblende. U_3O_8 is readily produced from UF_6 and has potential long-term stability in a geologic environment. In the presence of oxygen (O_2), uranium dioxide (UO_2) and uranium trioxide (UO_3) are oxidized to U_3O_8. U_3O_8 can be made by three primary chemical conversion processes, involving either UF_4 or UO_2F_2 as intermediates. It is generally considered to be the more attractive form for disposal purposes because, under normal environmental conditions, U_3O_8 is one of the most kinetically and thermodynamically stable forms of uranium and also because it is the form of uranium found in nature.

A.1.5 Uranium Dioxide

Uranium dioxide (UO_2) is the form in which uranium is most commonly used as a nuclear reactor fuel. It is a stable ceramic that can be heated almost to its melting point, 5,212°F (2,878°C), without serious mechanical deterioration. It does not react with water to any significant level. At ambient temperatures, UO_2 will gradually convert to U_3O_8.

A.1.6 Uranium Metal

Uranium metal appears as a heavy, silvery white, malleable, ductile, softer-than-steel, metallic element. It is one of the densest materials known, being 1.6 times more dense than lead. Uranium metal is not as stable as U_3O_8 or UF_4 because it is subject to surface oxidation. It tarnishes in air, with the oxide film preventing further oxidation of massive metal at room temperature. Water attacks uranium metal slowly at room temperature and rapidly at higher temperatures. UO_2 and uranium hydride (UH_3) are formed while heat is evolved, and the metal swells and disintegrates.

A.2 CHEMICAL PROPERTIES

A.2.1 Uranium Hexafluoride

Uranium hexafluoride (UF_6) combines with water to form the soluble reaction products UO_2F_2 and HF. UF_6 is essentially inert to clean aluminum, steel, Monel, nickel, aluminum, bronze, copper, and Teflon™. Teflon is commonly used in the packing and cap gasket for cylinders storing depleted UF_6.

When released to the atmosphere, gaseous UF_6 combines with humidity to form a cloud of particulate UO_2F_2 and HF fumes. The reaction is very fast and is dependent on the availability of water vapor. Following a large-scale release of UF_6 in an open area, the dispersion is governed by

meteorological conditions, and the plume could still contain unhydrolyzed material even after traveling a distance of several hundred meters. After hydrolysis, UO_2F_2 can be deposited as a finely divided solid, while HF remains as part of the gas plume.

In enclosed situations, the reaction products form a dense fog, reducing visibility for occupants of the area and hindering evacuation and emergency response. Fog can occur in unconfined areas if the humidity is high.

In a fire, the reaction of UF_6 with water is accelerated because of the increased UF_6 vapor pressure and the large quantities of water formed in combustion of organic materials or hydrocarbons. Reaction of liquid UF_6 with hydrocarbon vapors is extremely vigorous in flames, with formation of UF_4 and low-molecular-weight fluorinated compounds. More heat is generally released in these hydrocarbon interactions with UF_6 than in the corresponding reactions of hydrocarbons with oxygen.

A.2.2 Uranyl Fluoride

Uranyl fluoride (UO_2F_2) is a yellow hygroscopic solid that is very soluble in water. In accidental releases of UF_6, UO_2F_2 as a solid particulate compound may deposit on the ground over a large area.

A.2.3 Uranium Tetrafluoride

Uranium tetrafluoride (UF_4) reacts slowly with moisture at ambient temperature, forming UO_2 and HF, which are very corrosive.

A.2.4 Triuranium Octaoxide

Triuranium octaoxide (U_3O_8) has no hazardous chemical properties that are significant.

A.2.5 Uranium Dioxide

Uranium dioxide (UO_2) will ignite spontaneously in heated air and burn brilliantly. It will slowly convert to U_3O_8 in air at ambient temperature. Its stability in air can be improved by sintering the powder in hydrogen.

A.2.6 Uranium Metal

Uranium powder or chips will ignite spontaneously in air at ambient temperature. During storage, uranium ingots can form a pyrophoric surface because of reaction with air and moisture. Uranium metal will also react with water at ambient temperature, forming UO_2 and UH_3. The metal swells and disintegrates. Hydrogen gas can be released.

Solid uranium, either as chips or dust, is a very dangerous fire hazard when exposed to heat or flame. In addition, uranium metal can react violently with chlorine (Cl_2), fluorine (F_2), nitric acid (HNO_3), selenium (Se), sulfur (S), ammonia (NH_3), bromine fluoride (BrF_3), trichlorethylene (TCE), or nitryl fluoride and similar compounds.

APPENDIX B:

CYLINDER CORROSION AND MATERIAL LOSS FROM BREACHED CYLINDERS

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NOTATION (APPENDIX B)

The following is a list of acronyms and abbreviations, including units of measure, used in this appendix.

ACRONYMS AND ABBREVIATIONS

General

DOE	U.S. Department of Energy
PEIS	programmatic environmental impact statement
USEC	United States Enrichment Corporation

Chemicals

HF	hydrogen fluoride
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2F_2	uranyl fluoride

UNITS OF MEASURE

cm	centimeter(s)
in.	inch(es)
kg	kilogram(s)
lb	pound(s)
mil	mil(s)
psi	pound(s) per square inch
ton(s)	short ton(s)
yr	year(s)

APPENDIX B:

CYLINDER CORROSION AND MATERIAL LOSS FROM BREACHED CYLINDERS

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing cylinder corrosion and material loss from breached cylinders.

Depleted UF_6 has been stored in steel cylinders in outdoor yards at three DOE storage sites since the 1950s. Most cylinders have either a 10- or 14-ton (9- or 12-metric ton) capacity and a nominal wall thickness of 5/16 in. (0.79 cm, or 312.5 mil). The DOE-generated inventory consists of 46,422 cylinders, the oldest of which will have been in storage for about 45 years at the time of the PEIS record of decision and the youngest of which will have been in storage for about 5 years. United States Enrichment Corporation (USEC)-generated cylinders are considerably newer than the majority of DOE-generated cylinders.

An important criterion for the selection of a preferred management strategy for the depleted UF_6 cylinders is the expected condition of the cylinders throughout the time frames considered for various actions in the PEIS (i.e., 1999 through 2039). The condition of the cylinders is generally expressed in terms of remaining wall thickness (Nichols 1995), which determines whether the cylinders can be transported (thickness must be greater than 250 mil), pressurized in an autoclave (thickness must be greater than 200 mil), or lifted (thickness must be greater than 100 mil).[1] Cylinders that are breached (i.e., wall thickness at some part of the cylinder is 0) can produce environmental impacts by release of material.

All metals corrode to some extent when their surfaces are unprotected. In the past, depleted UF_6 cylinders have been stored in outdoor yards, and some groups of cylinders have been in contact with wet ground surfaces. An extensive cylinder maintenance program that began in the earlier 1990s has substantially improved storage conditions (e.g., paving of cylinder yards, restacking of cylinders onto concrete saddles, regular inspection of cylinders, and cylinder painting). However, accelerated corrosion has occurred on some cylinder surfaces, and eight breached cylinders have been identified

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[1] The wall thickness criteria were obtained from Hanrahan (1996). The transportation requirement is from the American National Standards Institute (ANSI 14.1, "American National Standards for Nuclear Materials — Packaging of Uranium Hexafluoride for Transport"); the pressurization standard is based on a requirement of the American Society of Mechanical Engineers ("Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessel") that pressure vessels pass a 100 psi rating; no source for the lift limit was cited.

in the inventory. The properties of depleted UF_6 in the solid form are such that release of material from breached cylinders occurs at a slow rate because the UF_6 degrades to a solid form of uranium that serves to "plug" the hole. To provide estimated impacts of continued storage for all or part of the cylinder inventory for an extended time period, it was necessary to estimate both the numbers of cylinders that might be breached and the amount of uranium compounds and hydrogen fluoride (HF) that would be expected to be released from any cylinder breaches that might occur in the future.

B.1 CYLINDER CORROSION MODELS

Efforts began in the mid 1970s and are ongoing to estimate the extent of corrosion of the depleted UF_6 cylinders and the numbers of breaches that might occur in the future. These studies are summarized in Nichols (1995). Generally, ultrasonic test measurements are used to estimate the current wall thickness at many locations on a single cylinder (current methods obtain 100,000 measurements for 0.1-in. [0.25-cm] squares on a single cylinder [Lyon 1996a]). In the simplest method for predicting breaches, the minimum wall thickness measurement is subtracted from a value assumed to be the initial wall thickness; this value is divided by the age of the cylinder to estimate an annual corrosion rate; the corrosion rate is then extrapolated forward from the cylinder age to arrive at an estimated year of breach. Because the ultrasonic tests are time-consuming and costly, only a small portion of the entire inventory has been measured. To estimate the numbers of breaches expected during various time intervals, several recent attempts have been made to extrapolate the results from the sample of cylinders measured to the entire inventory (Lyon 1995, 1996a-b, 1997; Nichols 1995; Rosen and Glaser 1996a-b).

Uncertainties associated with accurately estimating the expected number of breaches include the following:

- The sample of cylinders with ultrasonic test data available is not a random sample from the entire inventory of cylinders. Generally, cylinders showing signs of accelerated corrosion were chosen for ultrasonic testing. Therefore, basing the corrosion rate for the entire cylinder inventory on the ultrasonic test data may result in overestimation of potential breaching.

- The initial thickness of the cylinders is not known. Although the manufacturer-specified thickness for the most prevalent cylinder type is 312.5 mil, many of the cylinders actually had greater initial wall thicknesses. One estimate of the maximum initial wall thickness for the 5/16-in. (0.79-cm) cylinders is 345.5 mil, based on the nominal 312.5-mil thickness plus an American Society for Testing and Materials mill tolerance of 33 mil; however, estimates of up to 400-mil initial thickness have been made for some 5/16-in. (0.79-cm) cylinders at the Portsmouth site (Nichols 1995).

- Currently, it is not possible to reliably address the effects of past storage history on different cylinder inventories. Previously, some cylinders were stored under substandard conditions in which they were in prolonged contact with moisture. Improved storage conditions have undoubtedly reduced the corrosion rates. However, these changes have not been accounted for in the modeling studies because not enough data are available on corrosion rates under the improved storage conditions to support the predictive models.

In a more recent method used to predict numbers of breached cylinders over time (Lyon 1996b, 1997), the available ultrasonic test data were modeled using one to three functional forms (i.e., statistical equations) for predicting corrosion. (Corrosion is also referred to as penetration depth in Lyon 1996b.) Each statistical form of corrosion was assumed to be either normally or lognormally distributed. The three forms represent statistical methods that assume (1) the distribution of corrosion rates is constant with time or (2) the corrosion rates level off with time. For the modeling, the initial thickness of the cylinders was assumed to have a triangular distribution between 302.5 and 345.5 mil, with a most likely value of 330 mil.

B.2 BREACHED CYLINDERS AND MATERIAL LOSS

Before 1998, seven breached cylinders had been identified at the three storage locations: four at the K-25 site, two at the Portsmouth site, and one at the Paducah site. The first breached cylinders to be identified were those at the Portsmouth site. Investigation of these breached cylinders indicated that the initial damage occurred during stacking because of impact with an adjacent cylinder at the weld joint of the stiffening ring and the cylinder wall (Barber et al. 1991). The hole sizes increased over time due to moist air migrating into the cylinder and reacting with the UF_6 and iron. This reaction resulted in a dense plug of uranium tetrafluoride (UF_4) hydrates and various iron fluoride hydrates that prevented rapid loss of material from the cylinders. One breached cylinder that had been in storage for 13 years had an approximate hole size of 9 in. × 18 in. (23 cm × 46 cm); the mass of UF_6 lost from this cylinder was estimated to be between 17 and 109 lb (7.7 and 49 kg). The other breached cylinder had a hole 2 in. (5.1 cm) in diameter and had been in storage only 4 years; the mass of uranium lost from this cylinder was estimated to be less than 4 lb (1.8 kg).

Of the four breached cylinders identified at the K-25 site, two were concluded to have been damaged during handling in a manner similar to the breached cylinders at the Portsmouth site. However, external corrosion due to prolonged ground contact was concluded to be the cause of the other two breaches (Barber et al. 1994). The hole sizes in the four breached cylinders were 2 in. (5.1 cm) in diameter (cylinder stored for about 16 years), 6 in. (15 cm) in diameter (cylinder stored for about 28 years), 10 in. (25 cm) in diameter (cylinder stored for about 33 years), and 17 in. × 12 in. (43 cm × 30 cm) (cylinder stored for about 17 years). Because equipment to weigh the cylinders was not available at the K-25 site, the extent of material loss from the cylinders could not be determined.

The hole size of the breached cylinder identified at the Paducah site in 1992 was approximately 1/16 in. × 2 in. (0.16 cm × 5.1 cm); the cause of the breach was concluded to be damage during handling. The contents of the cylinder have been transferred to another cylinder.

In 1998, one additional breached cylinder occurred at the K-25 site during the course of cylinder maintenance operations (i.e., cylinder painting). Previous corrosion modeling had predicted that some additional cylinder breaches would be detected during such activities; see Table B.1. The breach occurred during steel grit blasting of the cylinder surface in preparation for painting. An as-fabricated weld defect was opened by the blast process. The cylinder management program includes provisions for patching newly identified breached cylinders to eliminate releases of material.

B.3 ESTIMATED NUMBER OF CYLINDER BREACHES AND MATERIAL LOSS USED FOR ANALYSIS

One of the strategies being used to maintain the cylinders is a painting program to mitigate external corrosion. It is estimated that the paint system currently in use will be effective for 12 years before significant maintenance or repainting would be needed (Pawel 1997). The painting program is therefore designed to eliminate further reduction in wall thickness on painted cylinders during the effective life of the paint. Furthermore, once painted, no additional wall thinning would occur as long as the paint was maintained.

For the no action alternative, the impacts of indefinite continued storage at the three sites were analyzed by estimating the number of expected cylinder breaches through 2039, assuming that the maintenance and painting program would be effective in controlling corrosion of cylinder surfaces. This is considered to be representative of the actual conditions that will occur at the three sites. To address the uncertainty associated with the effectiveness of painting and with future painting schedules, an analysis was also conducted that assumed that cylinder corrosion continued at historical rates (i.e., that improved storage conditions and cylinder painting had no effect on corrosion).

For the no action alternative analyses, corrosion of the cylinders was assumed to continue until cylinders were painted (painting estimated to be complete by 2009). Corrosion estimates through 2009 were based on modeling of corrosion that has occurred to date (Lyon 1996b, 1997). The possibility of initiating breaches during handling of the cylinders was incorporated into the breach estimates by using historical data regarding the approximate rates of such handling-initiated breaches that have occurred to date. (The rate assumed was 0.00014 breach per cylinder move; this value was based on five breaches that were initiated by handling damage and the estimated number of 50,000-cylinder moves during storage to date, plus an additional factor of 0.00004 to account for the possibility of a cylinder breaching during handling because it had been weakened from previous corrosion.) The number of cylinder breaches in the inventory at each site through 2039 was estimated

TABLE B.1 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the Paducah, Portsmouth, and K-25 Sites from 1999 through 2039, Assuming Control of External Corrosion by Painting[a]

	Paducah Site				Portsmouth Site				K-25 Site			
Year of Breach	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)
1999	28,351	2	2	4	13,388	0	0	0	4,683	1	1	2
2000	28,351	1	3	6	13,388	2	2	4	4,683	1	2	4
2001	28,351	1	4	8	13,388	0	2	4	4,683	0	2	4
2002	28,351	1	5	10	13,388	1	3	6	4,683	0	2	4
2003	28,351	2	5	10	13,388	0	3	6	4,683	0	1	2
2004	28,351	1	5	10	13,388	0	1	2	4,683	0	0	0
2005	28,351	0	4	8	13,388	1	2	4	4,683	0	0	0
2006	28,351	1	4	8	13,388	0	1	2	4,683	0	0	0
2007	28,351	1	3	6	13,388	0	1	2	4,683	0	0	0
2008	28,351	1	3	6	13,388	1	2	4	4,683	1	1	2
2009	28,351	1	4	8	13,388	0	1	2	4,683	0	1	2
2010	28,351	1	4	8	13,388	1	2	4	4,683	0	1	2
2011	28,351	0	3	6	13,388	0	2	4	4,683	1	2	4
2012	28,351	1	3	6	13,388	0	1	2	4,683	0	1	2
2013	28,351	1	3	6	13,388	1	2	4	4,683	0	1	2
2014	28,351	1	3	6	13,388	0	1	2	4,683	0	1	2
2015	28,351	0	3	6	13,388	0	1	2	4,683	0	0	0
2016	28,351	1	3	6	13,388	1	2	4	4,683	0	0	0
2017	28,351	1	3	6	13,388	0	1	2	4,683	0	0	0
2018	28,351	1	3	6	13,388	1	2	4	4,683	0	0	0
2019	28,351	1	4	8	13,388	0	2	4	4,683	0	0	0
2020	28,351	1	4	8	13,388	0	1	2	4,683	1	1	2
2021	28,351	0	3	6	13,388	1	2	4	4,683	0	1	2
2022	28,351	1	3	6	13,388	0	1	2	4,683	0	1	2
2023	28,351	1	3	6	13,388	0	1	2	4,683	0	1	2
2024	28,351	1	3	6	13,388	1	2	4	4,683	0	0	0
2025	28,351	0	3	6	13,388	0	1	2	4,683	0	0	0

TABLE B.1 (Cont.)

Year of Breach	Paducah Site				Portsmouth Site				K-25 Site			
	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)	Cylinder Inventory	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)
2026	28,351	1	3	6	13,388	1	2	4	4,683	0	0	0
2027	28,351	1	3	6	13,388	0	2	4	4,683	0	0	0
2028	28,351	1	3	6	13,388	0	1	2	4,683	0	0	0
2029	28,351	1	4	8	13,388	1	2	4	4,683	1	1	2
2030	28,351	0	3	6	13,388	0	1	2	4,683	0	1	2
2031	28,351	1	3	6	13,388	0	1	2	4,683	0	1	2
2032	28,351	1	3	6	13,388	1	2	4	4,683	0	1	2
2033	28,351	1	3	6	13,388	0	1	2	4,683	0	0	0
2034	28,351	1	4	8	13,388	1	2	4	4,683	0	0	0
2035	28,351	0	3	6	13,388	0	2	4	4,683	0	0	0
2036	28,351	1	3	6	13,388	0	1	2	4,683	0	0	0
2037	28,351	1	3	6	13,388	1	2	4	4,683	0	0	0
2038	28,351	1	3	6	13,388	0	1	2	4,683	1	1	2
2039	28,351	1	4	8	13,388	0	1	2	4,683	0	1	2
Total (1999-2039)		**36**				**16**				**7**		

[a] PEIS analyses conducted for the period 1999 through 2039. Existing models also predicted one possible breach at each site for 1998, because of either handling (Paducah and Portsmouth) or corrosion (K-25).

[b] Estimates based on the assumption that a painting program would be effective in eliminating external corrosion by the year 2009. Breaches prior to 2009 were calculated as the sum of corrosion-initiated breaches for the proportion left unpainted in each year (based on external corrosion statistical model [Lyon 1996b, 1997]) plus the handling-initiated breaches. For 2009-2039, only handling-initiated breaches were assumed. The breaches were assumed to go undetected for 4 years; in practice, improved storage conditions and maintenance and inspection procedures should prevent any breaches from occurring or going undetected for long periods.

[c] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[d] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

as the number of cylinder moves times the handling breach rate, added to the estimated number of corrosion breaches for unpainted cylinders through 2008. The number of cylinder moves through 2039 was estimated from the painting and relocation schedule given in Parks (1997), assuming two moves per painted cylinder. The annual numbers of breaches in DOE-generated cylinders estimated for the three sites on the basis of these assumptions are given in Table B.1.

The potential impacts that would occur using more conservative (i.e., higher) breach assumptions were estimated by assuming that the historical corrosion rates would continue through the year 2039. This assumption could be applicable if it was found that the effectiveness of the paint was significantly less than 12 years. For this analysis, the method of Lyon (1996b, 1997) for predicting numbers of cylinder breaches due to external corrosion was used to estimate the number of breaches expected through the year 2039 for the three sites, assuming that the entire inventory would remain in storage at the current sites. The values used were the maximums of the predicted ranges for each year, as summarized by Parks (1997). Separate breach rates were estimated for the Paducah site C-745-G-yard and the K-25 site K-1006-K-yard because the worst historical storage conditions have occurred in these yards. This method is subject to the uncertainties discussed in Section B.1. By using the maximum result of the range for a number of assumptions regarding the form of distribution of the penetration depth, this method probably overestimates the actual number of cylinder breaches that would occur at each site through the year 2039.

The estimated number of cylinder breaches among DOE-generated cylinders from 1999 through 2039, based on the method of Lyon (1996b, 1997), is listed in Tables B.2 through B.4 for the three sites. No adjustment was made to the breach estimates given in these tables to account for handling-initiated breaches. Handling-initiated breaches were considered less likely for these cylinders because no credit was taken for corrosion protection from painting (i.e., it is likely that much less painting and maintenance would be taking place). In any case, the number of handling-initiated breaches would be minor in comparison with the predicted corrosion-initiated breaches.

The potential impacts of continued DOE-generated cylinder storage through 2028 for the action alternatives considered in this PEIS were estimated on the basis of the conservative corrosion-initiated breaches predicted with Lyon's method (Lyon 1996b, 1997). However, for the period 2009 through 2028, the estimated number of breaches was reduced by the proportion of inventory reduction occurring in each year.

The estimated "active" breaches in specific years at the three sites are also shown in Tables B.1 through B.4. These values take into account that under the given assumptions for the continued storage period, the minimum required inspection frequency is once every 4 years, although some cylinders are inspected more frequently (i.e., suspect cylinders with signs of extensive exterior corrosion are inspected annually). Therefore, to calculate active breaches, it was assumed that all breaches would go undetected for 4 years. The number of active breaches is the sum of the current-year breaches and the previous-3-year breaches.

TABLE B.2 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the Paducah Site from 1999 through 2039, Assuming Historical Corrosion Rates

	Breaches and Releases at G-Yard				Breaches and Releases at All Other Yards			
Year of Breach	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
1999	5,733	1	1	2	22,618	0	0	0
2000	5,733	0	1	2	22,618	0	0	0
2001	5,733	1	2	4	22,618	0	0	0
2002	5,733	0	2	4	22,618	0	0	0
2003	5,733	1	2	4	22,618	1	1	2
2004	5,733	1	3	6	22,618	0	1	2
2005	5,733	1	3	6	22,618	0	1	2
2006	5,733	1	4	8	22,618	1	2	4
2007	5,733	2	5	10	22,618	1	2	4
2008	5,733	2	6	12	22,618	1	3	6
2009	5,733	2	7	14	22,618	1	4	8
2010	5,733	2	8	16	22,618	1	4	8
2011	5,733	3	9	18	22,618	1	4	8
2012	5,733	3	10	20	22,618	1	4	8
2013	5,733	3	11	22	22,618	1	4	8
2014	5,733	4	13	26	22,618	1	4	8
2015	5,733	4	14	28	22,618	1	4	8
2016	5,733	5	16	32	22,618	1	4	8
2017	5,733	5	18	36	22,618	2	5	10
2018	5,733	5	19	38	22,618	1	5	10
2019	5,733	6	21	42	22,618	2	6	12
2020	5,733	7	23	46	22,618	1	6	12
2021	5,733	7	25	50	22,618	2	6	12
2022	5,733	8	28	56	22,618	2	7	14
2023	5,733	8	30	60	22,618	3	8	16
2024	5,733	9	32	64	22,618	2	9	18
2025	5,733	10	35	70	22,618	3	10	20
2026	5,733	10	37	74	22,618	2	10	20
2027	5,733	11	40	80	22,618	3	10	20
2028	5,733	13	44	88	22,618	4	12	24
2029	5,733	13	47	94	22,618	3	12	24
2030	5,733	15	52	104	22,618	4	14	28
2031	5,733	17	58	116	22,618	4	15	30
2032	5,733	17	62	124	22,618	5	16	32
2033	5,733	19	68	137	22,618	4	17	34
2034	5,733	20	73	147	22,618	5	18	36

TABLE B.2 (Cont.)

	Breaches and Releases at G-Yard				Breaches and Releases at All Other Yards			
Year of Breach	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
2035	5,733	21	77	155	22,618	5	19	38
2036	5,733	22	82	165	22,618	6	20	40
2037	5,733	23	86	173	22,618	6	22	44
2038	5,733	24	90	181	22,618	6	23	46
2039	5,733	25	94	189	22,618	6	24	48
Total (1999-2039)		**351**				**93**		
Total Breaches at Site				**444**				

[a] These estimates are conservative estimates used for assessing potential impacts based on an external corrosion statistical model (Lyon 1996b, 1997). The estimates were based on the assumption that historical corrosion rates would continue through 2039 (i.e., that corrosion would not have been eliminated by painting and maintenance). In practice, painting of cylinders, improved storage conditions, and maintenance and inspection procedures should prevent any breaches from occurring or from going undetected for long periods.

[b] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[c] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

TABLE B.3 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the Portsmouth Site from 1999 through 2039, Assuming Historical Corrosion Rates

Year of Breach	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
1999	13,388	0	0	0
2000	13,388	1	1	2
2001	13,388	1	2	4
2002	13,388	0	2	4
2003	13,388	0	2	4
2004	13,388	1	2	4
2005	13,388	1	2	4
2006	13,388	1	3	6
2007	13,388	1	4	8
2008	13,388	1	4	8
2009	13,388	0	3	6
2010	13,388	1	3	6
2011	13,388	1	3	6
2012	13,388	0	2	4

TABLE B.3 (Cont.)

Year of Breach	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
2013	13,388	1	3	6
2014	13,388	1	3	6
2015	13,388	1	3	6
2016	13,388	1	4	8
2017	13,388	2	5	10
2018	13,388	1	5	10
2019	13,388	1	5	10
2020	13,388	2	6	12
2021	13,388	1	5	10
2022	13,388	2	6	12
2023	13,388	2	7	14
2024	13,388	2	7	14
2025	13,388	2	8	16
2026	13,388	2	8	16
2027	13,388	2	8	16
2028	13,388	3	9	18
2029	13,388	3	10	20
2030	13,388	2	10	20
2031	13,388	3	11	22
2032	13,388	4	12	24
2033	13,388	3	12	24
2034	13,388	3	13	26
2035	13,388	4	14	28
2036	13,388	4	14	28
2037	13,388	4	15	30
2038	13,388	4	16	32
2039	13,388	5	17	34
Total (1999-2039)		**74**		
Total Breaches at Site		**74**		

[a] These estimates are conservative estimates used for assessing potential impacts based on an external corrosion statistical model (Lyon 1996b, 1997). The estimates were based on the assumption that historical corrosion rates would continue through 2039 (i.e., that corrosion would not have been eliminated by painting and maintenance). In practice, painting of cylinders, improved storage conditions, and maintenance and inspection procedures should prevent any breaches from occurring or from going undetected for long periods.

[b] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[c] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

TABLE B.4 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the K-25 Site from 1999 through 2039, Assuming Historical Corrosion Rates

	Breaches and Releases at K-Yard				Breaches and Releases at E-Yard and L-Yard			
Year of Breach	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
1999	2,945	1	1	2	1,738	0	0	0
2000	2,945	0	1	2	1,738	0	0	0
2001	2,945	0	1	2	1,738	0	0	0
2002	2,945	0	1	2	1,738	0	0	0
2003	2,945	0	0	0	1,738	0	0	0
2004	2,945	0	0	0	1,738	0	0	0
2005	2,945	2	2	4	1,738	1	1	2
2006	2,945	1	3	6	1,738	1	2	4
2007	2,945	0	3	6	1,738	0	2	4
2008	2,945	2	5	10	1,738	0	2	4
2009	2,945	0	3	6	1,738	0	1	2
2010	2,945	1	3	6	1,738	0	0	0
2011	2,945	2	5	10	1,738	0	0	0
2012	2,945	2	5	10	1,738	0	0	0
2013	2,945	2	7	14	1,738	0	0	0
2014	2,945	2	8	16	1,738	1	1	2
2015	2,945	2	8	16	1,738	0	1	2
2016	2,945	2	8	16	1,738	1	2	4
2017	2,945	2	8	16	1,738	0	2	4
2018	2,945	3	9	18	1,738	0	1	2
2019	2,945	3	10	20	1,738	1	2	4
2020	2,945	4	12	24	1,738	1	2	4
2021	2,945	4	14	28	1,738	1	3	6
2022	2,945	4	15	30	1,738	1	4	8
2023	2,945	5	17	34	1,738	0	3	6
2024	2,945	6	19	38	1,738	1	3	6
2025	2,945	6	21	42	1,738	0	2	4
2026	2,945	7	24	48	1,738	0	1	2
2027	2,945	6	25	50	1,738	1	2	4
2028	2,945	7	26	52	1,738	1	2	4
2029	2,945	8	28	56	1,738	0	2	4
2030	2,945	9	30	60	1,738	1	3	6
2031	2,945	10	34	68	1,738	1	3	6
2032	2,945	8	35	70	1,738	1	3	6
2033	2,945	11	38	76	1,738	1	4	8
2034	2,945	11	40	80	1,738	1	4	8

TABLE B.4 (Cont.)

Year of Breach	Breaches and Releases at K-Yard: Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Breaches and Releases at E-Yard and L-Yard: Cylinder Inventory	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
2035	2,945	11	41	82	1,738	1	4	8
2036	2,945	12	45	90	1,738	1	4	8
2037	2,945	12	46	92	1,738	1	4	8
2038	2,945	12	47	94	1,738	1	4	8
2039	2,945	12	48	96	1,738	1	4	8
Total (1999-2039)		**192**				**21**		
Total Breaches at Site				**213**				

[a] These estimates are conservative estimates used for assessing potential impacts based on an external corrosion statistical model (Lyon 1996b, 1997). The estimates were based on the assumption that historical corrosion rates would continue through 2039 (i.e., that corrosion would not have been eliminated by painting and maintenance). In practice, painting of cylinders, improved storage conditions, and maintenance and inspection procedures should prevent any breaches from occurring or from going undetected for long periods.

[b] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[c] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

A reasonable estimate of material loss from breached cylinders was required to analyze the impacts of breached cylinders for the continued cylinder storage component of each alternative considered in this PEIS. For uranium, it was assumed that the amount lost would be similar to the amount lost from the cylinder at Portsmouth that had been in storage for 4 years at the time of breach identification. Therefore, the amount of uranium lost was assumed to be 4 lb (1.8 kg) per breached cylinder: 1 lb/yr (0.45 kg/yr) uranium per breached cylinder. It was assumed that uranium would be released as solid uranyl fluoride (UO_2F_2), which would be deposited on the ground, from where it could be transported as runoff to soil or surface water or infiltrate to groundwater.

The rate of HF loss from breached cylinders increases over time as the hole size increases. The time-dependent rate provided in Barber et al. (1994) was used to estimate the average daily HF emission rate that would be applicable over the assumed 4-year period that a breach could go undiscovered. An exponential equation for HF loss was used to estimate a value of 0.0055 kg per day HF emission per breached cylinder (Folga 1996a-b). Potential uranium and HF emissions from breached cylinders are summarized in Tables B.1 through B.4 for the Paducah, Portsmouth, and K-25 sites.

For analysis of continued storage (Appendix D), it was assumed that welded patches would be applied within about 1 week of any breach discovery and that no further uranium or HF leakage would occur after patch application.

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APPENDIX C:

ASSESSMENT METHODOLOGIES

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NOTATION (APPENDIX C)

The following is a list of acronyms and abbreviations, including units of measure, used in this appendix.

ACRONYMS AND ABBREVIATIONS

General

AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
BEA	U.S. Bureau of Economic Analysis
BEMR	*The 1996 Baseline Environmental Management Report*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilating, and air conditioning
ICRP	International Commission on Radiological Protection
INEL EIS	*Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*
IRIS	Integrated Risk Information System
ISCST	Industrial Source Complex Short Term model
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
LMES	Lockheed Martin Energy Systems, Inc.
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NRC	U.S. Nuclear Regulatory Commission
ORR	Oak Ridge Reservation
OSHA	U.S. Occupational Safety and Health Administration
PEIS	programmatic environmental impact statement
PEL	permissible exposure limit
$PM_{2.5}$	particulate matter having a particle diameter equal to or less than 2.5 μm
PM_{10}	particulate matter having a particle diameter equal to or less than 10 μm
ROI	region of influence
SIC	Standard Industrial Classification

TEDE	total effective dose equivalent
WM PEIS	*Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*

Chemicals

CaF_2	calcium fluoride
HF	hydrogen fluoride
MgF_2	magnesium fluoride
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

cm	centimeter(s)	µg	microgram(s)
cm^3	cubic centimeter(s)	m	meter(s)
d	day(s)	m^3	cubic meter(s)
ft	foot (feet)	mg	milligram(s)
g	gram(s)	min	minute(s)
h	hour(s)	mrem	millirem(s)
kg	kilogram(s)	ppm	part(s) per million
km	kilometer(s)	rem	roentgen-equivalent man (men)
km^2	square kilometer(s)	s	second(s)
L	liter(s)	Sv	sievert(s)
lb	pound(s)	yr	year(s)

APPENDIX C:

ASSESSMENT METHODOLOGIES

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and on the Oak Ridge Reservation in Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the methodology used to assess the potential environmental impacts for continued cylinder storage, cylinder preparation, conversion options, long-term storage, manufacture and use, and disposal. The general methodology is explained, and special applications for specific options or alternatives are summarized. For several technical areas — such as air resources, human health, water resources, socioeconomics, and transportation — separate technical reports provide additional details regarding these methods.

C.1 AIR RESOURCES

The assessment of air quality impacts in the depleted UF_6 PEIS considered pollutant emissions under normal operating conditions. Atmospheric dispersion of pollutant emissions from construction, operation, and maintenance activities were estimated with conventional modeling techniques, i.e., U.S. Environmental Protection Agency (EPA) Industrial Source Complex Short Term (ISCST) model (EPA 1995b) and SCREEN3 model (EPA 1995a).

For the evaluation of continued storage, internal combustion emissions and fugitive dust emissions from the planned construction of new storage areas were assessed. Additionally, material loss from hypothetical cylinder breaches was assessed. Loss of any depleted UF_6 through corrosion of cylinders in the storage yards would occur slowly enough that the depleted UF_6 would react with atmospheric moisture while still in the cylinder. The pollutant of concern from atmospheric releases due to cylinder breaches is hydrogen fluoride (HF). Emissions from postulated breaches were modeled using the ISCST model.

Estimated emissions were taken from the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997). Emissions data were provided for construction of facilities and for normal operations of the conversion, cylinder preparation, long-term storage, manufacture and use, and disposal options.

Air concentrations of radionuclides due to the emission of radioactive materials were estimated with the GENII code (Napier et al. 1988). Emissions of hazardous chemicals and other pollutants were estimated with the ISCST code (EPA 1995b). Results from the ISCST and GENII

codes for given conditions are in good agreement with each other. The hour-by-hour meteorological data from the three current storage sites show the range of air quality impacts that could be anticipated at the facility boundaries from the estimated emissions. For the Paducah and Portsmouth site-specific and representative analyses, the plant boundaries rather than the site perimeters were used (see Chapter 3). The SCREEN3 model (EPA 1995a) was used to determine the maximum impacts possible under worst-case meteorological conditions.

For impact analyses of representative environmental settings (i.e., analyses for the conversion and long-term storage options), the representative facility was assumed to be centered within a larger site (i.e., the plant boundaries of the three representative sites), and pollutant concentrations were estimated for the boundaries of that site. Screening modeling of construction emissions was used to estimate hourly pollutant concentrations under very conservative meteorological conditions at the boundary point that would be the shortest distance from the center of the facility. For impact analyses of generic environmental settings (i.e., analyses for the manufacture and use and disposal options), the pollutant concentrations at several distances from the center of the facility were estimated because of uncertainty regarding the size and location of the generic sites. Estimates at 2,460 ft (750 m) from the center of the generic facilities are comparable to the estimates for options based on representative environmental settings (i.e., conversion and long-term storage options using the three current storage sites as representative). The shortest distances from the centers of the representative sites to their boundaries range from 2,300 to 2,600 ft (700 to 800 m).

The radiological impacts under normal operational conditions would be long-term, cumulative impacts. Site-specific data (for facilities located at the existing cylinder storage sites) or representative long-term meteorological data (joint frequency data) were used to estimate air concentrations of the released radionuclides. For hazardous chemicals and other pollutants, short-term meteorological data were used because of the required regulatory compliance with short-term standards and different human health impact endpoints.

Additional meteorological data sets were used in the analyses of the disposal and manufacture and use options. The data sets were grouped into dry and wet environmental settings. The historical meteorological conditions for five actual "dry" locations in the southwestern United States and five actual "wet" locations in the central and southeastern United states were averaged to develop estimates for these generic environmental settings.

The type of data used for the air quality analysis included the following:

- On-site meteorological data — such as temperature, wind speed, and wind direction — and a description of the recording tower;
- Air quality data from the plant environs (state data); and
- State and federal ambient air quality standards.

Impacts relative to the ambient air quality standards for particulate matter with a particle diameter equal to or less than 2.5 μm ($PM_{2.5}$), announced by the EPA on July 17, 1997, were not estimated because the worst-case particulate emissions are likely to be coarse particulates (dust) emitted during construction, for which the PM_{10} (particulate matter with a particle diameter equal to or less than 10 μm) standards are more appropriate.

Complex terrain analysis was not required for SCREEN3 modeling. Also, to estimate air quality impacts at the facility perimeter and off the site, downwash calculations to determine the influence of on-site buildings were not needed.

Additional details on the analysis of air quality impacts are presented in Tschanz (1997).

C.2 WATER RESOURCES

For the depleted UF_6 PEIS, hydrological assessments were performed for all options for both surface water and groundwater. The assessment of water resources included evaluation of (1) existing hydrological environment for continued storage at the three current storage sites; (2) potential impacts of construction, operation, and accident scenarios for the cylinder preparation and conversion facility/storage options; and (3) potential impacts to the hydrological environment for hypothetical generic sites with respect to disposal and manufacture and use. For these generic options, two environmental settings were evaluated, a dry environment and a wet environment.

C.2.1 Continued Cylinder Storage

For the continued cylinder storage option, storage of depleted UF_6 cylinders would continue at each of the existing sites. A large number of cylinders containing depleted UF_6 are currently stored at the Paducah, Portsmouth, and K-25 sites. Because of their age, potential direct contact with the ground, and skirted ends (an extension of the cylinder walls to protect the cylinder valve from potential impact damage, which was used in a limited number of cylinder designs), many of these cylinders show signs of corrosion. Some instances of cylinder wall breach through corrosion have occurred, with subsequent exposure of depleted UF_6 to the environment (see Appendix B).

Unknown quantities (estimated to be small) of solid depleted UF_6, uranium tetrafluoride (UF_4), uranyl fluoride (UO_2F_2), and HF dissolved in water might come in contact with the material beneath a breached cylinder. For cylinders stored on concrete pads, the released material could be transported laterally by precipitation and surface runoff. If not collected or if the collection system failed, the transported material could gather in surface depressions or be swept into nearby surface drainages, potentially contaminating streams or other surface water bodies. Soluble forms could infiltrate the ground surface in areas of groundwater recharge and potentially contaminate underlying aquifers. The released material could also dissolve and infiltrate the surface and contaminate shallow

groundwater adjacent to the storage area. The released material would act as a source of potential contamination until it was fully dissolved or remediated.

For impact analysis, each active breached cylinder was assumed to release 4 lb (1.8 kg) of uranium over a 4-year period. For each of the three sites, the yard with the most predicted breaches was used in the calculations (C-745-G yard [G-yard] at Paducah, K-1066-K yard [K-yard] at Oak Ridge, and a combination of the X-745-E yard [E-yard] and X-745-C [C-yard] at Portsmouth). Because more than one breach could be active at any one time, the maximum number of active breaches was estimated by using a moving 4-year sum of breaches (see Appendix B).

For continued storage of cylinders, existing conditions were evaluated for surface water and groundwater. Surface water conditions were derived from field measurements of water quality in appropriate drainages where data were available. If data were not available, the existing conditions were estimated using the solubility of the potential contaminants and dilution estimates for the surface water features.

The concentrations of uranium leaving the yards at the three current storage sites were estimated with a simple mass balance based on the area of the yard, the average annual precipitation, and the maximum number of active breached cylinders (Tomasko 1997b). This contaminated water was then assumed to flow over land to the nearest stream, where it would mix with initially clean water and become more dilute. Maximum concentrations in the receiving water were evaluated at the point of discharge from the yards; additional downstream mixing and dispersion were not considered.

To estimate groundwater quality downgradient of the storage yards, the maximum concentration at the water table was estimated by using a one-dimensional analytical solution to a governing partial differential equation that incorporates advection, dispersion, adsorption, and decay for a time-dependent, step-function source (Tomasko 1997a-b). For groundwater quality calculations, the contaminant source was assumed to have a maximum concentration equal to the maximum value in water leaving the storage yard with the most breached cylinders. All water leaving the yard was then assumed to infiltrate the surface and move vertically downward to the underlying groundwater aquifer. To provide conservative yet realistic estimates of groundwater concentrations, the source was modeled as a step-function having a duration equal to the full width of the half-maximum concentration value (approximately 20 years for each of the three sites). Additional details on the groundwater modeling are discussed in Tomasko (1997a-b).

C.2.2 Other Options

For the cylinder preparation, conversion, and storage options, physical impacts to surface water (i.e., changes in runoff and floodplain encroachment) and groundwater (i.e., changes in recharge, depth to groundwater, and direction of flow) were evaluated for construction, operations, and accident scenarios identified in the engineering analysis report (LLNL 1997).

Impacts to runoff were evaluated with a two-step procedure. First, the amount of land area was estimated that would be changed by installing paved lots and other low-permeability features, which would modify surface permeability (ease with which water infiltrates the ground surface). Decreases in surface permeability would lead to increases in runoff, and increases in permeability would produce less runoff but more infiltration. Second, impacts to runoff were then evaluated by comparing the altered area to the total land area available at the actual or representative site that was contributing runoff to surface water. This method was used because of the direct relationship between impermeable area and runoff (Tomasko 1997b). On the basis of this procedure, large sites would be preferable to small ones because more land would be available at the larger site to mitigate the presence of the proposed construction and operation.

Potential impacts to floodplains during construction and normal operations were evaluated for two aspects: addition or subtraction (withdrawal) of water from a nearby river. In either case, the impacts were assessed by comparing the volume of water either added or withdrawn to average flow conditions in the actual or representative river. This method was implemented because of the direct relationship between volumetric flow and channel depth (Tomasko 1997b) and floodplain prediction. As with runoff, a site located near a large river would have smaller impacts than a site located near a small river or stream because the larger river would have a larger flow volume that could mitigate withdrawals or discharges easier than would a small stream.

Groundwater physical parameters could be impacted during construction by direct extraction from a well or a series of wells. Groundwater levels would decrease during pumping, and the direction of groundwater flow in the vicinity of the well would be changed. Similarly, groundwater extraction for normal operations could also impact the physical parameters. Potential impacts were evaluated by comparing the pumping rate with the current groundwater usage at the actual or representative sites and by using a simple drawdown model (Tomasko 1997b). This method was used because of the direct correlation between pumping rates and water table elevations.

Surface water quality was estimated by using simple mixing models to estimate contaminant concentrations based on the quantity and solubility of the constituents in the effluent stream and the average flow conditions in the actual or representative receiving water bodies (Tomasko 1997b). For groundwater quality, the maximum concentration at the water table (point of compliance) was estimated by using the one-dimensional analytical solution discussed in Section C.2.1.

Two generic environmental settings were evaluated for the disposal and manufacture and use options, a dry environment and a wet environment. For the dry environmental setting, the depth to groundwater was assumed to be large (100 to 500 ft [30 to 150 m]), consistent with the depth to groundwater at such locations as the mixed waste landfill at Sandia National Laboratories [Johnson et al. 1994]). For the wet setting, the depth to groundwater was assumed to be small (30 ft [9 m]). Because site-specific parameters are needed to quantify impacts, the PEIS provided only a qualitative discussion of impacts for activities assumed to occur in generic environmental settings

(i.e., discussion of non-site-specific parameters such as water use, effluent volumes, paved areas, and excavation volumes).

C.2.3 Data Requirements

Input data for the analyses performed for the PEIS were obtained from various site and contractor reports, when possible. Engineering judgment and professional experience were used to define input parameters if site-specific data were not available or calculations were for a representative or generic setting.

C.3 BIOTIC RESOURCES

Impacts to ecological resources were evaluated for continued cylinder storage, and for the cylinder preparation, conversion, storage, manufacture and use, and disposal options. Potential impacts were evaluated for terrestrial and aquatic biota, including vegetation and wildlife, wetlands, and federal- and state-listed threatened and endangered species. The impact analysis focused on the radiological and chemical toxicity effects to biota resulting from exposure to depleted UF_6 and related compounds and from physical disturbance to biota and habitats.

C.3.1 Continued Cylinder Storage and Cylinder Preparation

The impact analysis for continued cylinder storage and cylinder preparation included site-specific evaluation of impacts to biota in the vicinity of the Portsmouth, Paducah, and K-25 sites. Exposure to the contaminants of concern (depleted UF_6, UO_2F_2, and HF) under current management practices was analyzed in the context of storage cylinder integrity and potential release of contents, including effects of groundwater contamination, surface water contamination, contamination of soils, and airborne transport of contaminants. Also assessed were other effects of the operation of the three facilities associated with continued storage of depleted UF_6 that might impact biota (e.g., air quality) and potential impacts from cylinder preparation with respect to habitat loss and changes in biotic communities.

C.3.2 Other Options

The other options for management of depleted UF_6 were evaluated in generic terms, based on the following potential components: technologies for converting depleted UF_6 to other forms or products (including potential exposure to those forms or products and residual products and waste); technologies for using depleted UF_6, long-term storage of depleted UF_6 or uranium oxides; and disposal of depleted UF_6 or uranium oxides (including potential exposure to those compounds). The analysis considered potential impacts of these options to biota in the vicinity of the three

representative sites (i.e., Paducah, Portsmouth, and K-25 sites) for all options but disposal and manufacture and use, for which generic environmental settings were assumed.

C.3.3 Impact Analysis

The analysis of impacts to wildlife addressed the effects of facility construction and operations — such as air quality, radiological, and chemical toxicity effects — through the exposure pathways of inhalation, dermal contact, and ingestion. Exposures were based on predicted air, surface water, groundwater, and soil concentrations of contaminants. Predictive modeling is discussed in Sections C.1 and C.2 of this appendix. Radiological dose rate estimates (in rad/day) were calculated for aquatic biota (fish and shellfish) on the basis of undiluted effluent concentrations (in pCi/L), energy released per decay (MeV) for depleted uranium, and a bioconcentration factor (factors of 2 and 60 were applied for fish and shellfish, respectively). These dose rate estimates were compared with the dose limit of 1 rad/d specified in DOE Order 5400.5. Additionally, concentrations of uranium, uranium compounds, and HF in air, water, and/or soil were compared with published benchmark values (levels with no, or lowest observed, effects) for determination of potential toxicity effects. Benchmark values for air concentration lowest observable effects due to inhalation were 7 mg/m^3 for HF, 17 mg/m^3 for triuranium octaoxide (uranyl uranate, U_3O_8), 1 mg/m^3 for uranium dioxide (UO_2), and 0.5 mg/m^3 for UF_4 (Voegtlin and Hodge 1949). The benchmark value for aquatic toxicity was a lowest observable effect level of 150 µg/L for total uranium (Hyne et al. 1992). Potential impacts analyzed included impacts to individuals (such as mortality, physical disturbance, injury, or reduction of reproductive capacity) and potential changes in biotic community structure or function (such as changes in species dominance, trophic relationships, or ecological processes).

The analysis of ecological impacts to plant species addressed facility construction and operations effects (such as removal of vegetation during construction) and chemical toxicity effects. Estimated uranium soil concentrations were compared with a benchmark value of 5 µg/g, which is the lowest observed effects concentration (Will and Suter 1994). Potential impacts analyzed included impacts to individuals (such as mortality, reduction of productivity) and potential changes in biotic community structure or function (such as changes in species dominance, species diversity, or ecological processes).

Physical disturbances to biota and habitats were also evaluated. The general guidelines used to assess impacts of habitat loss and wildlife disturbance were as follows: (1) negligible impacts, corresponding to less than 10 acres of required land; (2) moderate impacts, corresponding to between 10 and 100 acres of required land; and (3) potential large impacts, corresponding to greater than 100 acres of required land. The potential for impacts to wetlands and federal- and state-listed threatened or endangered species is a site-specific consideration, and it would be determined in Phase II analyses and *National Environmental Policy Act* (NEPA) reviews.

C.3.4 Data Requirements

Data input for the impact analysis included plant and animal species known to occur or potentially occurring at each storage site and in ecosystems (such as wetland, forest, grassland) in the vicinity of each site. Also required was information regarding potential releases due to cylinder failure, transportation, processing of depleted UF_6 and related compounds, handling (such as during repackaging), and disposal. Chemical and physical properties of depleted UF_6 and related compounds were required, including fate in soil, air, and water (such as adsorption or transformation).

C.4 ENVIRONMENTAL RADIATION SOURCES AND EXPOSURES

C.4.1 Normal Operations

Radiological impacts to human health from normal operations at different facilities were assessed for the continued storage option and for different categories of options. The option categories corresponded to the different technologies developed in the engineering analysis report (LLNL 1997). Additional details on the analysis of radiological impacts under normal operations are presented in Cheng et al. (1997).

C.4.1.1 Receptors

For the PEIS, radiation effects during normal (or routine) operations were estimated by first calculating the radiation dose to workers and members of the general public from the anticipated activities required under each alternative. The analysis considered three groups of people: (1) involved workers, (2) noninvolved workers, and (3) members of the general public, defined as follows:

- ***Involved Workers*** — Persons working at a site who are directly involved with the handling of radioactive or hazardous materials:
  - Might be exposed to direct gamma radiation emitted from radioactive materials, such as depleted UF_6 or other uranium compounds.
  - Would receive very small radiation doses from inhaling uranium compared with the direct radiation doses resulting from enclosed processes; ventilation controls would be used to inhibit airborne emissions in facilities.

  - Would be protected by a dosimetry program to control doses below the maximum regulatory limit of 5 rem/yr for workers (10 *Code of Federal Regulations* [CFR] Part 835).

- ***Noninvolved Workers*** — Persons working at a site but not directly involved with the handling of radioactive or hazardous materials:

  - Might be exposed to direct radiation from radioactive materials (although at a great distance) and to trace amounts of uranium released to the environment through site exhaust stacks.

  - Would receive radiation exposure primarily through inhalation of radioactive material in the air, external radiation from radioactive material deposited on the ground, and incidental ingestion of soil.

- ***Members of the General Public*** — Persons living within 50 miles (80 km) of the site:

  - Might be exposed to trace amounts of uranium released to the environment through exhaust stacks or wastewater discharges.

  - Would receive radiation exposures primarily through inhalation of radioactive material in the air, external radiation from deposited radioactive material, and ingestion of contaminated water, food, or soil.

For each of these groups, doses were estimated for the group as a whole (population or collective dose), as well as for a maximally exposed individual (MEI). The MEI was defined as a hypothetical person who — because of proximity, activities, or living habits — could receive the highest possible dose. The MEI for noninvolved workers and members of the general public usually was assumed to be at the location of the highest on-site or off-site air concentrations of contaminants, respectively — even if no individual actually worked or lived there. The average individual dose for involved workers was estimated, rather than the MEI dose, because of uncertainties about involved worker activities and locations. Under actual conditions, all radiation exposures and releases of radioactive material to the environment are required to be as low as reasonably achievable (ALARA), a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

C.4.1.2 Radiation Doses and Health Effects

All radiological impacts were assessed in terms of committed dose and associated health effects. The calculated dose was the total effective dose equivalent (10 CFR Part 20), which is the sum of the effective dose equivalent from exposure to external radiation and the 50-year committed

effective dose equivalent from exposures to internal radiation. Radiation doses were calculated in units of milliroentgen-equivalent man (mrem) for individuals and in units of person-rem for collective populations.

The potential radiation doses resulting from normal operations would be so low that the primary adverse health effects would be the potential induction of latent cancer fatalities (LCFs). Health risk conversion factors (expected LCFs per absorbed dose) from Publication 60 of the International Commission on Radiological Protection (ICRP 1991) were used to convert radiation doses to LCFs, i.e., 0.0005 per person-rem for members of the general public and 0.0004 per person-rem for workers. Adverse health effects for individuals were assessed in terms of the probability of developing an excess LCF, whereas adverse health effects for collective populations were assessed as the number of excess LCFs expected in the population.

C.4.1.3 Exposure Pathways

External radiation would be the primary exposure pathway for involved workers due to the direct handling of radioactive materials and/or the close working distances to radiation sources. Radiation exposures through inhalation and incidental ingestion of contaminated particulates would be possible but would be expected to be very small compared with exposures from external radiation. Operations that could result in potential airborne emissions would be conducted under a fume hood or in glove boxes. Even if airborne emissions did occur, the use of high-efficiency particulate air (HEPA) filters and various air circulation systems would reduce the airborne pollutants in the working place to a minimal level. Exposures from inhalation could also be prevented by implementation, as required, of as low as reasonably achievable (ALARA) practices, such as workers wearing respirators while performing activities with potential airborne emissions. Potential exposure from incidental ingestion of particulates could be reduced by workers wearing gloves and exercising good working practices. On the basis of the small stack emission rates of radioactive materials estimated in the engineering analysis report (LLNL 1997) and the implementation of various mitigative measures, radiological impacts to involved workers were analyzed only for external radiation exposures.

Inhalation of contaminated particulates and incidental ingestion of deposited particulates were considered for noninvolved workers who, because of being located farther away from the radiation sources handled in the facilities, would not be exposed to direct external radiation from those sources. However, secondary external radiation would be possible from the deposited radionuclides on ground surfaces and from airborne radionuclides when the emission plume from the stacks of the processing buildings passed the locations of the noninvolved workers. To obtain conservative estimates with the calculation, the noninvolved workers were assumed to be exposed to radiation caused by airborne emissions without any shielding from buildings or other structures.

Radiation exposures of members of the off-site general public were assessed for both airborne and waterborne pathways. The airborne pathways included inhalation of contaminated

particulates, external radiation from deposited radionuclides and from airborne radionuclides, incidental ingestion of deposited radionuclides, and ingestion of contaminated food products (plants, meat, and dairy products). Plants grown in the area where the emission plume passed could become contaminated by deposition of radionuclides on the leaves or ground surfaces. Radionuclides deposited on leaves could subsequently translocate to the edible portions of the plants, and those deposited on ground surfaces could subsequently be absorbed by plant roots. Livestock and their products could become contaminated if the livestock ate the contaminated surface soil and plants.

The waterborne pathways included ingestion of surface water and groundwater; ingestion of contaminated plant foods, meat, and dairy products; and potential radon exposure from using contaminated water. Plant foods and fodder could be contaminated from irrigation with contaminated water, and the livestock and their products could become contaminated if the livestock were fed with contaminated water and ate contaminated fodder. Potential indoor radon exposures would be possible if contaminated water was used indoors and radon gas emanated from the water. Because of the large dilution capability of surface water at the representative sites, the estimated radionuclide concentrations in surface water were always very low, and potential radiation exposures from the food chain pathways associated with these low water concentrations would be negligible. Therefore, radiation exposures resulting from contaminated surface water were assessed only for the drinking water pathway. The dilution capability would be smaller for groundwater, resulting in higher groundwater concentrations. Therefore, if the groundwater would be contaminated, radiation exposures from the food chain pathways, radon pathway, and drinking water pathway were all estimated.

C.4.1.4 Sources of Data and Application of Software

The external exposures incurred by the involved workers were estimated on the basis of information on worker activities, radiation sources, and exposure distances provided in the radiation exposure and manpower distribution estimating data in the engineering analysis report (LLNL 1997), with the use of the MicroShield (Negin and Worku 1992) computer code. MicroShield is a commercial software program designed to estimate external radiation doses from a variety of sources; it is widely used for such applications. It was used to calculate the external radiation dose rate associated with each worker activity, which was then used to calculate collective worker exposures. After collective worker exposures were determined, the average worker dose was calculated by dividing the collective dose by the number of involved workers. At this preliminary stage of engineering design, the information on radiation sources, worker activities, and number of required workers is subject to a large degree of uncertainty, as are the calculated collective and average worker doses. Therefore, the calculation results presented should be used only for comparative purposes among different technologies and options. In reality, the radiation dose to the individual worker would be monitored and maintained below the DOE administrative control limit of 2,000 mrem/yr (DOE 1992b), which is below the regulatory dose limit of 5,000 mrem/yr (10 CFR Part 835).

Radiological impacts from airborne pathways were estimated with the emission data provided in the engineering analysis report (LLNL 1997), with the use of the GENII (Napier et al. 1988) computer code, which was also used in several previous environmental impact statement projects, such as the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS; DOE 1997), for the same application. The GENII computer code uses the site-specific or representative meteorological data (joint frequency data) selected for each option to estimate the air concentrations at downwind locations. It then calculates the biota concentrations by using biotransfer models and estimates the radiation doses with a built-in dosimetry model.

The MEI for the noninvolved workers was assumed to be within the site boundary at a location that would have the maximum air concentration and would yield the largest radiation dose. For the general public, the location of the MEI was assumed to be either at the site boundary or at an off-site location that would have the largest air concentration. The site boundary was determined with actual site information (for the three current storage sites) or with the information on facility dimensions provided in the engineering analysis report (LLNL 1997). If the facility was assumed to be at one of the three representative sites, the collective dose for the noninvolved workers was estimated with information on sitewide worker distribution. If no exact location was determined for the facility, the noninvolved workers in the facility were assumed to be evenly distributed between 100 to 200 m from the emission point. Population distributions within 50 miles (80 km) around the three representative sites were obtained from census data and were used to estimate the collective dose to the off-site public. For facilities without specific locations, a representative population density of 6 persons/km^2 was used for a rural environment and 275 persons/km^2 was used for an urban environment. These would result in a total population of approximately 120,000 and 5,600,000 within a radius of 50 miles (80 km) for a rural and urban environment, respectively.

Surface water and groundwater concentrations were obtained through water quality analyses. Biota concentrations (plant foods, meat, and milk) and indoor radon concentrations from using contaminated groundwater were estimated with the RESRAD code (Yu et al. 1993). The RESRAD code contains biotransfer models comparable with those in GENII to estimate biota concentrations but also has the capability to predict indoor radon concentrations and the associated radiation doses.

C.4.1.5 Exposure Parameters and Dose Conversion Factors

Inhalation rates for workers were assumed to be 1.2 m^3/h (ICRP 1994), with an exposure duration of 8 hours per day for 250 days per year. Incidental ingestion of particulates was assumed to be 50 mg/d for the workers. The inhalation rate for the general public was assumed to be 20 m^3/d, with an exposure duration of 24 hours per day for 365 days per year. The ingestion rates for drinking water and soil for the general public were assumed to be 2 L/d for water, 100 mg/d of soil for adults, and 200 mg/d of soil for children. No building shielding effect was considered for inhalation and

external radiation exposures. Therefore, radiation doses estimated in this way would be greater than the actual doses, which would always be associated with some shielding from buildings.

Site-specific agriculture data (yield per unit area) for food crops and fodder were used for the three cylinder storage sites (Oak Ridge National Laboratory 1995). When the location of the facility was not specified, the default agriculture data in the GENII and RESRAD computer codes were used. Default food consumption data from the two codes were also used, which were close to each other and would both result in conservative estimates of the ingestion doses. Nevertheless, in all the options examined, radiation doses from the food ingestion pathways constituted just a small fraction of the total dose, which is dominated (>95%) by doses from inhalation (for airborne pathways) or ingestion of drinking water (for waterborne pathways).

The GENII computer code incorporates an internal dosimetry model to estimate the committed effective doses from internal radiation, whereas the RESRAD code uses the EPA internal dose conversion factors (EPA 1988) to estimate internal doses. Previous benchmarking studies (Faillace et al. 1994) showed that the two methods resulted in approximately the same radiation doses under the same exposure conditions. The inhalation doses depend strongly on the solubilities of the inhaled chemicals. With high solubility, a chemical would be excreted from the human body within a shorter period of time and would result in less internal exposure. Except for UO_2F_2 and UF_4, which were assumed to be excreted from the human body within a few days and a few weeks, respectively (due to the high and moderate solubilities in water), all other uranium chemicals considered in this PEIS were assumed to remain in the human body for years, thus resulting in greater radiation exposures. The ingestion doses were estimated by assuming that the uranium compounds would be absorbed by the gastrointestinal tract to the largest extent possible for uranium compounds; this would result in the maximum internal exposure.

C.4.2 Accident Conditions

For the assessment of radiological impacts under accident conditions, an accident was defined as a series of unexpected or undesirable events leading to a release of radioactive or hazardous material within a facility or the general environment. Accident source terms were defined as the amounts of radioactive or hazardous materials released to the atmosphere from the primary container or confinement in dispersible forms. Accident scenarios, source terms, and frequencies for most component activities of the alternative management strategies are provided in the engineering analysis report (LLNL 1997). For continued cylinder storage at the current sites and long-term storage as UF_6 in yards, the accident information was obtained from the safety analysis reports for the three storage yards (Lockheed Martin Energy Systems, Inc. [LMES] 1997 a-c). The health impacts from depleted uranium compounds would be expected to be dominated by their chemical toxicity and not by their radiological effects. A lethal exposure from the chemical toxicity of uranium would occur with an internal radiation dose of about 1 rem, which is a dose not considered to have any significant radiation health effects.

C.4.2.1 Receptors

Radiation doses and health risk effects were calculated for noninvolved workers and the general public. Population doses were calculated up to a distance of 50 miles (80 km) from the release point. Except under the continued cylinder storage and cylinder preparation options, where actual locations of storage yards were used, all accidental releases were assumed to be at the centers of the representative or generic sites. Ten downwind distances and 16 wind directions were applied. Radiation doses were calculated for the following receptors for accident conditions:

- ***Noninvolved MEI Worker:*** A worker located on-site at the point of maximum air concentration for uranium compounds (but more than 330 ft [100 m] from the accident location).

- ***Noninvolved Worker Population:*** All workers on the site located more than 330 ft (100 m) from the accident location (including those workers in the facility where the accident occurred).

- ***Off-Site MEI:*** A hypothetical member of the general public living off-site and receiving the maximum exposure from accidental releases.

- ***General Population:*** General population within a 50-mile (80-km) radius of the site where the accident might occur.

During an accident, involved workers might be subject to severe physical and thermal (fire) forces and could be exposed to releases of chemicals and radiation. The risk to the involved workers is very sensitive to the specific circumstances of each accident and would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. However, it is recognized that worker injuries and fatalities are possible from chemical, radiological, and physical forces if an accident did occur.

C.4.2.2 Radiological Doses and Health Risks

Radiological consequences were calculated in terms of total effective dose equivalent (TEDE) and LCF. The TEDE is the sum of the effective dose equivalent from external radiation and the 50-year committed effective dose equivalent from internal radiation. Radiation doses were expressed in units of rem for individuals and in units of person-rem for populations. The health risk conversion factors provided in ICRP Publication 60 (ICRP 1991) were used to calculate LCFs. These factors are 0.0004/rem for workers and 0.0005/rem for members of the general public. The conversion factor for the public is slightly higher than that for workers because some individuals in the public, such as infants, are more sensitive to radiation than the average worker. If these

conversion factors are applied to the individual dose, the result is the individual increased lifetime probability of developing an LCF. If these factors are applied to collective (population) dose, the result is the number of excess LCFs.

C.4.2.3 Methodology

Radiation doses from atmospheric releases were evaluated by using the GENII computer code (Napier et al. 1988) developed at Pacific Northwest Laboratory. The code implements the internal dosimetry models recommended by the ICRP in Publication 26 (ICRP 1977) and Publication 30 (ICRP 1979). The GENII code considers the transport of radioactive material in air, soil, water, and food sources to the human body. To achieve consistency in the impact analysis among chemical and radiological releases, air concentrations per unit release were derived by using the HGSYSTEM (Post 1994a-b; Hanna et al. 1994) and FIREPLUME (Brown et al. 1997) models and used as input to GENII. The GENII code was used to develop baseline radiation doses from unit releases (release-to-dose conversion factors) to the various receptors. Accident consequences were then calculated by multiplying the dose conversion factors with the actual source terms for each accident.

Accident frequencies are categorized into four groups:

- I — Likely (L): Accidents estimated to occur one or more times in 100 years of facility operations (frequency $\geq 1 \times 10^{-2}$/yr).
- II — Unlikely (U): Accidents estimated to occur between once in 100 years and once in 10,000 years of facility operations (frequency = from 1×10^{-2}/yr to 1×10^{-4}/yr).
- III — Extremely Unlikely (EU): Accidents estimated to occur between once in 10,000 years and once in 1 million years of facility operations (frequency = from 1×10^{-4}/yr to 1×10^{-6}/yr).
- IV — Incredible (I): Accidents estimated to occur less than one time in 1 million years of facility operations (frequency $< 1 \times 10^{-6}$/yr).

The results of the accident impacts were summarized on the basis of these frequency categories. One accident was selected in each category. The chosen accident was the one that would result in the highest dose to the general public MEI; that accident was then the bounding accident (most conservative) in that frequency category. The probability of occurrence for an accident is indicated by its frequency category. For example, an accident that belongs to the extremely unlikely category has a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. Therefore, the overall risk of an LCF to the receptors can be estimated by multiplying the LCF result by the probability of occurrence of the accident and by the number of years of operations.

C.4.2.4 Exposure Pathways

Atmospheric releases from accidents would result in radiation exposure to various receptors through the following pathways: (1) external exposure from immersion in the plume containing the airborne radioactive material (air submersion), a pathway considered in the dose calculations for all receptors; (2) external exposure from radioactive material deposited on the ground (ground irradiation or groundshine), a pathway included in the dose calculations for the off-site MEI and general population; (3) internal exposure from inhalation of radioactive airborne material in the plume (inhalation), a pathway considered in the dose calculations for all receptors; (4) internal exposure from inhalation of radioactive airborne material suspended in air due to wind action (inhalation), a pathway included in the dose calculations for the off-site MEI and general population; and (5) internal exposure from the ingestion of food crops and animal products (ingestion), a pathway included in the dose calculations for the off-site MEI and general population. The plume inhalation pathway was found to dominate other pathways, accounting for more than 99% of the dose.

C.4.2.5 Data Requirements

A variety of data were used in GENII for dose calculations. Unless different values were provided, the values used in the PEIS are listed in Table C.1.

C.5 CHEMICAL SOURCES AND EXPOSURES

The approach taken for addressing nonradiological human health and safety impacts is outlined below. The assessment included risk during normal facility operations, risk from accidental chemical releases, and risk of physical injury (industrial risk).

C.5.1 Normal Operations

This section describes the methodologies used for assessing chemical impacts on human health from normal operations of different facilities. Chemical impacts were assessed for different categories of options, which correspond to the different technologies developed in the engineering analysis report (LLNL 1997), as well as to continued cylinder storage.

C.5.1.1 Receptors

The assessment of health risks associated with chemical sources and exposures was consistent with the assessment of radiological risks, insofar as possible. The receptors evaluated included MEIs for noninvolved workers (i.e., those not involved in handling hazardous chemicals) and the general public. Because the standard methodologies for chemical health risk assessment do

TABLE C.1 Parameters and Values Used for Dose Calculations with the GENII Code

Parameter	Values Used in GENII Code
Inhalation	Chronic breathing rate = 1.2 m^3/h Acute breathing rate = 1.5 m^3/h Plume exposure time = 100% of plume duration Internal exposure period for dose calculation = 50 years
Air submersion	Immersion duration = 100% of plume duration
Ground irradiation	Exposure to contaminated soil = 1 year Building shielding factor = 0.3, which represents exposure of an individual to contaminated soil 8 hours per day or 2,920 hours per year
Ingestion	Ingestion takes place over a period of 1 year Internal exposure period for dose calculation = 50 years Ingestion of contaminated food = 100% of total consumption rates for the MEI and 10% of total consumption rates (30% for milk) for the general population Annual dietary consumption rates (kg/yr): Leafy vegetables = 18.3; Beef = 84.7 Root vegetables = 73.4; Poultry = 9.5 Fruits = 68.3; Milk = 111.7 Grain = 35.4; Egg = 15.0
Meteorology	For 95% meteorological conditions, Pasquill Class F, with a wind speed of 1 m/s in all directions For 50% meteorological conditions, Pasquill Class D, with a wind speed of 4 m/s in all directions
Other default data	Plume mixing layer height = 1,000 m Infinite plume and far-field release conditions Wet deposition = 0 Deposition velocity = 0.001 m/s for particulates, 0.01 m/s for iodines, and 0 for noble gases Soil density = 1.5 g/cm^3 Depth of surface soil available for resuspension = 10 cm Soil resuspension calculated in the code using the Anspaugh model Leaf resuspension factor = 1.0×10^{-9}/m
Site-specific data	Population distribution at each site Location of MEI at each site Meteorological data at each site Description of accident scenarios Release elevation (m) (ground release vs. stack release) for each accident Frequency of each accident

not usually involve assessment of collective (population) dose or risk, population risk was not generally evaluated for chemical exposures. However, if a health risk was shown to exist for the MEI in any of the receptor groups assessed, additional assessment of the likely number of individuals affected was evaluated.

Because of the conceptual nature of the facility designs, individual worker activities were highly uncertain, and process-specific chemical concentrations could not be accurately estimated. As a result, potential impacts to the involved worker MEI were not quantified for normal operations at the different facilities. However, potential exposures of involved workers to chemicals generated during the various processes would be addressed by proposed U.S. Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) for soluble uranium compounds and for HF (29 CFR Part 1910, Subpart Z, as of March 1998). To maintain compliance with OSHA standards, it is likely that chemical exposures would be minimized by various engineering mitigative controls (e.g., fume hoods and glove boxes and heating, ventilating, and air conditioning [HVAC] designs for high hazard areas) and extensive indoor air monitoring.

C.5.1.2 Chemical Doses and Associated Health Effects

For normal operations, risks were expressed by using the hazard quotient concept for exposures to noncarcinogens (i.e., comparison of estimated receptor doses with reference levels or doses below which adverse effects would be very unlikely to occur). In general, the chemicals of concern for this PEIS were uranium and fluoride compounds, especially HF gas. These substances would not be chemical carcinogens, so cancer risk calculations were not applicable. The toxicity of the exposures for relevant receptors was estimated through comparison with oral and inhalation reference levels (levels below which adverse effects would be very unlikely to occur). The oral reference dose of 0.003 mg/kg-d was used for evaluating risks from ingestion of soluble uranium compounds; EPA derived this value based on a lowest-observed-adverse-effect level in rabbits of 3 mg/kg-d of uranyl nitrate hexahydrate combined with an uncertainty factor of 1,000 (Maynard and Hodge 1949; EPA 1998a). Because of conflicting results concerning absorption of insoluble uranium compounds such as U_3O_8 and UO_2 from the gastrointestinal tract, the oral reference dose of 0.003 mg/kg-d was also used in this analysis for calculating hazard quotients for these compounds. This assumption is conservative because the gastrointestinal tract would absorb a smaller amount of insoluble than soluble uranium compounds.

Inhalation reference concentrations for uranium compounds and hydrogen fluoride are not currently available from standard EPA sources. To assess potential risks from inhalation of these compounds, interim reference levels were developed from proposed OSHA PELs (29 CFR Part 1910, Subpart Z, as of March 1998). The 8-hour time-weighted-average PEL for soluble and insoluble uranium compounds is 0.05 mg/m^3; for HF it is 2.5 mg/m^3. These values were converted to assumed inhalation reference level values for noninvolved workers in mg/kg-d by assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg, resulting in interim worker inhalation reference level values of 0.014 and 0.71 mg/kg-d for uranium compounds and hydrogen fluoride,

respectively. To generate interim inhalation reference levels values for the general public, these worker values were adjusted to account for increased exposure duration of the general public (assumed 168 hours per week instead of 40 hours per week); an additional uncertainty factor of 10 was used to account for sensitive subpopulations in the general public. This results in interim inhalation reference levels for the general public of 0.0003 and 0.02 mg/kg-d for uranium compounds and hydrogen fluoride, respectively.

The reference levels used for preliminary evaluation of general public hazard quotients and carcinogenic risks from the existing environment at the three current storage sites (see Sections 3.1.7.2, 3.2.7.2 and 3.3.7.2) were obtained from the EPA's Integrated Risk Information System (IRIS) when available (EPA 1998a). The slope factor value used for trichloroethylene was obtained from the EPA's National Center for Environmental Assessment (Choudhury 1996). The derived reference concentration levels for uranium compounds and HF discussed above were used as reference levels for evaluating inhalation of these substances.

C.5.1.3 Exposure Pathways and Parameters

For the noninvolved worker MEI, chemical intakes and health risks from inhalation of uranium compounds and HF were assessed, provided that there were airborne emissions from the facility being evaluated. Incidental ingestion of uranium compounds deposited on soil was also assessed. For the general population MEI, intake of uranium compounds and HF was summed over all appropriate potential air-associated pathways (i.e., inhalation and incidental ingestion of contaminants deposited on soil). Soil-related pathways other than incidental ingestion would have been evaluated only if the predicted soil concentrations were high enough to indicate that intakes via the food chain would be significant. Data for uranium compounds generated for the radiological impact analyses by the GENII computer code were used to derive appropriate uranium concentration levels for the various environmental media. Air dispersion modeling for HF, as discussed in Section C.1, was used to obtain the air concentration of HF at the MEI location. Additional exposures for the MEI would include ingestion of contaminated water, for which uranium concentrations were provided through modeling of contaminant transport from effluent sources into surface waters and/or groundwater. Pathways involving the ingestion of plant foods, meat, and dairy products contaminated through the use of groundwater for irrigation were included when failure of engineering barriers and containers could result in the eventual leaching of uranium to groundwater.

Appropriate exposure factors for the various pathways evaluated can generally be obtained from EPA guidance documents. Generally, the worker MEI was assumed to be exposed for 8 hours per day, 250 days per year, for a period of 25 years. The MEI for the general public was assumed to be exposed for 24 hours per day, 365 days per year, for a period of 30 years. These exposure factors were modified as appropriate for various options and predicted exposure circumstances.

C.5.1.4 Exposure Modeling and Risk Evaluation

Media-specific concentrations of contaminants associated with the normal operation of facilities for the various options were modeled on the basis of effluent data provided in the engineering analysis report (LLNL 1997). For airborne pathways, these effluent amounts were modeled by using either the GENII computer code (see Section C.4.1.4) or the ISCST computer code (see Section C.1). Surface water and groundwater concentrations were obtained through water quality analyses (see Section C.2).

Modeled concentrations of contaminants in the various environmental media were used to estimate average daily intakes for the various receptors examined. The ratios of the daily intakes to appropriate reference dose levels were calculated to generate hazard quotients. Hazard quotients were summed for individual contaminants and across all appropriate exposure routes (e.g., inhalation, soil ingestion) to generate hazard indices for the noninvolved worker and general public MEIs for the various options. These hazard indices were compared with the reference hazard index of 1. A hazard index of less than 1 is interpreted to indicate that adverse noncancer effects are very unlikely; a hazard index of greater than 1 would indicate that adverse effects are possible for the MEI, and that further investigation of potential exposures and additivity of individual contaminant toxicity would be warranted.

When no adverse effects would be expected for the MEI of a given population (i.e., the hazard index is less than 1), then by definition no adverse effects would be expected in that population. Therefore, calculation of population risks is not applicable when MEI hazard indexes are less than 1.

C.5.2 Accident Conditions

C.5.2.1 Health Criteria

For the assessment of the impact of source terms from accidental releases in this PEIS, two primary potential health effects endpoints were evaluated: adverse effects and irreversible adverse effects. Evaluation of these two health endpoints was consistent with the accident evaluations typically conducted to assess industrial risks (American Industrial Hygiene Association [AIHA] 1996) and with the approach taken in the safety analysis reports (LMES 1997a-c) for the three sites. The selection of appropriate health criteria (e.g., intake levels or air concentrations) to represent these health effect endpoints for uranium compounds and for other chemicals of potential concern is discussed in the following subsections. It should be noted that human responses do not occur at precise exposure levels but can extend over a wide range of concentrations. The values used as guidelines for potential adverse effects and potential irreversible adverse effects in this PEIS should not be expected to protect everyone but should be applicable to most individuals in the general population. In all populations, there are hypersensitive individuals who will show adverse responses

at exposure concentrations far below levels at which most individuals would normally respond (AIHA 1996). Alternatively, some individuals will show no adverse response even at exposure concentrations somewhat higher than the guideline levels.

On the basis of health criteria levels discussed below, the models described in Section C.5.2.2 were used to generate contours for the appropriate air concentration levels. The number of workers or the number of people from the general population projected to be inside each contour were the number of individuals tabulated as at risk for the health effect endpoint (e.g., potential irreversible adverse effects).

In addition to potential adverse effects and irreversible adverse effects, the number of fatalities from accidental chemical exposures was estimated to facilitate comparisons with radiological impacts. For exposures to uranium and HF, it was estimated that the number of fatalities occurring would be about 1% of the number of irreversible adverse effects (EPA 1993a; Policastro et al. 1997). Similarly, for exposure to ammonia, the number of fatalities was estimated to be about 2% of the number of irreversible adverse effects (Policastro et al. 1997).

C.5.2.1.1 Potential Irreversible Adverse Effects

Uranium. An intake of 30 mg of uranium was used as the health criterion for potential irreversible adverse effects for exposure to all forms of uranium evaluated in the PEIS. The background document for the U.S. Nuclear Regulatory Commission (NRC) regulations for the Certification of Gaseous Diffusion Plants (10 CFR 76) states that "in assessing the adequacy of protection of the public health and safety from potential accidents, the NRC will consider whether the potential consequences of a reasonable spectrum of postulated accident scenarios exceed 0.25 Sv (25 rem), or uranium intakes of 30 mg, taking into account the uncertainties associated with modeling and estimating such consequences" (NRC 1994). According to these regulations, the selection of the 30 mg uranium intake level as an evaluation guideline level for irreversible injury was based on information provided in Fisher et al. (1994). This intake level was also used as the evaluation guideline for the off-site public and for noninvolved workers in accident analysis for evaluation basis events (annual frequency between 0.01 and 10^{-6}) conducted for the safety analysis reports for the three sites (LMES 1997a-c).

In applying the 30 mg uranium intake to accident analysis for the many uranium compounds considered in this PEIS (i.e., UO_2F_2, UF_4, uranium metal, U_3O_8, and UO_2), the following parameters were accounted for: molecular weight, solubility, inhalation rate, and duration of predicted exposure. On the basis of an inhalation rate of 1.5 m^3/h as the ventilation rate during light exercise (ICRP 1994), and on appropriate adjustments to account for the percent uranium in each compound, air concentrations corresponding to an intake level of 30 mg were calculated for modeled

exposure durations. For example, the air concentration of 26 mg/m^3 UO_2F_2 corresponding to a 30 mg uranium intake for a 60-minute exposure to UO_2F_2 would be calculated as follows:

$$\frac{\text{30 mg uranium} \times \text{308/238 (molecular weight } UO_2F_2\text{/molecular weight uranium)}}{\text{1.5 m}^3\text{/h} \times \text{modeled exposure duration (h)}}$$

Additionally, for the insoluble uranium compounds, an uptake factor was incorporated into the calculated air concentrations, based on ICRP guidance that 0.2% absorption be assumed for inhalation of less soluble uranium compounds that have biological half-lives of years (i.e., U_3O_8 and UO_2), as compared with 5% absorption for soluble and slightly soluble compounds such as UO_2F_2 and UF_4 (ICRP 1979).

Other Chemicals. Potential irreversible adverse effects were also assessed for exposure to other chemicals of concern with respect to accidental releases; these chemicals were HF, hydrochloric acid, ammonia, sulfuric acid, and nitric acid. Several of these substances would be used and/or transported only in dilute forms that would not result in potential for irreversible adverse effects if accidentally released (i.e., hydrochloric acid, sulfuric acid, and nitric acid). For HF and ammonia, levels corresponding to irreversible adverse effects for exposures of 1-hour duration were set at corresponding Emergency Response Planning Guideline 2 (ERPG-2) levels. The ERPG levels are developed for a variety of chemicals by the AIHA; ERPG-2 levels are defined as "the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action" (AIHA 1996). The ERPG-2 values are 20 parts per million (ppm) for HF and 200 ppm for ammonia; these values were used in the PEIS as evaluation guideline levels for potential for irreversible adverse effects for modeled exposure durations of 60 minutes.

The guideline exposure level of 20 ppm used to estimate irreversible adverse effects from HF exposure is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm (AIHA 1988), and generally, if death does not occur quickly after HF exposure, recovery is complete (McGuire 1991).

The chemicals evaluated exhibit irritant characteristics; the toxicity of these substances is generally not linearly proportional to the intake amount. For example, the toxic effect of exposure to 32 mg/m^3 HF for 30 minutes would actually be greater than the toxic effect of exposure to 16 mg/m^3 HF for 60 minutes, because the irritant action of the HF is greater at higher air concentrations. Data on the appropriate adjustments of HF concentrations for evaluation of shorter exposure times are presented and discussed in various documents dealing with the toxicity of uranium hexafluoride (Fisher et al. 1994; McGuire 1991). On the basis of these data, for modeled exposure

durations of between 5 and 60 minutes, the air concentrations of HF and ammonia corresponding to the ERPG-2 value were calculated from:

$$C = C_{ERPG\text{-}2}(60/t)^{0.5}$$

where:

C = adjusted exposure guideline value and

t = modeled exposure duration (min).

It was conservatively assumed that the 5-minute adjusted exposure guideline value would be applied even for modeled exposure durations of less than 5 minutes.

C.5.2.1.2 Potential Adverse Effects

Uranium. An intake of 10 mg of uranium was used as the health criterion for potential adverse effects for exposure to all forms of uranium evaluated in the PEIS. This value was based on conclusions stated in NUREG-1391 (McGuire 1991) that "an intake level of soluble uranium with no significant detectable health effects, transient or permanent, appears to be about 10 mg in round numbers." This level was also used as the evaluation guideline for the off-site public and noninvolved workers for accident analysis of anticipated events (annual frequency between 0.1 and 0.01) conducted for the safety analysis reports for the three sites (LMES 1997a-c).

Adjustment of the 10-mg intake level for the various uranium compounds and modeled exposure durations was conducted in the same manner as for evaluation of irreversible adverse effects (see Section C.5.2.1.1).

Other Chemicals. Potential adverse effects were assessed for exposure to HF and ammonia by using ERPG-1 levels. ERPG-1 levels are defined as "the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing any but mild transient adverse health effects or perceiving a clearly defined objectionable odor" (AIHA 1996). The ERPG-1 value is 1.6 mg/m^3 for HF and 25 ppm for ammonia; these values were used in the PEIS as evaluation guideline levels for potential adverse effects for modeled exposure durations of 60 minutes. Scaling of these values for modeled exposure durations of less than 60 minutes was conducted in the same manner as for evaluation of irreversible adverse effects (see Section C.5.2.1.1). As for irreversible adverse effects, it was conservatively assumed that the 5-minute adjusted exposure guideline value would be applied even for modeled exposure durations of less than 5 minutes.

C.5.2.2 Methods and Models

Accident scenarios, source terms, and frequencies for most component activities of the alternative management strategies were provided in the engineering analysis report (LLNL 1997). For continued cylinder storage at the current sites and long-term storage as UF_6 in yards, this accident information was obtained from the safety analysis reports for the three storage yards (LMES 1997a-c). For options considered under each activity, the reference document(s) provided the hypothetical accident, as well as the release amount as a function of time and duration of release and any special characteristics of the accidents. Accidents may be due to natural phenomena (earthquakes, tornadoes, etc.) or due to process accidents or temporary storage facility accidents at the various facilities. The chemical accidents often include fires and involve such chemicals as depleted UF_6 (liquid or solid form), and its degradation products UO_2F_2 and HF, uranium oxides, or the metallic form of uranium. The chemicals identified for accident scenarios depend upon the specific options chosen (e.g., conversion, disposal).

Although all accident scenarios presented in the engineering analysis report for the various options were evaluated and consequences and impacts predicted, only those scenarios necessary to fully represent the range of potential consequences were quantitatively assessed in the PEIS. The following models were used to estimate downwind dispersion through air of releases of chemicals:

- HGSYSTEM (Post 1994a-b) for HF releases and releases of uranium compounds,
- HGSYSTEM/UF_6 model (Hanna et al. 1994) for UF_6 vapor releases, and
- FIREPLUME model (Brown et al. 1997) for releases from toxic fires of UF_6 and other chemicals.

Detailed descriptions of these models are provided in Policastro et al. (1997). Except for the tornado accident scenario, two meteorological conditions were assumed: D stability with 4 m/s wind speed and F stability with 1 m/s wind speed. Both sets of assumptions were evaluated, and the results are presented in this PEIS.

C.5.2.3 Receptors

For each accident, the impacts on noninvolved workers and the general population were estimated. No quantitative predictions of impacts were made for involved workers (see Section C.4.2.1).

Noninvolved workers were considered to be at risk for a given health endpoint if they were located within the plume contour (based on ERPG level or uranium intake level) for the wind direction that would lead to the largest worker count. Workers were assumed to be in the locations

where they work and for conservatism, the protection provided by the building structure was not included. This computation involved the overlay of the plume contour from the source point and the rotation of the plume 30 to 100 times to identify the direction with the highest worker count. That count was reported in the impact evaluation.

Individuals in the general population were also considered to be at risk if they were located within the plume contour. For the wind direction that would lead to the largest general population count, a separate overlay was done for the predicted plume to determine maximum population affected for the human health endpoint for that accident. As usually was the case, the direction leading to the maximum worker count did not necessarily match the direction for the maximum general population count. The adverse effects and irreversible adverse effects contours were predicted for each accident, with the adverse effects contour the larger of the two. For UF_6 releases, both the UO_2F_2 contour and the HF contour were predicted for both adverse effects and irreversible adverse effects levels; in general, the HF contours were larger than the uranium contours and led to larger population risks.

The MEI worker was assumed to be located 100 m from the accident location. The MEI for the general population was assumed to be located at the nearest fence line position, although there are currently no residences at these locations at the three current storage sites. Impacts for MEIs are presented as "yes" or "no," depending upon whether the air concentrations of chemicals greater than or equal to corresponding adverse effects and irreversible adverse effects were modeled at the MEI locations.

C.5.2.4 Data Requirements

General data used in the accident predictions included the following:

- Estimate of the frequency of the accident per year,
- Release amounts (time history) and quantities for each chemical released,
- Number of workers on site and population off-site by direction, and
- Relative locations of source and receptors for both workers and members of the general public.

In the fire accident scenarios, the release quantities were presented as a function of time for the three phases of the release: puff, fire release, and cooldown. Fire and vapor temperatures were available as well for predictions.

C.5.3 Physical Hazards

The expected number of worker fatalities and injuries associated with each option was calculated based on statistics available from the Bureau of Labor Statistics, as reported by the National Safety Council (1995), and on estimates of total worker hours required for construction and operational activities for each option, as given in the engineering analysis report (LLNL 1997).

Construction and manufacturing annual fatality and injury rates were used for the construction and operational phases of each option. For injuries, rates for 1993 were used because 1994 rates were not yet available; for fatalities, estimated rates for 1994 were used. The use of data from two years should not result in incompatible data, since fatality rates in the applicable industry divisions were identical for 1993 and 1994. Injury incidence rates used were for injuries involving lost workdays (not including the day of injury).

The specific rates used in calculations for each option were as follows: fatalities during construction, 15 per 100,000 workers; fatalities during operations, 4 per 100,000 workers; injuries during construction, 5.5 per 100 full-time workers; injuries during operations, 5.3 per 100 full-time workers.

Fatality and injury risks were calculated as the product of the appropriate incidence rate (given above), the number of years for construction and operations, and the number of full-time equivalent employees for construction and operations for each option. The employment data reported in the engineering analysis report (LLNL 1997) were used to calculate option-specific risks. For construction, the data were generally reported in the engineering analysis report as peak and average employment for each year of construction (construction periods ranged from 4 to 20 years); the average number of employees for the peak construction year was used in risk calculations. For the operations phase, the fatality and injury rates were computed for all facility employees for each option (no distinction was made between involved and noninvolved workers). The available fatality and injury statistics by industry are not refined enough to warrant analysis of involved and noninvolved workers as separate classes.

The calculation of risks of fatality and injury from industrial accidents was based solely on historical industrywide statistics and therefore did not consider a threshold (i.e., any activity would result in some estimated risk of fatality and injury). Whatever alternative was implemented would be accompanied by best management practices, thereby reducing fatality and injury incidence rates.

C.6 SOCIOECONOMICS

C.6.1 Scope of the Analysis

Analysis of the socioeconomic impacts of the depleted UF_6 management options included assessment of the construction and operations impacts of continued storage, cylinder preparation, conversion, manufacture and use, long-term storage, and disposal. For continued storage and cylinder preparation, site-specific impacts were estimated by using the regions of influence (ROIs) surrounding the Paducah, Portsmouth, and K-25 sites. For conversion and long-term storage options (except long-term storage in mines), the ROIs surrounding the three current storage sites were also used as representative of locations where these types of facilities might be located in the future. For site-specific and representative site impacts, the analysis estimated the impacts of each option on (1) regional economic activity, including direct (on-site) and indirect (off-site) employment and income, (2) population in-migration, (3) local housing markets, and (4) local jurisdictional revenues and expenditures. The analyses for the manufacture and use, long-term storage in mines, and disposal options assumed generic, nonspecific sites for the required activities, although it was assumed that disposal would occur in a rural environment, whereas manufacture and use could occur in a range of population densities, from rural to urban. For the generic sites, the analysis was limited to estimating the impacts of each option on direct (on-site) employment and income. Additional details on the analysis of socioeconomic impacts is provided in Allison and Folga (1997).

Assessment of the socioeconomic impacts for transportation of depleted UF_6 was not included in the PEIS analysis. The transportation of depleted UF_6 would not be likely to lead to significant en route socioeconomic impacts because total expenditures for transportation related to depleted UF_6 would probably be small compared with expenditures related to total shipments of all other goods for any of the routes that might be used. The analysis might also have considered the socioeconomic impacts of potential accidents, particularly for depleted UF_6-related transportation activities. However, because it is unlikely that any potential accident would release large quantities of hazardous or radioactive material into the environment, accidents would be expected to create only minor local economic disruption, and substantial commitment of fiscal resources for accident remediation is unlikely to be necessary at any of the current storage sites or along transportation routes.

C.6.2 Technical Approach for the Analysis of Site-Specific and Representative Site Impacts

C.6.2.1 Regional Economic Impacts

The analysis of regional economic impacts used engineering cost data for facilities that would be constructed and operated for each option and input-output economic data for the ROI

surrounding each storage site. The ROI at each site was defined as the counties in which 90% of site employees currently reside (see Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8). Additional data taken from data files of the U.S. Bureau of the Census (1994) and from regional economic information system data files of the U.S. Bureau of Economic Analysis (BEA) (1996a-c) were also used to forecast economic data at each site to provide the basis for the presentation of relative impacts.

To perform the analysis, engineering cost data for the construction and operation of each facility were taken from the cost data obtained from LLNL (1996). This report specifies cost and schedule data for the appropriate work breakdown structure elements, including the cost of materials, direct labor (installation) costs, and indirect labor (contractor field costs, contractor overhead and profit, architecture and engineering, construction management, and program management) costs.

Direct (on-site) employment and income impacts were then calculated on the basis of average total labor costs (i.e., fully loaded labor costs, including site overhead, contractor profit, and employee benefits) in each category. Estimates of direct income impacts were calculated by adjusting average fully loaded labor costs to exclude the various components of site overhead, state and federal income taxes, and other payroll deductions. This process produces a measure of disposable wage and salary income that would likely be spent in the regional economy at each of the sites.

Indirect (off-site) impacts were based on detailed item-specific procurement data for material and adjusted direct and indirect labor costs. Cost information was associated with the relevant Standard Industrial Classification (SIC) codes and construction and operation schedule information to provide estimates of procurement and wage and salary expenditures for each sector in the local economy for the year in which expenditures would be made. Information on the expected pattern of local and nonlocal procurement for the various materials and labor expenditures by SIC code were then calculated on the basis of local shares of national employment in each material and labor procurement category and information provided for each site. Expenditures by SIC code by year occurring in the ROI at each site were then mapped into the BEA sectors used in an IMPLAN input-output model (Minnesota IMPLAN Group, Inc. 1994) specified for the ROI at each site (see Section C.6.2.2). Each model was used to produce employment and income multipliers for each sector where procurement and labor expenditures occur. Indirect impacts were then calculated by multiplying expenditures in each sector by the input-output multipliers produced by the model for the ROI at each site.

Site-specific and representative site impacts are presented in terms of (1) the direct, indirect, and total employment impacts of each option; (2) the direct and total income impacts of each option; and (3) the relative employment impact of each option, or the magnitude of the absolute impact compared to the growth in the local economic employment baseline. Construction impacts for each option are presented for the peak construction year. Operations impacts are generally presented as annual averages, except for continued cylinder storage, for which peak operation year values are presented.

C.6.2.2 Description of the Regional Economic Impact Assessment Model

The analysis used county-level IMPLAN input-output economic data (Minnesota IMPLAN Group, Inc. 1994) to measure the regional economic impacts for the three representative sites for applicable options. The IMPLAN input-output model is a microcomputer-based program that allows construction of input-output models for counties or combinations of counties for any location in the United States. Input-output data are the economic accounts of any given region and show the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region. The model contains 528 sectors, representing industries in agriculture, mining, construction, manufacturing, wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation; proprietary and property income; personal consumption expenditure; federal, state, and local expenditure; inventory and capital formation; and imports and exports. The model can be used to produce accurate estimates of the impact of changes in expenditures in specific local activities on employment and income in any given year. The analysis of regional economic impacts uses the model to calculate multipliers for each sector in the ROI at each site for which procurement and wage and salary expenditures would be likely to occur. These multipliers were calculated for the year 1993, the latest year available at the time the analysis was undertaken.

C.6.2.3 Impacts on Population

Construction and operation of continued storage, cylinder preparation, and long-term storage options would likely lead to population in-migration into the ROI surrounding each of the representative sites. In-migration would be both direct, related to new employment created on site, and indirect, related to changes in employment opportunities in the ROI as a whole. The number of direct employees in-migrating to each site was based on information on employment in existing DOE programs and on the level of contractor support at each site. Indirect in-migration that would occur for each ROI was calculated by using assumed in-migration rates at each site associated with changes in employment in the local industries most significantly affected indirectly by construction and operation expenditures for each option, with residual in-migration rates assumed for the remaining industries in the economy indirectly affected. Population impacts are presented in terms of (1) the absolute total (direct and indirect) in-migration impact of each option and (2) the relative population impact of each option, or the magnitude of the absolute impact compared to the growth in the local economic population baseline.

C.6.2.4 Impacts on Local Housing Markets

In-migration occurring with construction and operation at each facility has the potential to affect the local housing market in the ROI at the representative sites for each option. The analysis considered these impacts by estimating the increase in demand for housing units in each year of

construction and operation based on the number of in-migrating workers to the area surrounding each of the representative sites and average household size. The results were compared to forecasts for housing supply and demand and owner-occupied and rental vacancy rates, for each year during construction and operation, based on information provided by the U.S. Bureau of the Census (1994) and in regional economic forecasts (BEA 1996a-c).

C.6.2.5 Impacts on Local Jurisdictions

Construction and operation of each facility would likely lead to some in-migration into the area surrounding each site, which would translate into changes in demand for educational services provided by school districts and for public services (police, fire protection, health services, etc.) provided by cities and counties. To assess the impacts on local jurisdictions, in-migration estimates (see Section C.6.2.3) were used as the basis for estimating impacts of revenues and expenditures for the various counties, cities, and school districts in each ROI. Revenue and expenditure data were based on the annual comprehensive financial reports produced by individual jurisdictions surrounding each site and on information provided by the U.S. Bureau of the Census (1994). Impacts are presented in terms of percentage change in forecasted revenues and expenditures for counties, cities, and school districts in the peak year of construction and in the first year of operations for each facility.

C.6.3 Technical Approach for the Analysis of Generic Site Impacts

The analysis of the socioeconomic impacts of the long-term storage in mines, manufacture and use, and disposal options was limited to the calculation of direct (on-site) employment and income impacts. No indirect impacts were calculated because the sites for these facilities have not been determined. The calculation of direct impacts was based on similar engineering cost information provided by LLNL (1996, 1997) for each facility and used the same methods as described in Section 6.2.2. The impacts of long-term storage in mines, manufacture and use, and disposal are presented in terms of the absolute direct impacts of each option at the generic site. No relative impacts were calculated because the site for these options has not been determined. For the same reason, estimates of population in-migration, local housing market impacts, and impacts on local jurisdiction revenues and expenditures are not provided.

C.7 LAND USE

The assessment of potential land-use impacts for the continued storage, cylinder preparation, conversion, manufacturing and use, long-term storage, and disposal options was based on a determination of areal requirements and incompatibility. Where appropriate, the amount of land that would be required under each option was calculated as a percentage of existing or available land at the three representative sites. The potential for program options to result in land conversion,

land-use conflicts, or incompatibility with existing site planning documents or controls was explored. Conversion refers to the potential of an action to convert land from one type of use to another (e.g., from agricultural to commercial). The potential for program options to result in impacts to surrounding land use is discussed qualitatively and includes an examination of potential level-of-service traffic impacts. Levels of service are defined by the Transportation Research Board (1994) and describe service characteristics and thresholds of congestion for highways.

For purposes of analysis in this PEIS, general criteria for estimation of impacts were as follows: land-use requirement of less than 50 acres corresponds to negligible impacts, land-use requirement of between 50 and 200 acres corresponds to potential moderate impacts, and land-use requirement of greater than 200 acres corresponds to potential large impacts. The actual potential for land conversion in conflict with existing land-use plans and controls and/or traffic flow problems will be determined during the Phase II analyses and NEPA reviews. Potential impacts to prime farmland will also be assessed in the site-specific tier of NEPA documentation that will accompany facility site selection.

No land-use impacts beyond respective site boundaries would be expected from the off-site transport aspect of the various management options under consideration. Any commitment of land at existing facilities that would be necessary for the off-site transport of UF_6, oxide, or uranium by-products is expected to be so small that no impacts would result.

C.8 ENVIRONMENTAL JUSTICE

C.8.1 Background

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," was issued by President Clinton in February of 1994 and directs federal agencies to incorporate environmental justice into all agency missions (U.S. President 1994). Under Executive Order 12898, federal agencies are directed to identify and address, as appropriate, high and adverse human health or environmental effects caused by agency programs, policies, or actions that disproportionately impact minority or low-income populations. Environmental justice refers to the equal and fair application of all environmental laws, regulations, and policies to all races, cultures, and income levels. The goal of the Executive Order is to ensure that no federal agency program, policy, or action results in impacts that affect minority or low-income populations to a greater degree than would be expected for the general population.

Executive Order 12898 directed the Administrator of the U.S. Environmental Protection Agency to establish an interagency working group (called the Federal Working Group on Environmental Justice) to develop criteria for identifying disproportionately high and adverse human health or environmental effects and to assist every federal agency in developing an environmental justice strategy. The Working Group, in coordination with the Council on Environmental Quality, has issued

definitions to describe disproportionately high and adverse human health effects and disproportionately high and adverse environmental impacts as they apply to NEPA (Council on Environmental Quality 1997). DOE has also issued interim guidance for implementation of the Executive Order (DOE 1995e), and EPA has issued guidance for incorporating environmental justice concerns in EPA's NEPA activities (EPA 1998b).

C.8.2 Methodology

A determination of the potential for a given project or action to result in environmental justice impacts requires (1) an examination of the composition of the population residing within a defined zone of impact and (2) the existence of high and adverse human health effects or impacts resulting from the project or action under analysis. The potential for a given project or action to unfairly or "disproportionately" affect a particular segment of the affected population can only be determined after the minority and low-income populations that make up all or a portion of the affected population have been defined and identified. Once these populations have been defined and identified, high and adverse human health effects, if any, can be examined in the context of their likelihood to disproportionately affect minority or low-income populations.

The analysis of potential environmental justice impacts was limited to site-specific options because such an analysis requires an examination of the composition of a specific local population. Surrogate populations cannot be substituted for facilities that have not been specifically sited or located.

C.8.2.1 Definitions

The following definitions were used in the analysis of potential environmental justice impacts and were derived from the U.S. Census Bureau and the Working Group's definitions:

- ***Census Tract*** — An area usually containing between 2,500 and 8,000 persons that is used for organizing and monitoring census data. The spatial dimensions of census tracts vary widely, depending on population settlement density. Census tracts do not cross county borders.

- ***Disproportionately High and Adverse Environmental Impact*** — A deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an environmental hazard with a risk or rate of exposure for a low-income or minority population that exceeds the risk or rate of exposure for the general population.

- ***Disproportionately High and Adverse Human Health Effects*** — Any human health effect from exposure to environmental hazards that exceeds generally accepted levels of risk and affects low-income and minority populations at a rate that appreciably exceeds the rate for the general population. Adverse health effects were measured in risks and rates that could result in LCFs as well as nonfatal adverse impacts to human health.

- ***Low-Income Population*** — Persons of low-income status. Low-income status was based on U.S. Census Bureau data definitions of individuals living below the poverty line. The poverty line is defined by a statistical threshold that considers family size and income. For 1990, the poverty line threshold for a family unit consisting of four individuals was $12,674 (based on 1989 income). For purposes of this analysis, low-income population consists of any census tract located within a 50-mile (80-km) radius of a storage site that has a low-income population proportion greater than the respective state average.

- ***Minority Population*** — Persons classified by the U.S. Bureau of the Census as Negro/Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, or other nonwhite, based on self-classification by individuals according to the race with which they most closely identify. To avoid double-counting minority Hispanic persons (Hispanics can be of any race), only white Hispanics were included in the tabulation of minorities. Nonwhite Hispanics had already been counted under their respective minority classification (Black, American Indian, etc.). For purposes of this analysis, a minority population consists of any census tract located within a 50-mile (80-km) radius of a storage site that has a minority population proportion greater than the respective state average.

C.8.2.2 Identification and Illustration of Minority and Low-Income Populations

Demographic information obtained from the U.S. Bureau of the Census was used to profile the population residing within a 50-mile (80-km) radius of each current storage site. A 50-mile (80-km) radius was selected because it would capture virtually all of the human health risks and environmental impacts that could potentially occur. For each current storage site, a geographic information system based on 1990 Census Bureau *Tiger Line Files* and Summary Tape Files 1 and 3A was utilized to generate maps illustrating minority and low-income populations residing within the 50-mile (80-km) zone of impact surrounding each site (U.S. Bureau of the Census 1992a-c).

The unit of analysis was the census tract. For those census tracts only partially located inside a 50-mile (80-km) radius of a given site, an even population distribution was assumed, and the population was calculated as a proportion of the tract area physically located within the 50-mile (80-km) radius (i.e., if 50% of the census area was inside of the 50-mile (80-km) radius, then 50%

of its population was counted). The maps are presented as Figures C.1 through C.3 and depict the distribution of minority and low-income census tracts within a 50-mile (80-km) radius of each site. Information regarding the proportion of the total population residing within 50 miles (80 km) of each site that is minority or low-income accompanies each figure.

For each current storage site, the proportion thresholds for determining the low-income and/or minority status of a census tract were based on the proportion of low-income and minority populations residing within the state where the storage site was located. If the 50-mile (80-km) radius around a particular current storage site included a portion of another state or states, a weighted average based on all the affected state low-income and minority population proportions was assigned. Other reference threshold proportions were considered (i.e., national, multistate regional), but state population proportions were chosen because they tend to present a more accurate portrayal of the affected population.

C.8.2.3 Impact Approach

The analysis of potential environmental justice impacts resulting from continued storage and cylinder preparation was based on the conclusions drawn in the risk assessment of human health effects (radiological and chemical) and a review of environmental impacts presented in discussions of other technical areas such as air quality, water quality and soils, socioeconomics, and ecological resources. The analysis of health effects included an examination of risks to the off-site population associated with normal facility operations and accidents. On-site worker populations were not included in the analysis because minority population proportion information for each site was not available and low-income status for workers, regardless of site, could not be determined. If conclusions drawn in the health risk assessment indicated negligible or low risks to the general population residing within a 50-mile (80-km) radius of any of the three storage sites, then no particular subset of the general population, including minorities and low-income persons, was assumed to experience high and adverse health effects. Consequently, no disproportionate impacts (i.e., environmental justice impacts) would occur. Likewise, if the review of environmental impacts across the other technical areas indicated that impacts were negligible or low within a 50-mile (80-km) radius of a particular site, then no environmental justice impacts would result because the potential for high and adverse impacts to disproportionately affect minority or low-income populations would be essentially removed.

An assessment of human health risks for persons or population groups residing within 50 miles (80 km) of a storage site who rely on local plants or animals for a portion of their food supply was not included in this analysis. A comprehensive analysis that includes an evaluation of an affected population's dietary and consumption habits would be considered in the site-specific tier of NEPA documentation that would follow a Depleted Uranium Hexafluoride Management Program decision.

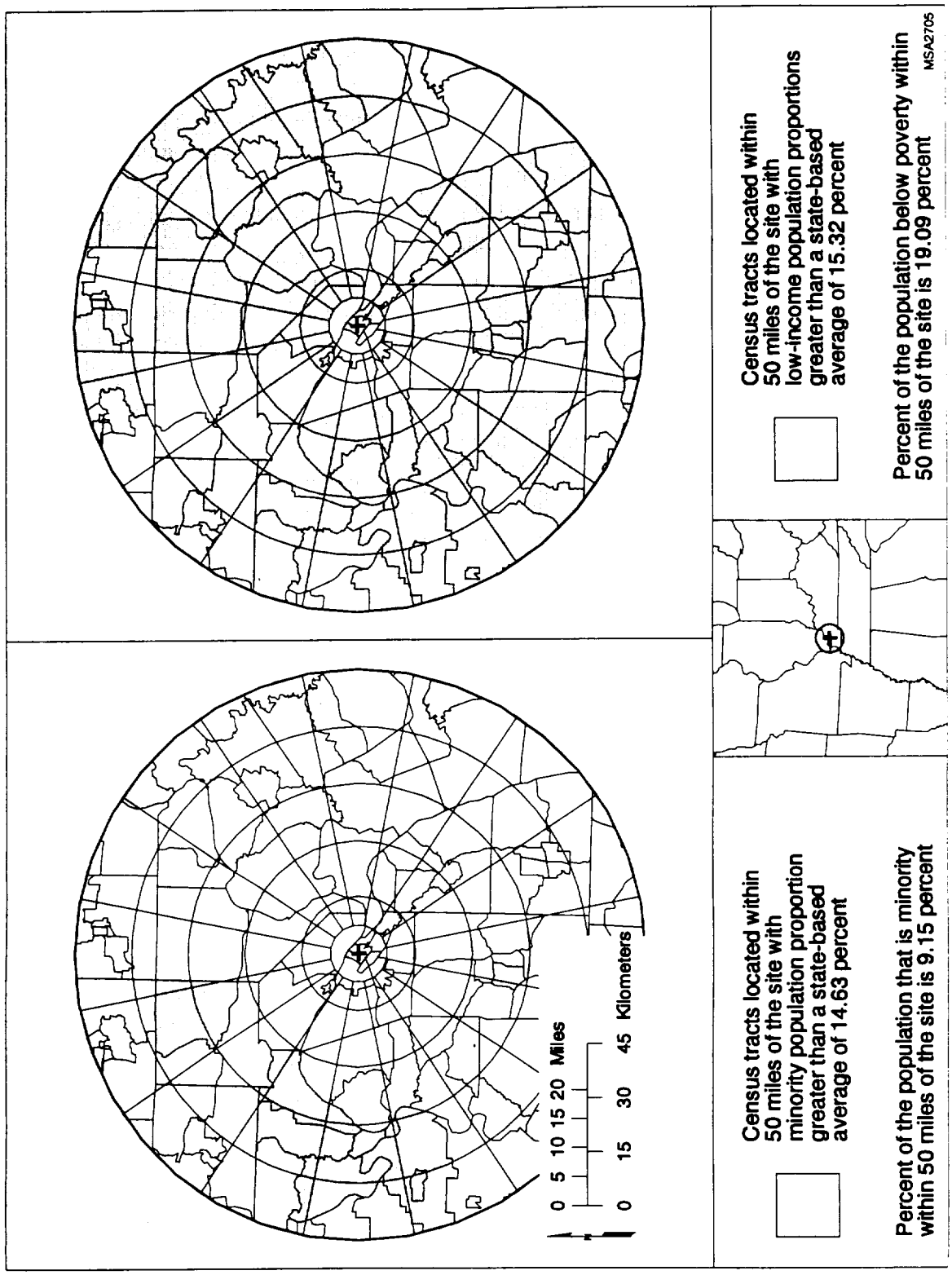

FIGURE C.1 Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the Paducah Site

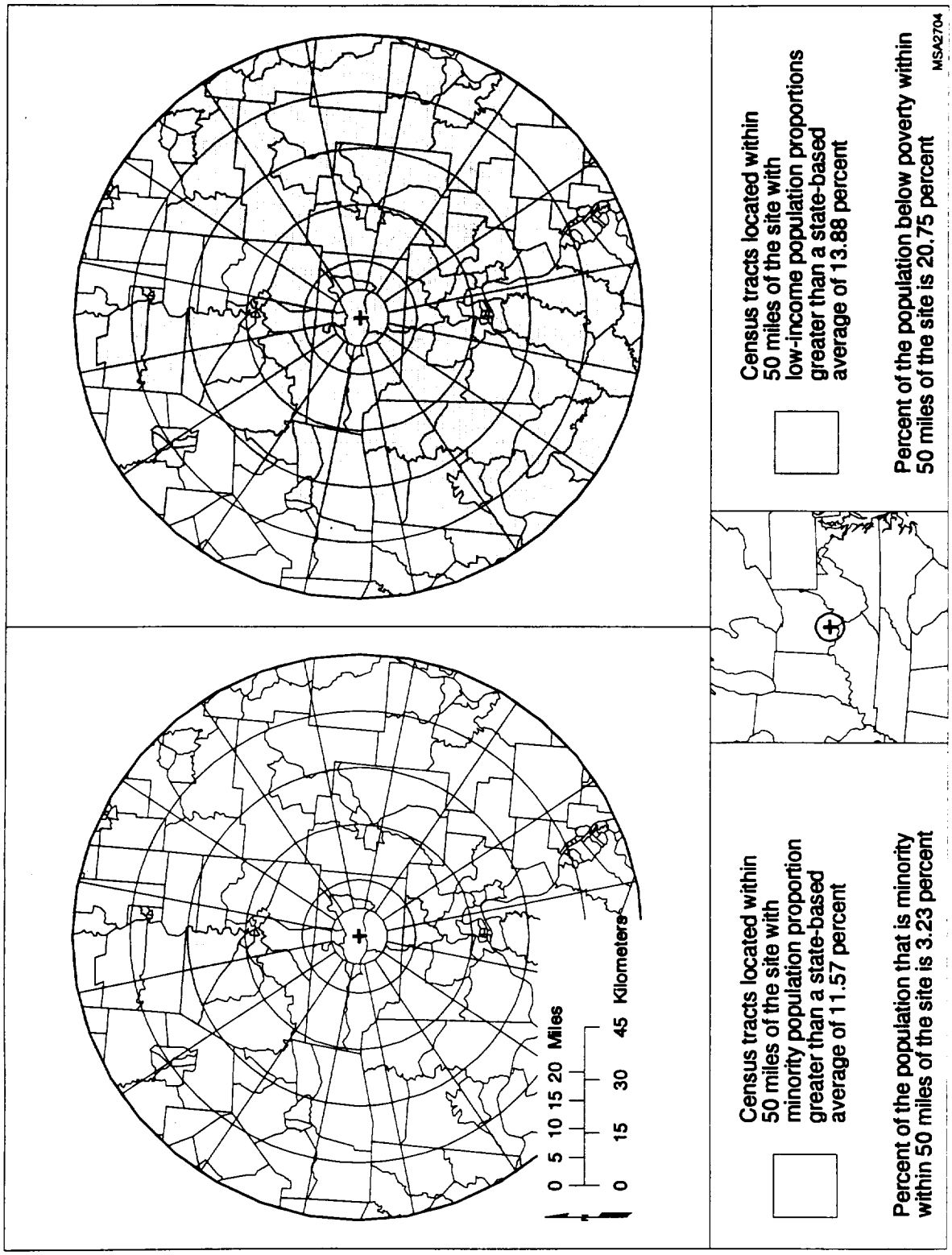

FIGURE C.2 Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the Portsmouth Site

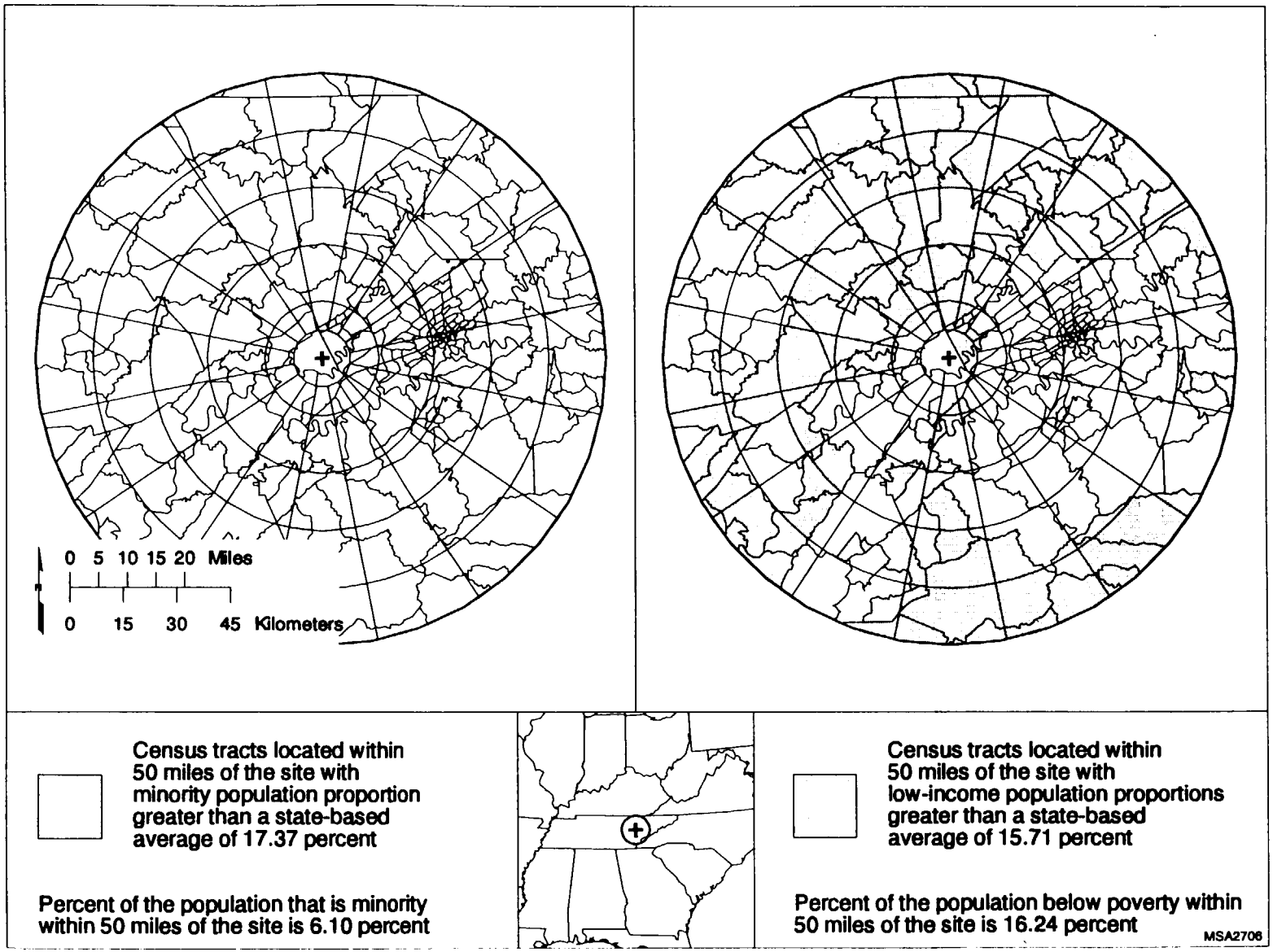

FIGURE C.3 Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the K-25 Site

An assessment of potential environmental justice impacts resulting from transportation accidents was not conducted for this analysis. Although environmental justice impacts could occur within a given transportation corridor following an accident, a site-specific (i.e., corridor-specific) demographic analysis cannot be conducted because the transportation analysis did not predict the location of accidents, and because it is impossible to predict reliably who will be involved in transportation accidents. There is no reason to believe that impacts of transportation accidents will affect minority or low-income populations disproportionately.

C.8.2.3.1 Screening Criteria

To evaluate the potential for continued storage to result in disproportionate impacts to minority and low-income populations, screening criteria based on the assessment of radiological and chemical risks were used to determine what sites, if any, would require further analysis. These criteria included:

- A dose to the general public MEI exceeding 100 mrem/yr under normal operations.
- An expected LCF equal to or greater than 1 from radioactive sources under accident conditions.
- A hazard index for the MEI equal to or greater than 1 from chemical sources under normal operations.
- An expected incidence of irreversible adverse effects equal to or greater than 1 from accidental chemical releases, when accident frequency categories and duration of operations were considered.

In assessing accident risks, the consequence of an accident must be considered as a function of the expected frequency of the accident. For example, if a particular accidental chemical release was projected to result in 100 fatalities but was expected to occur only once in 10,000 years (also expressed as 1×10^{-4} per year), then expected annual fatalities could be calculated by multiplying the consequence (100 fatalities) of the accident by the expected accident frequency (1×10^{-4} per year), which yields 0.01 expected fatalities per year from the particular accident analyzed. The PEIS assessment of human health risk categorizes accident frequencies according to the likelihood of occurrence. A discussion of risk conversion factors, accident consequences, and frequency categories is presented in Chapter 4.

The hazard index for the MEI (see Appendix D, Table D.5) was used to determine health effects from chemical sources under normal operations. This methodology is discussed in greater detail in Section C.5.

To determine expected LCFs from radiological source accidents, the LCF risk for the general public (see Appendix D, Table D.8) was multiplied by the frequency category value of the worst accident scenarios to determine maximum effects. For purposes of this analysis, the midrange value of the frequency category under consideration was used (i.e., 10^{-5} for the frequency category that is defined by a range of 10^{-4} to 10^{-6}).

The expected incidence of irreversible adverse effects from accidental chemical releases was determined by multiplying the number of persons projected to be affected under the worst accidental release scenario by the midrange value of the appropriate frequency category value, and then multiplying that total by the number of years under consideration. Although the depleted UF_6 PEIS risk assessment projected possible radiological and chemical human health effects from disposal beyond the year 2039, such effects could not be included in the analysis of potential environmental justice impacts because the composition of the population residing within 50 miles (80 km) of a site cannot be projected with accuracy beyond the year 2040. Current minority and low-income population proportions for each site were assumed to the year 2039.

C.8.2.3.2 Demographic Analysis

If projected human health effects exceeded screening criteria limits at any of the three sites, a demographic analysis would be conducted. For radiological impacts from normal operations, the 50-mile (80-km) radius surrounding each site would be divided into sectors and blocks for a higher resolution examination. A grid consisting of pie-shaped sectors (see Figures C.1 through C.3) positioned 360° around the centroid of the storage yards and six concentric circles (with interval sizes of 5 and 10 miles [8 and 16 km]) radiating outward would be used to break the 50-mile (80-km) zone of impact surrounding each site into sectors and blocks. A block consists of the portion of a preshaped sector bounded by (or located between) two concentric circles.

If the dose to the general public MEI from radiological sources under normal operations equaled or exceeded 100 mrem/yr, a block dose value would be assigned to each census tract in the affected sector block or blocks. A comparative analysis of the tracts receiving the highest doses (upper 10%) would be conducted to determine the proportion of tracts that were minority or low-income. If the proportion of minority or low-income tracts in the upper 10% was higher than the proportion of minority or low-income tracts inside the 50-mile (80-km) zone of impact surrounding an affected site, then an environmental justice impact would be declared.

For chemical releases associated with routine operations that resulted in a hazard index equal to or greater than 1 for the MEI, the block containing the MEI would be examined for population composition. If the MEI block was composed of minority or low-income census tracts, then a declaration of potential disproportionate health impacts would be included in the impact discussion for the appropriate site. In cases where the MEI block would contain more than one census tract, the tract closest to the site would be used to determine potential disproportionality.

If screening criteria were exceeded for radiological and chemical accident releases, a population composition analysis would be conducted for census tracts in all sectors and blocks within a 5-mile (8-km) radius of the release source. A 5-mile (8-km) limit was chosen because release plume analysis indicated that at least 95% of the effects from accidental releases would occur within 5 miles (8 km) of the release point. Although an accidental release would have the greatest potential to affect persons residing in sectors and blocks located downwind from the release, a 5-mile (8-km) radius provides a conservative means to estimate potential disproportionate effects, regardless of wind direction at the time of release. If the proportion of minority or low-income census tracts located within a 5-mile (8-km) radius of release points was higher than the proportion for the entire 50-mile (80-km) zone of impact surrounding the site, then a declaration of potential disproportionate health impacts would be included in the impact discussion for the affected site.

C.9 TRANSPORTATION

The technical approach for conducting the transportation risk assessment was developed following an extensive review of the literature and existing NEPA documentation for federal actions involving transportation of radioactive materials. The transportation risk assessment approach for the PEIS is consistent with the approach developed to support the WM PEIS (DOE 1997). Recently, the same approach was also applied in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (INEL EIS; DOE 1995a) and in the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (DOE 1996a). The basic assessment approach has been previously reviewed by DOE and by representatives of DOE, including a transportation technical review group whose mission was to evaluate available analytical methods for the INEL EIS. The review group included technical representatives of Argonne National Laboratory; Bettis Atomic Power Laboratory (Naval Reactors); and Savannah River Site, Hanford Site, and Science Applications International Corporation-Idaho (preparers of the INEL EIS). In addition, comments on the approach were also solicited from the NRC for the WM PEIS. The approach is described below.

The approach for the hazardous chemical component of the transportation risk assessment was similar to the radiological approach. However, no cargo-related impacts were assessed under routine conditions.

C.9.1 Scope of the Analysis

The transportation risk assessment for management of depleted UF_6 involved estimating the potential human health risks during transportation of depleted uranium in different forms. Risks were estimated from both "vehicle-related" and "cargo-related" causes. Vehicle-related risks result from the nature of transportation itself, independent of the radioactive characteristics of the cargo.

For example, increased levels of pollution from vehicular exhaust emissions may affect human health. Similarly, accidents during transportation may cause injuries and fatalities from physical trauma. On the other hand, cargo-related risk generally refers to risks that would be attributable to the characteristics of the shipment cargo. The cargo-related risks from the transportation of depleted uranium would be caused by exposure to ionizing radiation. Exposures to radiation occur under both routine (i.e., incident-free) transportation and during accident conditions.

For each of the alternatives considered for managing depleted UF_6 that would involve transportation, cargo-related and vehicle-related risks were calculated for shipments between each of the origin and destination sites (see Table C.2). Options evaluated included the shipment of depleted UF_6 from its current location(s) to storage or conversion facilities; the shipment of UO_2 from conversion facilities to storage, cask manufacture, or disposal facilities; the shipment of U_3O_8 from conversion facilities to storage or disposal facilities; the shipment of depleted uranium metal from conversion facilities to cask manufacture facilities; and the shipment of low-level radioactive waste (LLW) from conversion and manufacturing facilities to LLW disposal sites. The number of shipments between each pair of origin and destination sites was calculated for truck and rail modes by using projected site-specific inventories.

Unit risks per kilometer were developed because the locations of the conversion, storage, manufacturing, end user, and disposal facilities have not been determined. These unit risks were based on national average data derived from the data discussed below for route-specific data. The application of these data is discussed in the PEIS.

The technical approach for estimating transportation risks uses several computer models and databases. Transportation risks were assessed for both routine and accident conditions. For the routine assessment, risks were calculated for the collective populations of all potentially exposed individuals, as well as for a small set of MEI receptors. The accident assessment consisted of two components: (1) an accident risk assessment, which considered the probabilities and consequences of a range of possible transportation-related accidents, including low-probability accidents that have high consequences, and high-probability accidents that have low consequences; and (2) an accident consequence assessment, which considered only the radiological consequences of low-probability accidents that were postulated to result in the largest releases of radioactive material. The release fractions used in the accident risk assessment were based on the data in NUREG-0170 (NRC 1977a) and independent engineering analyses.

C.9.2 Routine Risk Assessment Method

The RADTRAN 4 computer code (Neuhauser and Kanipe 1993) was used for the routine and accident cargo-related risk assessments to estimate the radiological impacts to collective populations. RADTRAN 4 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including

TABLE C.2 Potential Shipments of Radioactive Material Analyzed in the PEIS for Depleted UF_6

Material	Origin	Destination
Depleted UF_6	Gaseous diffusion plants site storage yards	Storage or conversion facilities
UO_2	Conversion facilities	Storage, manufacturing, or disposal facilities
Uranium oxide cask	Manufacturing facilities	End user
U_3O_8	Conversion facilities	Storage or disposal facilities
Depleted uranium metal	Conversion facilities	Manufacturing facilities
Depleted uranium metal cask	Manufacturing facilities	End user
Low-level waste (depleted uranium-contaminated material)	Conversion, manufacturing, and cylinder transfer and treatment facilities	Low-level waste disposal sites
Mixed waste	Conversion, manufacturing, and cylinder transfer and treatment facilities	Mixed waste treatment

truck, rail, air, ship, and barge. The code has been used extensively for transportation risk assessments since it was issued in the late 1970s and has been reviewed and updated periodically.

As a complement to the RADTRAN calculations, the RISKIND computer code (Yuan et al. 1995) was used to estimate scenario-specific doses to MEIs for both routine operation and accident conditions and to estimate population impacts for the accident consequence assessment. The RISKIND computer code was originally developed for the DOE Office of Civilian Radioactive Waste Management specifically to analyze radiological consequences to individuals and population subgroups from the transportation of spent nuclear fuel and is now capable of analyzing the transport of other radioactive materials.

Routine risks from hazardous chemical shipments would not be expected. The shipping packages were assumed not to leak during routine transportation operations.

C.9.2.1 Collective Population Risk

The radiological risk associated with routine transportation results from the potential exposure of people to low-level external radiation in the vicinity of loaded shipments. Because the radiological consequences (dose) occur as a direct result of normal operations, the probability of routine consequences is taken to be unity in the RADTRAN 4 code. Therefore, the dose risk is equivalent to the estimated dose.

For routine transportation, the RADTRAN 4 computer code considers all major groups of potentially exposed persons. The RADTRAN 4 calculations of risk for routine highway and rail transportation include exposures of the following population groups:

- ***Persons along the Route (Off-Link Population).*** Collective doses were calculated for all persons living or working within 0.5 mile (0.8 km) of each side of a transportation route. The total number of persons within the 1-mile (1.6-km) corridor was calculated separately for each route considered in the assessment.

- ***Persons Sharing the Route (On-Link Population).*** Collective doses were calculated for persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or opposite directions as the shipment, as well as persons in vehicles passing the shipment.

- ***Persons at Stops.*** Collective doses were calculated for people who might be exposed while a shipment was stopped en route. For truck transportation, these stops include stops for refueling, food, and rest. For rail transportation, stops were assumed to occur for purposes of classification.

- ***Crew Members.*** Collective doses were calculated for truck and rail transportation crew members involved in the actual shipment of material. Workers involved in loading or unloading were not considered.

The doses calculated for the first three population groups were added together to yield the collective dose to the general public; the dose calculated for the fourth group represents the collective dose to workers. The RADTRAN 4 models for routine dose are not intended for use in estimating specific risks to individuals.

The RADTRAN 4 calculations for routine dose are based on generically expressing the dose rate as a function of distance from a point source (Neuhauser and Kanipe 1993). Associated with the calculation of routine doses for each exposed population group are parameters such as the radiation field strength, the source-receptor distance, the duration of exposure, vehicular speed, stopping time, traffic density, and route characteristics such as population density. The RADTRAN manual contains derivations of the equations and descriptions of these parameters (Neuhauser and Kanipe 1993).

For the depleted UF_6 PEIS, the collective routine risks were calculated for each set of shipments as follows. Impacts were estimated on a unit risk per kilometer traveled basis because the origin and destination sites for the alternatives have not yet been determined. As such, RADTRAN 4 was used to calculate the collective risks to workers and the public on the basis of accident rates and population densities, which are summarized in Biwer et al. (1997), and representative radiological and physical properties of the transported material. The collective risks presented incorporated the total number of shipments over the life of the project (20 years in most cases). For a given option, the number of shipments for each type of material was determined by the annual input or output capacities for the facility under consideration (conversion, treatment, storage, manufacture, or disposal). To give the reader a perspective on the routine risks involved, results were presented for shipment distances of 250, 1,000, and 5,000 km.

C.9.2.2 Maximally Exposed Individual Risk

In addition to the assessment of the routine collective population risk, the risk to MEIs was estimated for a number of hypothetical exposure scenarios by using RISKIND. The receptors included transportation crew members, departure inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near a facility.

The dose to each MEI considered was calculated with RISKIND for an exposure scenario defined by a given distance, duration, and frequency of exposure specific to that receptor. The distances and durations of exposure were similar to those given in previous transportation risk assessments (DOE 1990, 1995a, 1996a) The scenarios were not meant to be exhaustive but were selected to provide a range of potential exposure situations.

The RISKIND external dose model considers direct external exposure and exposure from radiation scattered from the ground and air. RISKIND was used to calculate the dose as a function of distance from a shipment on the basis of the dimensions of the shipment (millirem per hour for stationary exposures and millirem per event for moving shipments). The code approximates the shipment as a cylindrical volume source, and the calculated dose includes contributions from secondary radiation scattering from buildup (scattering by the material contents), cloudshine (scattering by the air), and groundshine (scattering by the ground). The dose rate curve (relative dose rate as a function of distance) specific to depleted uranium was determined by using the MicroShield code (Negin and Worku 1992; see Section C.4.1.4) for input into RISKIND. As a conservative measure, credit for potential shielding between the shipment and the receptor was not considered.

C.9.2.3 Vehicle-Related Risk

Vehicle-related health risks resulting from routine transportation might be associated with the generation of air pollutants by transport vehicles during shipment and would be independent of the radioactive or chemical nature of the shipment. The health endpoint assessed under routine

transportation conditions was the excess latent mortality due to inhalation of vehicular emissions. These emissions consist of particulate matter in the form of diesel engine exhaust and fugitive dust raised from the road/railway by the transport vehicle.

Risk factors for pollutant inhalation in terms of latent mortality have been generated by Rao et al. (1982). These risk factors are 1.6×10^{-7}/mile (1×10^{-7} mortality/km) and 2.1×10^{-7}/mile (1.3×10^{-7} mortality/km) for truck and rail travel, respectively, in urban areas. The risk factors are based on regression analyses of the effects of sulfur dioxide and particulate releases from diesel exhaust on mortality rates. Excess latent mortalities were assumed to be equivalent to LCFs. Vehicle-related risks from routine transportation were calculated for each shipment by multiplying the total distance traveled in urban areas by the appropriate risk factor. This method has been used in several reports to calculate risks from routine transportation of radioactive wastes (DOE 1990, 1995a, 1996a).

The routine vehicle-related health risks were considered to be incremental risks. The risk of mortality from air pollutants is thought to occur after some threshold air concentration is exceeded (EPA 1993b). In addition, the air concentration thresholds were derived when considering chronic exposure over extended periods of time. Such higher air pollutant concentrations exist primarily in populated urban areas, where the increase in pollutant levels by a single shipment would incrementally add to the mortality risk. Rural and suburban population areas generally do not have such high air pollutant levels, and the relatively small amount added as the result of a single shipment would not be enough to raise air concentrations above threshold levels for injury for even a brief period of time.

C.9.3 Accident Assessment Methodology

As discussed in the previous section, the radiological transportation accident risk assessment uses the RADTRAN 4 code for estimating collective population risks and the RISKIND code for MEI and population consequences.

The hazardous chemical transportation accident risk assessment relies on the HGSYSTEM model (Post 1994a-b) for both the collective population and individuals. The model is a widely applied code recognized by the EPA for chemical accident consequence predictions.

The collective accident risk for each type of shipment was determined in a manner similar to that described for routine collective risks. Unit accident risks on a per kilometer traveled basis were first calculated for each type of shipment. As discussed in Chapter 4, the accident risk assessment uses national route average characteristics such as accident rates and population density information. In addition, the radiological, chemical, and physical properties of the material transported and its packaging characteristics were incorporated into the calculations. The collective accident risks presented incorporated the total number of shipments over the life of the project (20 years in most cases). For a given option, the number of shipments for each type of material was

determined by the annual input or output capacities for the facility under consideration (conversion, treatment, storage, manufacture, or disposal). To give the reader a perspective on the accident risks involved, results were presented for shipment distances of 250, 1,000, and 5,000 km.

C.9.3.1 Radiological Accident Risk Assessment

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. The accident risk assessment is treated probabilistically in RADTRAN 4 and in the HGSYSTEM approach used to estimate the hazardous chemical component of risk. Accident risk is defined as the product of the accident consequence (dose or exposure) and the probability of the accident occurring. In this respect, RADTRAN 4 and the HGSYSTEM approach both estimate the collective accident risk to populations by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences, and high-probability accidents that have low consequences (such as "fender benders"). The total collective radiological accident dose risk was calculated as:

$$R_{Total} = D \times A \times \sum_{i=1,n} (P_i \times C_i) \quad ,$$

where:

R_{Total} = total collective dose risk for a single shipment distance *D* (person-rem),

D = distance traveled (km),

A = accident rate for transport mode under consideration (accidents/km),

P_i = conditional probability that the accident is in severity category *I*, and

C_i = collective dose received (consequence) should an accident of severity category *I* occur (person-rem).

The results for collective accident risk can be directly compared with the results for routine collective risk because the latter results implicitly incorporate a probability of occurrence of one if the shipment takes place.

The RADTRAN 4 calculation of collective accident risk employs models that quantify the range of potential accident severities and the responses of transported packages to accidents. The spectrum of accident severity is divided into a number of categories. Each category of severity is assigned a conditional probability of occurrence — that is, the probability that an accident will be of a particular severity if an accident occurs. The more severe the accident, the more remote the chance of such an accident. Release fractions, defined as the fraction of the material in a package that

could be released in an accident, are assigned to each accident severity category on the basis of the physical and chemical form of the material. The model takes into account the mode of transportation and the type of packaging being considered. The accident rates, the definition of accident severity categories, and the release fractions used in this analysis are discussed further in Biwer et al. (1997). The approach for hazardous chemicals incorporates the same accident severity categories and release fractions used by RADTRAN 4.

For accidents involving the release of radioactive material, RADTRAN 4 assumes that the material is dispersed in the environment according to standard Gaussian diffusion models. For the risk assessment, default data for atmospheric dispersion were used, representing an instantaneous ground-level release and a small-diameter source cloud (Neuhauser and Kanipe 1993). The calculation of the collective population dose following the release and dispersal of radioactive material includes the following exposure pathways:

- External exposure to the passing radioactive cloud,
- External exposure to contaminated ground,
- Internal exposure from inhalation of airborne contaminants, and
- Internal exposure from the ingestion of contaminated food.

For the pathway of ingestion, national-average food transfer factors, which relate the amount of radioactive material ingested to the amount deposited on the ground, were calculated in accordance with the methods described by NRC Regulatory Guide 1.109 (NRC 1977b) and were used as input to the RADTRAN code. Doses of radiation from the ingestion or inhalation of radionuclides were calculated by using standard dose conversion factors (DOE 1988a-b).

C.9.3.2 Chemical Accident Risk Assessment

The risks from exposure to hazardous chemicals during transportation-related accidents can be either acute (result in immediate injury or fatality) or latent (result in cancer that would present itself after a latency period of several years). Both population risks and risks to the MEI were evaluated for transportation accidents. The acute health endpoint, potential irreversible adverse effects, was evaluated for the assessment of cargo-related population impacts from transportation accidents. Accidental releases during transport of various uranium compounds (e.g., UF_6, UO_2, U_3O_8, uranium metal), HF, and ammonia were evaluated quantitatively.

The acute effects evaluated were assumed to exhibit a threshold nonlinear relationship with exposure; that is, some low level of exposure can be tolerated without inducing a health effect. To estimate risks, chemical-specific concentrations were developed for potential irreversible adverse effects. All individuals exposed at these levels or higher following an accident were included in the

transportation risk estimates. In addition to acute health effects, the cargo-related risk of excess cases of latent cancer from accidental chemical exposures could be evaluated. However, none of the chemicals that might be released in any of the accidents would be carcinogenic. As a result, no predictions for excess latent cancers are presented in this report for accidental chemical releases.

Additionally, to address MEIs, the locations of maximum hazardous chemical concentration were identified for shipments with the largest potential releases. Estimates of exposure duration at those locations were obtained from modeling output and used to assess whether MEI exposure to uranium and other compounds exceeded the criteria for potential irreversible adverse effects.

The primary exposure route of concern with respect to accidental release of hazardous chemicals would be inhalation. Although direct exposure to hazardous chemicals via other pathways, such as ingestion or dermal absorption, would also be possible, these routes would be expected to result in much lower exposure than the inhalation pathway doses for the chemicals of concern in the depleted UF_6 PEIS. The likelihood of acute effects would be much less for the ingestion and dermal pathways than for inhalation.

The HGSYSTEM Version 3.0 model (Hanna et al. 1994) has a built-in source-term algorithm that is used to compute the rate, quantity, and type of atmospheric release of a hazardous air pollutant, including pool evaporation from a volatile organic liquid spill. The model is able to handle frequently encountered accidental releases from ruptured tanks, drums, and pipes. The model incorporates a chemical data library of physical and chemical properties (such as vapor pressure, boiling point, and molecular weight) for 30 chemical compounds. Physical properties of the chemical released, along with container content input, such as the container geometry and rupture characteristics (e.g., hole size), are used by HGSYSTEM to compute chemical release rate and duration. The risk assessment for hazardous chemicals assumed that organic liquid spills and particulate releases would be of short duration as liquid and solid (as respirable fraction) aerosols. The release fractions were estimated with the approach used for radionuclide releases. The risks associated with the consequences estimated with the HGSYSTEM code were computed separately with a risk quantification spreadsheet program.

C.9.3.3 Accident Consequence Assessment

Because predicting the exact location of a severe transportation-related accident is impossible when estimating population impacts, separate accident consequences were calculated for accidents occurring in rural, suburban, and urban zones of population density. Moreover, to address the effects of the atmospheric conditions existing at the time of an accident, two different atmospheric conditions were considered. The first case assumed neutral (i.e., unstable) atmospheric conditions, and the second assumed stable conditions.

The MEI for severe transportation accidents was considered to be located at the point of highest hazardous material concentration that would be accessible to the general public. This

location was assumed to be 100 ft (30 m) or farther from the release point at the location of highest air concentration as determined by the HGSYTSTEM and FIREPLUME models. Only the shipment accident resulting in the highest contaminant concentration was evaluated for the MEI.

C.9.3.3.1 Radiological Accident Consequence Assessment

The RISKIND code was used to provide a scenario-specific assessment of radiological consequences of severe transportation-related accidents. Whereas the RADTRAN 4 accident risk assessment considers the entire range of accident severities and their related probabilities, the RISKIND accident consequence assessment focuses on accidents that result in the largest releases of radioactive material to the environment. Accident consequences were presented for each type of shipment that might occur under any given option for each alternative. The accident consequence assessment was intended to provide an estimate of the potential impacts posed by a severe transportation-related accident.

The severe accidents considered in the consequence assessment are characterized by extreme mechanical and thermal forces. In all cases, these accidents result in a release of radioactive material to the environment. The accidents correspond to those within the highest accident severity category, as described previously. These accidents represent low-probability, high-consequence events. The probability of accidents of this magnitude would be dependent on the number of shipments and the total shipping distance for the options considered; however, accidents of this severity would be expected to be extremely rare.

Severe accidents involving solid radioactive material that result in the highest impacts generally are related to fire. The fire acts to break down and distribute the material of concern. Air concentrations of radioactive contaminants at receptor locations following a hypothetical accident were determined by using the FIREPLUME model. On the basis of these air concentrations, RISKIND was used to calculate the radiological impacts for the accident consequence assessment.

The accident consequences were calculated for both local populations and MEIs. The population dose includes the population within 50 miles (80 km) of the site of the accident. The exposure pathways considered would be similar to those discussed previously for the accident risk assessment. Although remedial activities after the accident (e.g., evacuation or ground cleanup) would reduce the consequences of an accident, these activities were not given credit in the consequence assessment.

C.9.3.3.2 Chemical Accident Consequence Assessment

The HGSYSTEM model version 3.0 was used to estimate the potential consequences from severe hazardous chemical accidents. The FIREPLUME model was used to predict the consequences of transportation accidents involving fires. The HGSYSTEM model is described in Section C.9.3.2.

C.9.3.4 Vehicle-Related Accident Risk Assessment

The vehicle-related accident risk refers to the potential for transportation-related accidents that could directly result in fatalities not related to the cargo in the shipment. This risk represents fatalities from mechanical causes. National-average rates for transportation-related fatalities were used in the assessment. Vehicle-related accident risks were calculated by multiplying the total distance traveled by the rate for transportation-related fatalities. In all cases, the vehicle-related accident risks were calculated by using distances for round-trip shipment.

C.10 WASTE MANAGEMENT

C.10.1 General Methods

Impacts to the waste management resources at each of the sites were evaluated for the continued storage, cylinder preparation, conversion, manufacture and use, long-term storage, and disposal options. For the continued storage and cylinder preparation options, site-specific impacts were estimated on the basis of actual cylinder populations in the storage yards of the Paducah, Portsmouth, and K-25 sites. For the conversion and long-term storage options (except long-term storage in mines), the three current storage sites were used as representative locations. The analysis of site-specific and representative site impacts compared the volume throughputs resulting from normal activities at the waste management facilities at each site with the waste throughputs expected from the different options. Wastes were considered according to the standard categories of LLW, low-level mixed waste (LLMW), hazardous waste, and nonhazardous waste. In addition, waste streams were identified as to media type (e.g., solid or liquid) and the likely treatment (e.g., incineration, compaction, or sanitary discharge). Where new waste management facilities would be needed at a particular site, the impacts for waste management from construction of these facilities were also evaluated. The analysis for manufacturing and use, long-term storage in mines, and disposal options assumed generic, nonspecific environmental settings for the required activities.

For purposes of analysis for the generic options, the wastes generated at each site were compared with the total amount of waste generated nationwide in all DOE waste management activities. The comparison of waste generation rates with available capacity for depleted UF_6 waste (especially LLW) was limited primarily to the DOE waste management system. Currently three commercial facilities (Barnwell, South Carolina; Richland, Washington; and Envirocare in Utah) are accepting about 37,000 m^3/yr of commercial LLW, and DOE is disposing of about 65,000 m^3/yr of LLW at DOE facilities. DOE LLW generation is expected to increase to about 100,000 to 200,000 m^3/yr once environmental restoration operations begin. Commercial facilities that manage LLW have the capability to expand rapidly and may accept DOE LLW in the future if it can be managed profitably. Also, some of the depleted UF_6 wastes might not be considered DOE wastes (e.g., calcium fluoride [CaF_2] or magnesium fluoride [MgF_2] possibly generated during conversion processes, if the conversion were conducted by a private commercial enterprise).

The analysis also included the secondary waste streams associated with storage of treated or untreated waste and any secondary waste streams associated with the packaging or handling of treated wastes in preparation for disposal.

C.10.2 Data Requirements

For each option considered, projected annual generation volumes for the various waste types were compared with waste treatment volumes/disposal capacities projected from existing programs at the representative sites or projected to be available at the national level (especially for the disposal, manufacturing and use, and long-term storage in mines). The projected waste generation volumes and contaminant levels for each option were obtained from the engineering analysis report (LLNL 1997) and other programmatic sources for continued storage and long-term yard storage (Parks 1997; Folga 1996). The waste generation volumes projected for each site (or nationwide) are shown in Table C.3. To estimate waste, these projected site-dependent LLW and LLMW data were obtained from analysis of site-generated data listed in the *Integrated Data Base Report — 1994* (DOE 1995b) for LLW and from the *Mixed Waste Inventory Summary Report* (DOE 1995c) for LLMW. The estimated wastes generated from each depleted UF_6 management option are compared with the estimated waste treatment volumes listed in Table C.3. The treatment volumes in Table C.3 are associated with operations and do not include waste from environmental restoration activities.

Estimates of projected wastes for the next 20 years were used in this comparison rather than current waste volumes because the comparison should represent waste management conditions some 10 to 30 years from now. Waste management programs at particular sites could change over time.

Estimates of the LLW to be disposed of at DOE waste management disposal facilities depend critically upon the time frame under consideration and the types of waste to be included. The WM PEIS estimates that approximately 1,060,000 m^3 of LLW will be disposed of during the time frame 1995-2014 (DOE 1997). This estimate does not include any LLW from environmental restoration activities or facility stabilization activities. A more appropriate estimate that includes environmental restoration waste (perhaps more uncertain) comes from *The 1996 Baseline Environmental Management Report* (BEMR) (DOE 1996b), which estimates the total amount of LLW for treatment at waste management facilities to be 3,400,000 m^3. This estimate is for the next 75 years and includes contributions from environmental restoration and facility stabilization programs. The majority of environmental restoration wastes are expected to be generated between 2003 and 2033, approximately the correct time frame to compare with the depleted UF_6 program. For this reason, the BEMR estimate was used for comparison with the estimated depleted UF_6 waste. Adjustments must be made to the BEMR estimate to convert treatment volumes into disposal volumes. Both volume reductions and expansions would occur during waste treatment and grouting, depending on the relative amounts of the different types of waste. On the basis of the WM PEIS analysis (DOE 1997), the BEMR estimate was adjusted to 4,250,000 m^3 for the estimated disposal volume. The total disposal volumes for LLW generated from various depleted UF_6 alternatives were

TABLE C.3 Projected Site and National DOE Waste Treatment Volumes

Waste Category	Waste Treatment Volume[a] (m^3/yr)			
	Paducah	Portsmouth	K-25 (ORR)[b]	Nationwide
Low-level waste[c]	2,200	4,800	8,100	68,000[d]
Low-level mixed waste[e]	100	1,600	(5,000)	19,000[d]
Hazardous waste[f]	76	120	1,000	–
Nonhazardous waste[f]				
Solids	2,100	–	(27,500)	–
Wastewater	–	–	–	–
Sanitary waste	560,000	500,000	880,000	–

[a] A hyphen (–) indicates no data reported.

[b] Waste treatment volumes for the K-25 site are listed where available. Much of the waste generated at K-25 is included in the combined treatment volumes listed under the Oak Ridge Reservation (ORR) treatment, storage, and disposal facilities. These combined volumes (enclosed in parentheses) include waste generated at ORNL, K-25, and Y-12.

[c] Source: DOE (1995b).

[d] Estimated operational waste for 1995 for all DOE sources combined (DOE 1997).

[e] Source: DOE (1995c).

[f] Source: DOE (1995d).

compared to the total estimated disposal volume for LLW for all DOE waste management activities (including environmental restoration waste).

A distinction is made between treatment volumes and disposal volume. Treatment volumes were compared as cubic meters per year (m^3/yr) because the limitations to the treatment facility are likely related to the throughput volume (m^3/yr) of the treatment facility. Disposal volumes were compared as total cubic meters (m^3) because disposal facilities generally have no throughput limitations but rather are limited by the total volume of waste (m^3) they can accept.

Although the current LLW disposal capacity is inadequate to dispose of the projected 4 million m^3 of LLW, such land is available at DOE and commercial LLW disposal facilities to accommodate disposal of this waste (DOE 1992a). These lands will be developed for LLW disposal, as needed.

C.11 CULTURAL RESOURCES

Cultural resources were generally evaluated with respect to the potential for impact to archaeological sites and historic structures listed on or eligible for the *National Register of Historic Places*, the environmental setting of a listed or eligible property, and traditional use areas (e.g., cemetery, Native American resource). Because specific sites have not been chosen for the options (with the exception of continued storage and cylinder preparation activities), only limited impact evaluation was possible. A site-specific evaluation as a part of the second tier of NEPA documentation will assess the location of proposed ground disturbance with respect to locations of significant cultural resources to determine impacts.

For the continued storage and cylinder preparation options, information regarding cultural resources was collected from each of the three current storage sites (Paducah, Portsmouth, and K-25). The potential for impacts resulting from these options was determined on the basis of ground disturbance caused by the construction of the new storage yards (if any), or a new transfer facility. Although each of the sites will prepare its own NEPA documentation for these projects, this PEIS provides a general discussion of what potential impacts might occur.

C.12 RESOURCE REQUIREMENTS

The evaluation of resource requirements identified the major irreversible and irretrievable commitments of resources that could be determined at this programmatic level of analysis. The commitment of material and energy resources during the entire life cycle of the various options in this PEIS includes construction materials that could not be recovered or recycled, materials rendered radioactive that could not be decontaminated, and materials consumed or reduced to unrecoverable forms or waste. Where construction would be necessary, materials required could include wood, concrete, sand, gravel, steel, and other metals. Materials consumed during operations could include operating supplies, miscellaneous chemicals, and gases. Strategic and critical materials, or resources with small reserves, were also identified and considered.

Energy resources irretrievably committed during construction and operations would include the consumption of fossil fuels used to generate heat and electricity. Energy would also be expended in the form of diesel fuel, gasoline, and oil for construction equipment and transportation vehicles.

The assessment of potential resource requirements for the continued storage, cylinder preparation, conversion, and long-term storage options was based on comparing the resource requirements of building and operating proposed facilities to existing capacities of on-site infrastructure systems and to current off-site demands at the three current storage sites. A variation of the methodology applied in the WM PEIS (DOE 1997) was utilized in this study. The effects of the various options on on-site infrastructure systems such as electrical demand were assessed qualitatively by comparing the new demand to the existing maximum capacity. The demand on

off-site infrastructure resulting from new resource requirements for each option was compared to estimated current demand.

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APPENDIX D:

ENVIRONMENTAL IMPACTS OF CONTINUED CYLINDER STORAGE AT CURRENT STORAGE SITES

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NOTATION (APPENDIX D)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
K_d	distribution coefficient
LCF	latent cancer fatality
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LMES	Lockheed Martin Energy Systems, Inc.
MCL	maximum contaminant level
MEI	maximally exposed individual
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 µm or less
ROI	region of influence
VOC	volatile organic compound

Chemicals

CO	carbon monoxide
HC	hydrocarbon
HF	hydrogen fluoride
NO_x	nitrogen oxides
SO_x	sulfur oxides
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2F_2	uranyl fluoride

UNITS OF MEASURE

ft	foot (feet)
ft^2	square foot (feet)
g	gram(s)
gal	gallon(s)
ha	hectare(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
L	liter(s)
lb	pound(s)
µg	microgram(s)
µm	micrometer(s)
m	meter(s)
m^3	cubic meter(s)
mg	milligram(s)
min	minute(s)
mrem	millirem(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
rem	roentgen equivalent man
s	second(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)

APPENDIX D:

ENVIRONMENTAL IMPACTS OF CONTINUED CYLINDER STORAGE AT CURRENT STORAGE SITES

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing continued storage of DOE-generated cylinders at the three current storage sites. The discussion provides background information, as well as a summary of the estimated environmental impacts associated with this option.

Continued Storage of Cylinders

The continued storage of depleted UF_6 cylinders at the Paducah, Portsmouth, and K-25 sites would be required for some period of time for all alternative management strategies. Continued storage would involve maintenance of the cylinders — including inspections, painting, and cylinder yard upgrades — as well as valve replacement and cylinder repair, as needed. The impacts of continued storage were assessed separately for the following:

No Action Alternative: Potential impacts were assessed for continued storage of the entire cylinder inventory at the three current storage sites through the year 2039, including potential long-term impacts to groundwater and human health and safety.

Action Alternatives: Potential impacts were assessed for continued storage at the three current storage sites based on the assumption that the number of cylinders at these sites would begin to decrease in the year 2009 and that all of the cylinders would be removed from the three sites by the end of the year 2028 (corresponding to the period during which conversion or long-term storage would be implemented). Potential long-term impacts were also assessed.

Continued cylinder storage at the Paducah, Portsmouth, and K-25 sites would be required for some period of time for all alternative management strategies. It was assumed that the entire depleted UF_6 cylinder inventory would continue to be stored at the three sites through 2008 for all alternatives. Under the no action alternative, the entire cylinder inventory would continue to be stored at the three sites indefinitely. For purposes of analysis and for comparison with action alternatives, the assessment period considered in this PEIS was through the year 2039. Under action alternatives, the number of cylinders stored at the three sites would decrease as the cylinders were transported to another location for conversion or long-term storage. This decrease at the sites was assumed to occur from 2009 through 2028.[1] The assessment of impacts from

[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

continued cylinder storage at the three sites considers all anticipated activities required to safely manage the cylinder inventory from 1999 through 2039 for the no action alternative and from 1999 through 2028 for the action alternatives. Potential long-term impacts from cylinder breaches potentially occurring at the sites through the year 2039 (No Action Alternative) or through 2028 (action alternatives) were estimated by calculating the maximum groundwater contamination levels possible in the future from those breaches.

The cylinder surveillance and maintenance activities that are to be undertaken from now through September 30, 2002, are described in detail in the *UF_6 Cylinder Project Management Plan* (Lockheed Martin Energy Systems [LMES] 1997d). However, because the assessment period for this PEIS extends through the year 2039, a set of assumptions was needed to define the activities for estimating the impacts of continued storage through 2039. The assumptions used are documented in a memo by J.W. Parks, Assistant Manager for Enrichment Facilities, DOE Oak Ridge Operations Office (Parks 1997). In developing these assumptions, it was recognized that the activities actually undertaken might differ from those described in the cylinder project management plan. Therefore, assumptions were chosen such that anticipated impacts of continued cylinder storage made in the PEIS would result in conservative estimates (that is, the assumptions used would overestimate impacts rather than underestimate them).

Impacts associated with the following activities were analyzed: (1) storage yard reconstruction and cylinder relocations; (2) routine and ultrasonic testing inspections of cylinders and valve monitoring and maintenance; (3) cylinder painting; and (4) repair and removal of the contents of any cylinders that might be breached during the storage period. Although actual activities occurring at the three storage sites during the time period considered might vary from those described in the cylinder project management plan, the estimated impacts of continued storage activities assessed in this PEIS are likely to encompass and bound the impacts at these sites. The assumptions for each activity are discussed further in the following paragraphs.

The total inventory of 46,422 depleted UF_6 cylinders generated by DOE before 1993 is currently stored as follows: 28,351 cylinders (about 60%) in 13 yards at the Paducah site; 13,388 cylinders (about 30%) in two yards at the Portsmouth site; and 4,683 cylinders (about 10%) in three yards at the K-25 site. An intensive effort is ongoing to improve yard storage conditions. This effort includes (1) relocation of some cylinders, which are currently either in contact with the ground or are too close to one another to allow for adequate inspections, and (2) construction of new storage yards or reconstruction of existing storage yards to provide a stabilized concrete base and monitored drainage for the cylinder storage areas. The impacts from planned relocation and construction activities that will not be complete by 1999 are included in the PEIS for consideration as part of continued cylinder storage; these activities include reconstruction of four Paducah yards, construction of a new yard for the K-25 site cylinders, relocation of about 19,000 cylinders at Paducah, and relocation of all cylinders at K-25.

The stored cylinders are regularly inspected for evidence of damage or accelerated corrosion; about 75% are inspected every 4 years, and 25% are inspected annually. Annual

inspections are required for those cylinders that have been stored previously in substandard conditions and/or those that show areas of heavy pitting or corrosion. In addition to these routine inspections, ultrasonic inspections are currently conducted on some of the relocated cylinders. The ultrasonic testing is a nondestructive method to measure the wall thickness of cylinders. Valve monitoring and maintenance are also conducted for cylinders that exhibit discoloration of the valve or surrounding area during routine inspections. Leaking valves are replaced in the field. Impacts from routine inspections, ultrasonic inspections, and valve maintenance are evaluated as components of continued cylinder storage. For assessment of the no action alternative, the frequency of routine inspections and valve monitoring was assumed to remain constant through 2039, and ultrasonic testing was assumed to be conducted annually for 10% of the relocated cylinders. Relocation activities would be completed in about 2003, after which 10% of the cylinders painted each year were assumed to be inspected by ultrasonic testing. For the action alternatives, the frequency of inspections was assumed to decrease with decreasing cylinder inventory (about a 5% decrease in inspections per year) from 2009 through 2028.

Current plans call for cylinder painting at the three sites to control cylinder corrosion. On the basis of information from the cylinder painting program (Pawel 1997), the analysis assumed that the paint would protect the cylinders for at least 10 years and that, once painted, the cylinders would not undergo further corrosion during that time. Although repainting might not actually be required every 10 years, the analysis assumed that every cylinder would be repainted every 10 years (except for the period 2019 through 2028 for the action alternatives, during which time no painting was assumed because of decreasing inventory size — i.e., cylinders being removed within 10 years for conversion or long-term storage elsewhere would not be repainted). The painting activity includes cylinder surface preparation (e.g., scraping and removal of rust deposits). Because some radioactive contaminants may exist on the surface of cylinders and because the metal content of the paints used previously are unknown, for purposes of the PEIS analysis the waste generated during surface preparation was considered to be low-level-mixed waste. Cylinder painting activities would be the primary source of potential radiological exposures for involved workers under the continued cylinder storage option.

Before 1998, seven breached cylinders had been identified at the three storage sites. Breached cylinders are cylinders that have a hole of any size at some location on the wall. Investigation of these breaches indicated that five of the seven were initiated by mechanical damage during stacking; the damage was not noticed immediately, and subsequent corrosion occurred at the damaged point. The other two cylinder breaches were concluded to have been caused by external corrosion due to prolonged ground contact. In 1998, one additional breached cylinder occurred during the course of cylinder maintenance operations. When cylinders are breached, moist air reacts with the exposed UF_6 and iron, resulting in the formation of a dense plug of uranium tetrafluoride (UF_4) and iron fluoride hydrates that prevents rapid loss of material from the cylinders. Further details on cylinder corrosion and releases due to breaches are given in Appendix B.

Considering the improved storage conditions in the yards, intensive inspection schedule, and the planned cylinder painting, the impact analysis for the no action alternative was based on the

assumption that breaches resulting from corrosion would cease. Therefore, the primary potential cause of breaches considered for continued storage was mechanical damage occurring during cylinder handling (e.g., for painting or relocations). Although stringent inspection procedures are now in place to immediately identify and repair any cylinder breaches that might occur during handling, for purposes of analysis it was nonetheless assumed that breaches caused by mechanical damage would continue to occur at the same rate as in the past and that the breaches would go unidentified for a long enough time for releases to occur (see Appendix B). Using these assumptions, the total numbers of breaches assumed to occur from 1999 through 2039 for the no action alternative analyses (base case) were 36 for the Paducah site, 16 for the Portsmouth site, and 7 for the K-25 site.

The above breach numbers were used to estimate potential impacts from repairing breached cylinders and from releases that might occur during continued storage through 2039 under the no action alternative. Potential radiological exposures of involved workers could result from patching breached cylinders and subsequently emptying the cylinder contents into new cylinders. The impacts to groundwater and human health and safety from uranium releases were assessed by estimating the amount of uranium that could be transported from the yards in surface runoff, followed by estimating migration through the soil to the groundwater.

The uncertainty in both the effectiveness of painting in controlling further corrosion and in the future painting schedule was addressed by also conducting a conservative assessment based on the assumption that external corrosion was not halted by improved storage conditions and painting, resulting in more breaches (see Section D.3). Using these assumptions, the total numbers of breaches estimated from 1999 through 2039 were 444 for the Paducah site, 74 for the Portsmouth site, and 213 for the K-25 site. The results of this assessment were used to provide an estimate of the earliest time when continued cylinder storage could begin to raise regulatory concerns under these worst-case conditions.

For the action alternatives, continued storage at the three sites would occur through 2028, with the inventory decreasing by about 5% per year starting in 2009 until no cylinders would remain at the current sites in 2028. Because the status of a cylinder painting program is less certain for the action alternatives, the estimated number of breached cylinders for these alternatives was based on the assumption that external corrosion was not controlled by painting (see Appendix B for the specific number of breaches assumed and Section D.4 for discussion of potential impacts for the action alternatives).

For all hypothetical cylinder breaches, it was assumed that the breach would go undetected for a period of 4 years, which is the duration between planned inspections for most of the cylinders. In practice, cylinders that show evidence of damage or heavy external corrosion are inspected annually, so it is unlikely that a breach would go undetected for a 4-year period. On the basis of estimates from investigation of cylinder breaches that have occurred to date, 1 lb (0.45 kg) of uranium (in the form of uranyl fluoride [UO_2F_2]) and 4.4 lb (2 kg) of hydrogen fluoride (HF) were assumed to be released from each breached cylinder annually for a period of 4 years.

D.1 SUMMARY OF CONTINUED CYLINDER STORAGE IMPACTS

This section provides a summary of the potential environmental impacts associated with continued cylinder storage at the three current storage sites for the no action alternative and for the other alternatives. Additional discussion and details related to the assessment methodologies and results for each area of impact are provided in Sections D.2 and D.4. The potential environmental impacts of continued cylinder storage are summarized in Table D.1 and as follows:

- Through the year 2039 for the no action alternative and the year 2028 for the action alternatives, all health and safety impacts to workers and the general public in the vicinity of the sites as a result of cylinder storage and maintenance activities are estimated to be well within the applicable health and safety standards.

- All postulated accidents, including the highest consequence accidents, were estimated to result in zero latent cancer fatalities (LCFs) due to radiological causes among both workers and members of the general public. Some accidents, if they occurred, could result in up to 300 irreversible adverse effects among workers and 1 irreversible adverse effect among the general public due to chemical effects of released materials. However, such accidents have a very low probability and would not be expected to occur through the year 2039 for the no action alternative and the year 2028 for the action alternatives.

- During the assessment period (through 2039 under the no action alternative and 2028 under the action alternatives), all environmental impacts resulting from continued storage activities, including impacts to air resources, water resources, socioeconomics, ecological resources, waste management, land and other resources, cultural resources, and the environmental justice impacts would be negligibly small or well within the applicable standards.

- Long-term impacts from cylinder breaches estimated to occur through 2039 under the no action alternative would be well within the applicable standards assuming that cylinder painting would be effective in controlling corrosion. If no credit were taken for corrosion reduction through painting and continued maintenance, and on the basis of conservative estimates of numbers of breaches and material loss from breached cylinders, it is estimated that the uranium concentrations in the groundwater around the three sites would exceed the guideline of 20 µg/L used for comparison at some time in the future (around the year 2100 or later). Similarly, if the larger number of cylinder breaches occurred because of uncontrolled cylinder corrosion, air concentrations of HF at the K-25 site could exceed the State of Tennessee standard around the year 2020. For the action alternatives, all long-term impacts are estimated to remain within the guideline values with or without taking credit for reduced corrosion through painting.

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TABLE D.1 Summary of Continued Cylinder Storage Impacts[a]

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
Human Health – Normal Operations: Radiological			
Involved Workers: Total collective dose (3 sites): 1,500 person-rem Total number of LCFs (3 sites): 0.6 LCF	**Involved Workers:** No impacts	**Involved Workers:** Total collective dose (3 sites): 720 person-rem Total number of LCFs (3 sites): 0.3 LCF	**Involved Workers:** No impacts
Noninvolved Workers: Maximum annual dose to MEI : 0.043 – 0.11 mrem/yr Maximum annual cancer risk to MEI: $2 \times 10^{-8} - 4 \times 10^{-8}$ per year Total collective dose (3 sites): 0.12 person-rem Total number of LCFs (3 sites): 5×10^{-5} LCF	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** Maximum annual dose to MEI : 0.057 – 0.26 mrem/yr Maximum annual cancer risk to MEI: $2 \times 10^{-8} - 1 \times 10^{-7}$ per year Total collective dose (3 sites): 0.47 person-rem Total number of LCFs (3 sites): 0.0002 LCF	**Noninvolved Workers:** No impacts
General Public: Maximum annual dose to MEI: 0.02 – 0.16 mrem/yr Maximum annual cancer risk to MEI: $1 \times 10^{-8} - 8 \times 10^{-8}$ per year Total collective dose to population within 50 miles (3 sites): 0.38 person-rem Total number of LCFs in population within 50 miles (3 sites): 2×10^{-4} LCF	**General Public:** Maximum annual dose to MEI: 0.026 – 0.49 mrem/yr Maximum annual cancer risk to MEI: $1 \times 10^{-8} - 2 \times 10^{-7}$ per year Total collective dose to population within 50 miles (3 sites): not determined Total number of LCFs in population within 50 miles (3 sites): not determined	**General Public:** Maximum annual dose to MEI: 0.022 – 0.46 mrem/yr Maximum annual cancer risk to MEI: $1 \times 10^{-8} - 2 \times 10^{-7}$ per year Total collective dose to population within 50 miles (3 sites): 1.07 person-rem Total number of LCFs in population within 50 miles (3 sites): 0.0005 LCF	**General Public:** Maximum annual dose to MEI: 0.021 – 1.3 mrem/yr Maximum annual cancer risk to MEI: $1 \times 10^{-8} - 7 \times 10^{-7}$ per year Total collective dose to population within 50 miles (3 sites): not determined Total number of LCFs in population within 50 miles (3 sites): not determined

TABLE D.1 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
Human Health – Normal Operations: Chemical			
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts	**General Public:** No impacts
Human Health – Accidents: Radiological			
Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents	Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} per year Collective dose: 16 person-rem Number of LCFs: 6×10^{-3}		**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} per year Collective dose: 16 person-rem Number of LCFs: 6×10^{-3}	
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 1×10^{-5} per year Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 3×10^{-2}		**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 1×10^{-5} per year Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 3×10^{-2}	

TABLE D.1 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
Human Health – Accidents: Chemical			
Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents	Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	No accidents
Noninvolved Workers: Bounding accident consequences (per occurrence):		**Noninvolved Workers:** Bounding accident consequences (per occurrence):	
Number of persons with potential for adverse effects: 1,000 persons		Number of persons with potential for adverse effects: 1,000 persons	
Number of persons with potential for irreversible adverse effects: 300 persons		Number of persons with potential for irreversible adverse effects: 300 persons	
General Public: Bounding accident consequences (per occurrence):		**General Public:** Bounding accident consequences (per occurrence):	
Number of persons with potential for adverse effects: 1,900 persons		Number of persons with potential for adverse effects: 1,900 persons	
Number of persons with potential for irreversible adverse effects: 1 person		Number of persons with potential for irreversible adverse effects: 1 person	
Human Health — Accidents: Physical Hazards			
Construction and Operations: **All Workers:** Less than 1 (0.11) fatality, approximately 143 injuries	No activities in the long term	**Construction and Operations:** **All Workers:** Less than 1 (0.07) fatality, approximately 90 injuries	No activities in the long term

TABLE D.1 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
		Air Quality	
Construction: 24-hour PM_{10} potentially as large as 82% of standard and 96% of standard at the Paducah and K-25 sites, respectively. Concentrations of other pollutants all below 3% of respective standards. No construction at the Portsmouth site.	No activities in the long term	**Construction:** 24-hour PM_{10} potentially as large as 82% of standard and 96% of standard at the Paducah and K-25 sites, respectively. Concentrations of other pollutants all below 3% of respective standards. No construction at the Portsmouth site.	No activities in the long term
Operations: 24-hour HF impact potentially as large as 23% of standard at the K-25 site. Criteria pollutant impacts all below 0.3% of respective standards.		**Operations:** 24-hour HF impact potentially as large as 92% of standard at the K-25 site. Criteria pollutant impacts all below 0.1% of respective standards.	
		Water	
Construction: Negligible impacts	Negligible impacts to surface water and groundwater in the long term	**Construction:** No impacts	Negligible impacts to surface water and groundwater in the long term
Operations: Negligible impacts to surface water and groundwater		**Operations:** Negligible impacts to surface water; negligible to minor impacts to groundwater	
		Soil	
Construction: Minor, but temporary, impacts	No activities in the long term	**Construction:** No impacts	No activities in the long term
Operations: Negligible impacts		**Operations:** Negligible impacts	

TABLE D.1 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
		Socioeconomics	
Construction and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing	No activities in the long term	**Construction and Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing	No activities in the long term
		Ecology	
Construction: Negligible impacts **Operations:** Negligible impacts to vegetation and wildlife	Negligible impacts to vegetation and wildlife in the long term	**Construction:** Negligible impacts **Operations:** Negligible impacts to vegetation and wildlife	Negligible to low impacts to vegetation and wildlife in the long term
		Waste Management	
Negligible impacts for the Portsmouth and K-25 sites; moderate impacts for the Paducah site waste management operations; negligible impacts to regional or national waste management operations for all three sites	No activities in the long term	Negligible impacts for the Portsmouth and K-25 sites; moderate impacts for the Paducah site waste management operations; negligible impacts to regional or national waste management operations for all three sites	No activities in the long term
		Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term
		Land Use	
Negligible impacts	No activities in the long term	Negligible impacts	No activities in the long term

TABLE D.1 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999-2039)	Long-Term Impacts	Impacts during Storage (1999-2028)	Long-Term Impacts
		Cultural Resources	
No impacts at the Paducah and Portsmouth sites. Impacts cannot be determined at K-25 for construction	No activities in the long term	No impacts at the Paducah and Portsmouth sites. Impacts cannot be determined at K-25 for construction	No activities in the long term
		Environmental Justice	
No disproportionate impacts	No activities in the long term	No disproportionate impacts	No activities in the long term

[a] Under the no action alternative, continued storage of the entire cylinder inventory would take place at the three sites; under the action alternatives, the number of cylinders stored at the three sites would decrease by 5% annually from 2009 through 2028.

Under all alternatives, potential long-term impacts were evaluated for uranium contamination of soil and groundwater from cylinder breaches through 2028 or 2039.

[b] The bounding radiological accident was defined as the accident that would result in the highest dose and risk to the general public MEI; the bounding chemical accident was defined as the accident that would result in the highest population risk (number of people affected).

Notation: HF = hydrogen fluoride; LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

D.2 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE NO ACTION ALTERNATIVE

The potential environmental impacts from continued cylinder storage for the no action alternative were evaluated on the basis of activities that were assumed to be required to ensure safe storage of the cylinders (Parks 1997). These activities include routine and ultrasonic inspections of cylinders, valve maintenance, cylinder painting, storage yard reconstruction, and cylinder relocations. Although these activities would minimize the occurrence of cylinder breaches and would aid in the early identification of breached cylinders, the impacts associated with cylinder breaches that might occur during continued storage were assessed. The assessment methodologies are described in Appendix C.

Assumptions for continued storage were generally selected in a manner intended to produce conservative estimates of impact, that is, the assumptions result in an overestimate of the expected impact. Therefore, although actual activities occurring at the three storage sites during the time period considered might vary, the estimated impacts of continued storage activities assessed in this PEIS are likely to encompass and bound the impacts that could occur at these sites. The following general assumptions apply to continued cylinder storage for the no action alternative:

- The current inventories of cylinders at the three sites would be maintained at the sites through the year 2039.

- The number of breaches assumed to occur under the no action alternative accounts for continued external corrosion prior to the completion of painting of the cylinder inventory. After painting, external corrosion was assumed to cease. Estimated numbers of breaches initiated by mechanical damage caused during cylinder handling are also included. Although current maintenance procedures would most likely lead to immediate identification and repair of any cylinder breaches, some releases of uranium and HF from breached cylinders were assumed for assessment purposes. Impacts were assessed for workers handling the breached cylinders, as well as for noninvolved workers and members of the general public exposed to materials released from breached cylinders.

- To assess potential long-term impacts to groundwater and human health and safety from breached cylinders, potential future groundwater contamination was assessed by assuming that released uranium would be transported from the cylinder storage yards in surface runoff and then migrate through the soil and into groundwater. It was further assumed that public access would be possible for groundwater at the location of the nearest discharge point (i.e., the nearest surface water body in the direction of groundwater flow).

- To address uncertainty in corrosion and cylinder breach assumptions, an assessment was also conducted assuming that external corrosion was not halted by improved maintenance conditions (see Section D.3 for a discussion of potential impacts).

D.2.1 Human Health — Normal Operations

D.2.1.1 Radiological Impacts

Radiological impacts from normal operations of the cylinder storage yards were assessed for the involved workers, noninvolved workers, and off-site general public. Radiation exposures of involved workers would result primarily from external radiation from inspecting and handling the cylinders. Exposures of noninvolved workers would result from airborne releases of uranyl fluoride (UO_2F_2) from breached cylinders. In addition to exposures from airborne releases of UO_2F_2, the analysis also considered potential exposures of the off-site public to waterborne releases of UO_2F_2. Such releases would be possible if UO_2F_2 was deposited on the ground surface and washed off by rain to a surface water body or infiltrated with rain to the deeper soil, thereby reaching the groundwater underlying the storage yards. Detailed discussions of the methodologies used in radiological impact analyses are provided in Appendix C and Cheng et al. (1997).

The estimated radiation doses and latent cancer risks for each of the three storage sites are provided in Tables D.2 and D.3, respectively. During the storage periods, average radiation exposures of involved workers would be less than 750 mrem/yr; exposures of noninvolved workers and members of the general public would be less than 1 mrem/yr. The long-term effects of radiation exposure on the general public resulting from groundwater contamination would be less than 2 mrem/yr. Potential long-term radiological impacts (based on groundwater contamination) are provided in Table D.4.

D.2.1.1.1 Paducah Site

The average annual collective worker dose for continued storage activities at the Paducah site would be about 22 person-rem/yr for about 30 workers for the period from 1999 through 2039. The number of workers required for this period was estimated on the basis of the anticipated activities (Parks 1997) and the assumption that the workers would work 5 hours per day in the storage yard. The average individual worker dose would vary from year to year and was estimated to average 740 mrem/yr, which is considerably below the regulatory limit of 5,000 mrem/yr (*10 Code of Federal Regulations* [CFR] Part 835) and also below the DOE administrative control limit of 2,000 mrem/yr (DOE 1992). Compared with the historical data for worker exposure of 16 to 56 mrem/yr (Hodges 1996), the estimated exposures are greater because of the conservative

TABLE D.2 Radiological Doses from Continued Cylinder Storage under Normal Operations for the No Action Alternative

	Annual Dose to Receptor					
	Involved Workers[a]		Noninvolved Workers[b]		General Public	
Site	Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[c] (mrem/yr)	Collective Dose[d] (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
Paducah	740	22	0.11	0.0023	0.013 (< 0.017)	0.0053
Portsmouth	600	9.2	0.043	0.00031	0.012 (< 0.0077)	0.0013
K-25	410	4.9	0.048	0.00021	0.11 (< 0.051)	0.0026

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999-2039. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

[d] The reported collective doses are averages over the time periods considered. Population size of the noninvolved workers was assumed to be about 2,000 for Paducah, 2,700 for Portsmouth, and 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective dose was estimated for the population within a radius of 50 miles (80 km) around the three sites. The reported values are averages over the time period considered. The off-site populations are 500,000 persons for Paducah, 605,000 for Portsmouth, and 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE D.3 Latent Cancer Risks from Continued Cylinder Storage under Normal Operations for the No Action Alternative

	Annual Risk of Latent Cancer Fatality to Receptor					
	Involved Worker[a]		Noninvolved Worker[b]		General Public	
Site	Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[c] (risk/yr)	Collective Risk[d] (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
Paducah	3×10^{-4}	9×10^{-3}	4×10^{-8}	9×10^{-7}	6×10^{-9} ($< 2 \times 10^{-9}$)	3×10^{-6}
Portsmouth	2×10^{-4}	4×10^{-3}	2×10^{-8}	1×10^{-7}	6×10^{-9} ($< 8 \times 10^{-10}$)	6×10^{-7}
K-25	2×10^{-4}	2×10^{-3}	2×10^{-8}	8×10^{-8}	5×10^{-8} ($< 5 \times 10^{-9}$)	1×10^{-6}

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999-2039.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

[d] The reported collective risks are averages over the time period considered. Population size of the noninvolved workers was assumed to be about 2,000 for Paducah, 2,700 for Portsmouth, and 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective risk was estimated for the population within a radius of 50 miles (80 km) around the three sites. The reported values are averages over the time period considered. The off-site populations are 500,000 persons for Paducah, 605,000 for Portsmouth, and 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE D.4 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage under the No Action Alternative[a,b]

	Impact to MEI of General Public	
Storage Location	Radiation Dose[c] (mrem/yr)	Latent Cancer Risk[c] (risk/yr)
Paducah site	0.051 – 0.41	$3 \times 10^{-8} - 2 \times 10^{-7}$
Portsmouth site	0.026 – 0.33	$1 \times 10^{-8} - 2 \times 10^{-7}$
K-25 site	0.051 - 0.49	$3 \times 10^{-8} - 2 \times 10^{-7}$

[a] The long-term impacts correspond to the time after the year 2039.

[b] Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

[c] Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigation action was taken.

assumptions made regarding future inspection and maintenance activities (Parks 1997) and the conservatism applied in the analytical methods (see Appendix C, Section C.4.1).

Radiation doses to noninvolved workers who worked on-site but not within the cylinder storage yards would be less than 0.11 mrem/yr, primarily from inhalation of UO_2F_2 released from breached cylinders. Radiation exposures of members of the off-site general public would result from both airborne and waterborne releases of UO_2F_2. The radiation dose to the maximally exposed individual (MEI) would be less than 0.03 mrem/yr (0.013 mrem/yr from exposure to airborne releases and 0.017 mrem/yr from using contaminated groundwater). The radiation dose from drinking contaminated surface water would be less than 2×10^{-7} mrem/yr. The dose of 0.03 mrem/yr is considerably below the regulatory limit of 10 mrem/yr (40 CFR Part 61) from airborne emissions and 100 mrem/yr (DOE Order 5400.5) from all exposure pathways. The exposure to the off-site public from continued storage activities would be very small compared with the existing exposures (about 3.03 mrem/yr) (LMES 1996a) from operations of the entire Paducah site.

Potential exposures to members of the off-site public after the year 2039 were also assessed for the use of contaminated groundwater resulting from breaches occurring prior to 2039. Depending on the soil properties that determine the time it takes the uranium to reach the groundwater, the maximum individual dose could range from 0.051 to 0.41 mrem/yr, which is considerably lower than the regulatory limit of 100 mrem/yr.

D.2.1.1.2 Portsmouth Site

In general, the estimated radiation doses from continued storage activities at the Portsmouth site would be less than those for the Paducah site because a smaller number of cylinders would be managed at Portsmouth. The average annual collective worker dose would be 9.2 person-rem/yr for about 16 workers for the period from 1999 through 2039. The average individual worker dose would be about 600 mrem/yr for this operational period, which is below the regulatory limit of 5,000 mrem/yr and the DOE administrative control limit of 2,000 mrem/yr. The estimated average worker dose is greater than the historical data of 55 to 196 mrem/yr (Hodges 1996) because of the more vigorous inspection and maintenance activities planned to be implemented. The radiation dose to noninvolved workers from airborne release of UO_2F_2 would be less than 0.043 mrem/yr for all periods.

The radiation dose to the maximally exposed member of the public would be less than 0.02 mrem/yr (0.012 mrem/yr from airborne releases plus 0.0077 mrem/yr from using contaminated groundwater), considerably below the regulatory limit of 10 mrem/yr from airborne emissions and 100 mrem/yr from all exposure pathways. The radiation dose from drinking contaminated surface water would be 2.1×10^{-5} mrem/yr. Compared with the existing exposure from operations for the entire Portsmouth site (0.066 mrem/yr; LMES 1996b), the dose to the MEI from continued storage activities would be smaller. The long-term radiological impacts to the general public from using contaminated groundwater would range from 0.026 to 0.33 mrem/yr — depending on the soil properties, which would determine the time it took for the uranium to reach the groundwater.

D.2.1.1.3 K-25 Site

The estimated radiation doses to involved workers from continued storage activities at the K-25 site would be less than those for the Paducah and Portsmouth sites because the smallest number of cylinders would be managed at K-25. The average annual collective worker dose would be about 4.9 person-rem/yr for approximately 13 workers for the period from 1999 through 2039. The average individual dose would be about 410 mrem/yr for this period, considerably below the regulatory limit of 5,000 mrem/yr and the DOE administrative control limit of 2,000 mrem/yr. Exposure of involved workers would be greater than the historical data of 32 to 92 mrem/yr (Hodges 1996) because of more worker activities planned to be implemented. Radiation exposure of noninvolved workers at the K-25 site would be less than 0.048 mrem/yr from airborne release of UO_2F_2.

The radiation dose to the MEI of the off-site public resulting from breached cylinders at the K-25 site would be greater than the doses at the Paducah and Portsmouth sites because of the shorter distance assumed between the emission point and the site boundary. As a result, the estimated radiation dose to the MEI of the general public would also be greater than the dose to noninvolved workers. Potential exposure of the general public MEI would be less than 0.16 mrem/yr (0.11 mrem/yr from exposure to airborne releases and 0.051 mrem/yr from using contaminated groundwater). The radiation dose from drinking contaminated surface water would be less than 0.000011 mrem/yr. The radiation dose of 0.16 mrem/yr would be less than the existing exposure of approximately 5 mrem/yr from operation of the entire Oak Ridge Reservation (LMES 1995). The long-term radiological impacts to the general public from using contaminated groundwater would range from 0.051 to 0.49 mrem/yr, which is very low compared with the dose limit of 100 mrem/yr from all exposure pathways.

D.2.1.2 Chemical Impacts

Chemical impacts during continued cylinder storage could result primarily from exposure to UO_2F_2 (the product formed when UF_6 is exposed to moist air) and HF released from hypothetical cylinder breaches. Risks from normal operations were quantified on the basis of calculated hazard indexes. Detailed discussions of the exposure assumptions, health effects assumptions, reference doses used for uranium compounds and HF, and calculational methods used in the chemical impact analysis are provided in Appendix C and Cheng et al. (1997).

Hazardous chemical impacts to the MEI at the three current storage yards were calculated for both noninvolved workers and members of the general public; the results are summarized in Table D.5. Chemical exposures of noninvolved workers and the off-site general public could result from airborne emissions of UO_2F_2 and HF that could be dispersed from hypothetical cylinder breaches into the atmosphere and to the ground surface. The exposure pathways assessed included inhalation of UO_2F_2 and HF and ingestion of UO_2F_2 in soil. In all cases, the MEI hazard index would be considerably below 1, indicating no potential adverse health effects.

D.2.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents was presented in the safety analysis reports (SARs) for the three storage sites (LMES 1997a–c). The potential accidents discussed in the SARs included natural phenomena events such as earthquakes, tornadoes, and floods, and spills from corroded cylinders under various weather conditions. The accidents selected for PEIS analyses were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites for each of the four frequency categories (likely, unlikely, extremely unlikely, and incredible); these accidents are listed in Table D.6. The accidents selected for the PEIS analyses and

TABLE D.5 Chemical Impacts to Human Health from Continued Cylinder Storage under Normal Operations for the No Action Alternative

Site/Time Period	Impacts to Receptor: Noninvolved Workers[a] Hazard Index[c] for MEI	Noninvolved Workers[a] Population Risk[d] (ind. at risk/yr)	General Public[b] Hazard Index[c] for MEI	General Public[b] Population Risk[d] (ind. at risk/yr)
Paducah site 1999-2039	1.0×10^{-3}	–	2.6×10^{-3} ($\leq 2.1 \times 10^{-3}$)	–
Long-term impacts[e]	NA[f]	–	0.01 – 0.05	–
Portsmouth site 1999-2039	4.4×10^{-5}	–	2.6×10^{-3} ($\leq 9.7 \times 10^{-4}$)	–
Long-term impacts[e]	NA	–	0.003 – 0.04	–
K-25 site 1999-2039	4.8×10^{-4}	–	2.3×10^{-2} ($\leq 6.4 \times 10^{-3}$)	–
Long-term impacts[e]	NA	–	0.01 – 0.06	–

[a] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

[b] The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values over the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999-2039 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[e] Long-term impacts would result from using contaminated groundwater. Ranges result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigative measures were taken.

[f] NA = not applicable; workers were assumed not to ingest groundwater.

TABLE D.6 Accidents Considered for the Continued Storage Option

Site/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Paducah Site					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Vehicle-induced fire, 3 full 48Y cylinders	Three full 48Y UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 18,000 2,770 8,010	0 to 24 24 24 to 30 30 to 236	Ground
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Small plane crash, 2 full 48Y cylinders	A small plane crash affects two full 48Y UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 6,020 920 2,670	0 to 24 24 24 to 30 30 to 236	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	3,210 2,730	0 to 30 30 to 236	Ground

TABLE D.6 (Cont.)

Site/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Portsmouth Site					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Vehicle-induced fire, 3 full 48Y cylinders	Three full 48Y UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 18,000 2,770 8,010	0 to 24 24 24 to 30 30 to 236	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Small plane crash, 2 full 48Y cylinders	A small plane crash affects two full 48Y UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 6,020 920 2,670	0 to 24 24 24 to 30 30 to 236	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	3,210 2,730	0 to 30 30 to 236	Ground

TABLE D.6 (Cont.)

Site/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
K-25 Site					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground

[a] Ground-level releases were assumed to occur outdoors on the concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

listed in Table D.6 do not include natural phenomena events, which were found in the SARs to have less serious consequences than other types of accident scenarios (e.g., a vehicle-induced fire affecting three UF_6 cylinders). In those instances where it was not absolutely clear from the SAR which accident would be the bounding accident in a frequency category at a site, several accidents were included in the PEIS analyses, as indicated in Table D.6. The resulting radiological doses and adverse health impacts from chemical exposures for all the accidents listed in Table D.6 are presented in Policastro et al. (1997). In the following sections, the results for only the bounding accident in each frequency category at each site are presented. Detailed descriptions of the methodology and assumptions used in these calculations are provided in Appendix C and Policastro et al. (1997).

D.2.2.1 Radiological Impacts

Table D.7 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table D.8. The doses and the risks are presented for two different meteorological conditions (D and F stability classes) at the three current storage sites (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely (EU) category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to worker and general public MEIs (assuming that an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- The overall radiological risk to worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table D.8] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the continued storage accidents.

D.2.2.2 Chemical Impacts

The accidents discussed in this section are listed in Table D.6. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables D.9 and D.10. The results are presented as (1) number of persons with the potential for adverse effects and (2) number of persons with the potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of workers and off-site population) (Policastro et al. 1997). The impacts presented are based on the assumption that the accidents would occur. The accidents listed in Tables D.9 and D.10 are not identical because an accident with the largest impacts for the adverse effects endpoint might not lead to the largest impacts for the irreversible adverse effects endpoint. Detailed descriptions of the

TABLE D.7 Estimated Radiological Doses per Accident Occurrence for Continued Cylinder Storage under the No Action Alternative

Site/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Paducah									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.4	2.3×10^{-3}	2.6×10^{-1}	3.3×10^{-3}	6.3×10^{-2}	9.8×10^{-5}	3.0×10^{-2}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.5×10^{1}	1.5×10^{-2}	2.8×10^{1}	3.7×10^{-3}	1.3	1.9×10^{-3}	1.1
Portsmouth									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	2.2	2.2×10^{-3}	2.1×10^{-1}	3.3×10^{-3}	9.5×10^{-2}	9.3×10^{-5}	2.8×10^{-2}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	3.2×10^{1}	3.7×10^{-3}	2.0	1.9×10^{-3}	1.6
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.3	4.3×10^{-3}	5.5×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	6.2×10^{-4}	7.6×10^{-2}
K-25									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.3	2.7×10^{-3}	4.3×10^{-1}	3.3×10^{-3}	6.0×10^{-2}	1.1×10^{-4}	5.9×10^{-2}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	6.3×10^{1}	3.7×10^{-3}	2.4	1.9×10^{-3}	2.2
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.4	4.3×10^{-3}	7.4×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	7.1×10^{-4}	1.0×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

TABLE D.8 Estimated Radiological Health Risks per Accident Occurrence for Continued Cylinder Storage under the No Action Alternative[a]

Site/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Paducah									
Corroded cylinder, dry conditions	L	3×10^{-5}	6×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	3×10^{-5}	5×10^{-8}	1×10^{-5}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	1×10^{-2}	1×10^{-6}	5×10^{-4}	1×10^{-6}	5×10^{-4}
Portsmouth									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	9×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	4×10^{-5}	5×10^{-8}	1×10^{-5}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	6×10^{-6}	2×10^{-2}	1×10^{-6}	8×10^{-4}	1×10^{-6}	8×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	3×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	4×10^{-5}
K-25									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	5×10^{-4}	1×10^{-6}	2×10^{-4}	1×10^{-6}	2×10^{-5}	6×10^{-8}	3×10^{-5}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	9×10^{-4}	1×10^{-6}	1×10^{-3}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	4×10^{-4}	3×10^{-7}	3×10^{-4}	4×10^{-7}	5×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

TABLE D.9 Number of Persons with Potential for Adverse Effects from Accidents under Continued Cylinder Storage for the No Action Alternative[a]

Site/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah									
Corroded cylinder spill, dry conditions	L	Yes	10	No	0	Yes	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	690	Yes	14	Yes	7	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	910	Yes	1,900	Yes	4	Yes	3
Portsmouth									
Corroded cylinder spill, dry conditions	L	Yes	48	Yes[f]	0	No	0	No[f]	0
Corroded cylinder spill, wet conditions – rain	U	Yes	850	Yes	12	Yes	2	Yes[f]	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	1,000	Yes	650	Yes	160	Yes	4
Small plane crash, 2 full 48Y cylinders	I	Yes	760	Yes	6	No	0	No	0
K-25									
Corroded cylinder spill, dry conditions	L	Yes	69	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	700	Yes	18	Yes	47	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	770	Yes	550	No	0	Yes	12
Small plane crash, 2 full 48G cylinders	I	Yes	420	Yes	34	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE D.10 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under Continued Cylinder Storage for the No Action Alternative[a]

Site/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah									
Corroded cylinder spill, dry conditions	L	Yes	1	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	130	Yes[f]	0	Yes	1	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	300	Yes	1	Yes	1	No	0
Portsmouth									
Corroded cylinder spill, dry conditions[g]	L	Yes	0	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	90	Yes	1	Yes	0	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	110	Yes[f]	1	Yes	0	No	0
Small plane crash, 2 full 48Y cylinders[g]	I	No	0	No	0	No	0	No	0
K-25									
Corroded cylinder spill, dry conditions	L	Yes	3	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	140	Yes	0	Yes	2	No	0
Vehicle-induced fire, 3 full 48Y cylinders[g]	EU	No	0	No	0	No	0	No	0
Small plane crash, 2 full 48G cylinders[g]	I	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

methodology and assumptions for assessing chemical impacts are provided in Appendix C). The following conclusions may be drawn from the chemical impact results:

- If the accidents identified in Tables D.9 and D.10 did occur, the number of persons in the off-site population with the potential for adverse effects would range from 0 to 1,900 (maximum corresponding to the vehicle-induced fire scenario at the Paducah site), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 7 (maximum corresponding to the corroded cylinder spill with pooling conditions scenario at the Portsmouth site).

- If the accidents identified in Tables D.9 and D.10 did occur, the number of noninvolved workers with the potential for adverse effects would range from 0 to 1,000 (maximum corresponding to the vehicle-induced fire scenario at the Portsmouth site), and the number of noninvolved workers with the potential for irreversible adverse effects would range from 0 to 300 (maximum corresponding to the corroded cylinder spill with pooling scenario at the Paducah site).

- Accidents resulting in a vehicle-induced fire involving three full 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (41 years, 1999-2039). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

  - *Potential Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely):
    Workers at the Paducah, Portsmouth, and K-25 sites

    Corroded cylinder spill, wet conditions – rain (U, unlikely):
    Workers at the Paducah, Portsmouth, and K-25 sites

  - *Potential Irreversible Adverse Effects:*

    Corroded cylinder spill, dry conditions (L likely):
    Workers at the Paducah and K-25 sites

    Corroded cylinder spill, wet conditions – rain (U, unlikely):
    Workers at the Paducah, Portsmouth, and K-25 sites

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table D.10 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures would likely be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 300 irreversible adverse effects, approximately 0 to 3 deaths would be expected. Similarly, of the general public experiencing a range of 0 to 1 irreversible adverse effects, less than 1 death would be expected. These are the maximum potential consequences of the accidents, the upper ends of the ranges assume worst-case weather conditions and that the wind would be blowing in the direction where the highest number of people would be exposed.

D.2.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for workers (involved and noninvolved) conducting activities associated with continued storage was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Annual fatality and injury rates for manufacturing activities were used for all activities except cylinder yard construction or reconstruction; rates specific to construction were available for these activities. Injury incidence rates used were for injuries involving lost workdays (not including the day of injury). No on-the-job fatalities and less than 100 injuries would be expected during the entire continued cylinder storage period.

The activities included as part of the continued storage strategy are routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers for breached cylinders (Parks 1997). These activities were assumed to be continued at currently planned levels through the year 2039, except for yard construction and reconstruction, which were assumed to be completed by the year 2003. The annual labor requirements and the corresponding fatality and injury risks for these activities were estimated to be as follows: the total three-site fatality risk would be less than 1 (0.11), and the total three-site injury risk would be about 140 injuries (see Table D.11).

TABLE D.11 Estimated Impacts to Human Health from Physical Hazards under Continued Cylinder Storage for the No Action Alternative[a,b]

Impacts to All Workers (Involved and Noninvolved)[c]							
Fatality Incidence				Injury Incidence			
Paducah Site	Portsmouth Site	K-25 Site	Total, 3 Sites	Paducah Site	Portsmouth Site	K-25 Site	Total, 3 Sites
0.056	0.030	0.026	0.11	71	39	33	143

[a] Potential impacts are based on continued storage activities, which would include routine inspections, ultrasonic inspections, valve monitoring and maintenance, cylinder relocations, cylinder yard construction and reconstruction, cylinder painting, and patching and content transfers for breached cylinders for the time period 1999-2039.

[b] Risk estimates include reconstruction of L-, M-, N-, and P-yards at Paducah and construction of a new yard at K-25.

[c] Injury and fatality incidence rates used in the calculations were taken from National Safety Council (1995).

D.2.3 Air Quality

The analysis of air quality impacts for continued cylinder storage under the no action alternative was based on three emissions-producing activities: (1) construction of new storage yards; (2) relocation and painting of cylinders; and (3) estimated HF emissions resulting from hypothetical cylinder breaches. The air quality impacts of these three activities are addressed by site in Sections D.2.3.1 through D.2.3.3. Additional details on the assessment of air quality impacts is presented in Tschanz (1997a-b).

D.2.3.1 Paducah Site

The potential impacts of construction were modeled on the basis of assuming area sources located at the yards being reconstructed. The maximum impacts at the Paducah site would occur in 1999 when the L-yard is scheduled for reconstruction. The 1-hour and annual maximum concentrations of criteria pollutants — hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10}) — that would occur during construction of that yard are listed in Table D.12. The annual PM_{10} concentration of 16.7 $\mu g/m^3$ is about 33% of the applicable 50 $\mu g/m^3$ standard. The 24-hour estimated maximum PM_{10} concentration of 131 $\mu g/m^3$ is 87% of the 150 $\mu g/m^3$ standard. With monitored 24-hour PM_{10} concentrations in the vicinity of the Paducah site in the range of 50 to 60 $\mu g/m^3$, the estimated maximum concentration from construction of the yard could raise the total above the standard. The construction fugitive dust

TABLE D.12 Maximum Concentrations of Criteria Pollutants at Site Boundaries during Yard Construction[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]
Paducah Site								
CO	220	0.0055	112	0.011	37.3	–	4.76	–
HC[c]	22.5	–	11.5	–	3.84	–	0.489	–
NO_x	85.0	–	43.4	–	14.5	–	1.85	0.02
SO_x	9.02	–	4.59	–	1.53	–	0.196	0.003
PM_{10}	768	–	391	–	131	0.87	16.7	0.33
K-25 Site								
CO	266	0.0067	122	0.012	41.1	–	7.66	–
HC[c]	27.3	–	12.5	–	4.22	–	0.787	–
NO_x	103	–	47.1	–	15.9	–	2.97	0.03
SO_x	10.9	–	5.00	–	1.69	–	0.315	0.004
PM_{10}	930	–	425	–	144	0.96	26.8	0.54

[a] Paducah values are based on reconstruction of the L-yard; K-25 values are based on construction of a new yard assumed to be located at the site of the current K-yard. No yard construction is planned for the Portsmouth site.

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

emissions used here were based on a general emission factor that considers only the size of the disturbed area and might be an overestimate for the actual use of construction equipment on the site.

Detailed information about the planned construction would be required to more accurately assess the likely actual impacts. However, because the construction site would be adjacent to the facility boundary, it is likely that some measures would be required to reduce the generation of fugitive dust during reconstruction of the yard. Other estimated pollutant concentrations are much smaller fractions of their respective standards, in general being of the order of 1 to 2% of the standard.

Relocating and painting cylinders would involve powered units that produce internal combustion emissions. The paint to be used on the cylinders would be an additional source of volatile organic compound (VOC) emissions (HC is an indicator of VOC sources). Because the

relocation and painting of cylinders would generally occur at several locations for each site, emissions from those activities were modeled as point sources at the centers of the sites. The maximum number of annual cylinder relocations that would be required at Paducah during the no action alternative would be 4,200; the maximum number of cylinders painted annually would be 3,000. Table D.13 gives the estimated maximum concentrations of criteria pollutants at the Paducah site boundaries due to relocations; Table D.14 gives the estimated maximum concentrations due to painting activities.

Assumptions regarding the number of hypothetical cylinder breaches were used to estimate maximum annual HF emissions (Tschanz 1997b); these estimates are listed in Table D.15. The estimated 0.01 $\mu g/m^3$ maximum HF concentration at the Paducah site boundary is considerably below the Kentucky primary annual standard for HF of 0.5 ppm (400 $\mu g/m^3$).

TABLE D.13 Maximum Concentrations of Criteria Pollutants at Site Boundaries due to Cylinder Relocations[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]
Paducah Site								
CO	13.3	0.0033	1.66	0.00017	0.554	–	0.0244	–
HC[c]	1.07	–	0.134	–	0.0448	–	0.00197	–
NO_x	1.59	–	0.199	–	0.0665	–	0.00292	0.00003
SO_x	3.84	–	0.482	–	0.161	–	0.00706	0.00009
PM_{10}	0.337	–	0.0423	–	0.0141	0.0009	0.000620	0.00001
K-25 Site								
CO	5.36	0.00013	1.40	0.00014	0.469	–	0.0277	–
HC[c]	0.434	–	0.113	–	0.0379	–	0.00224	–
NO_x	0.643	–	0.168	–	0.0562	–	0.00332	0.00003
SO_x	1.55	–	0.405	–	0.136	–	0.00803	0.0001
PM_{10}	0.136	–	0.0356	–	0.0119	0.00008	0.000705	0.00001

[a] Cylinder relocations are planned for the Paducah and K-25 sites during the time frame considered (1999-2039).

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE D.14 Maximum Concentrations of Criteria Pollutants at Site Boundaries due to Cylinder Painting[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]	Concentration ($\mu g/m^3$)	Fraction of Standard[b]
Paducah Site								
CO	9.48	0.00024	1.19	0.00012	0.396	–	0.0174	–
HC[c]	127	–	15.9	–	5.31	–	0.233	–
NO_x	1.13	–	0.142	–	0.0472	–	0.0021	0.000021
SO_x	2.75	–	0.344	–	0.115	–	0.0050	0.000064
PM_{10}	0.244	–	0.031	–	0.0102	0.000068	0.00045	0.000009
Portsmouth Site								
CO	3.72	0.000093	0.583	0.000058	0.205	–	0.018	–
HC[c]	49.9	–	7.84	–	2.76	–	0.236	–
NO_x	0.445	–	0.070	–	0.025	–	0.0021	0.000021
SO_x	1.08	–	0.170	–	0.060	–	0.0051	0.000065
PM_{10}	0.097	–	0.015	–	0.0053	0.000035	0.00046	0.000092
K-25 Site								
CO	2.75	0.000069	0.716	0.000072	0.240	–	0.014	–
HC[c]	36.8	–	9.59	–	3.22	–	0.190	–
NO_x	0.321	–	0.084	–	0.028	–	0.0017	0.000017
SO_x	0.803	–	0.209	–	0.070	–	0.0042	0.000054
PM_{10}	0.064	–	0.017	–	0.0056	0.000037	0.00033	0.0000066

[a] Maximum pollutant concentrations are based on the maximum number of cylinders painted annually under the no action alternative: 3,000 at Paducah; 1,350 at Portsmouth; and 1,200 at K-25.

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE D.15 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Existing Storage Sites under the No Action Alternative

Site	Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration ($\mu g/m^3$)	
			24-Hour Average	Annual Average
Paducah	2	5	0.08	0.0093
Portsmouth	2	3	0.10	0.011
K-25	1	2	0.66	0.084

No quantitative estimate was made of the impacts on the criteria pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Paducah site. McCracken County in the Paducah-Cairo Interstate Air Quality Control Region is currently in attainment for all criteria pollutant standards, including ozone. The pollutants most related to ozone formation that could result from the continued storage options at the Paducah site would be HC and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in McCracken County, as recorded in the Kentucky Division of Air Quality Control "Emissions Inventory" for 1995 (Hogan 1996). The estimated maximum annual HC and NO_x emissions of 7.11 and 1.47 tons/yr would be only 1.2 and 0.004%, respectively, of the 1995 McCracken County emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the county.

D.2.3.2 Portsmouth Site

Because no storage yard construction is planned at the Portsmouth site, the maximum pollutant impacts, other than for HC, estimated at the facility boundary are much smaller than those estimated for the other two sites. The maximum criteria pollutant concentrations are shown in Table D.14; criteria pollutant emissions for Portsmouth are associated only with painting activities. For all pollutants, including PM_{10}, the concentrations are less than 0.1% of the standards. As shown in Table D.15, the HF concentrations would likewise be small (Tschanz 1997b). The State of Ohio does not have an ambient air quality standard for HF.

No quantitative estimate was made of the impacts on the criteria pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Portsmouth site. Pike and Scioto Counties in the Wilmington-Chillicothe-Logan Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from continued cylinder storage at the Portsmouth site would be HC and NO_x. The potential effects on ozone of those emissions can be put in

perspective by comparing them with the total emissions of HC and NO_x for point sources in Pike and Scioto Counties, as recorded in the Ohio Environmental Protection Agency "Emissions Inventory" for 1990 (Juris 1996). The estimated HC and NO_x emissions of 3.01 and 0.05 tons/yr from continued storage actions would be only 0.18 and 0.002%, respectively, of the 1990 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region.

D.2.3.3 K-25 Site

The maximum estimated criteria pollutant concentrations at the K-25 boundary during yard construction are shown in Table D.12. These maximum concentrations would occur when the planned new storage yard would be completed. The maximum monitored 24-hour PM_{10} concentration at the Y-12 site is about 29 $\mu g/m^3$, which when added to the estimated maximum PM_{10} concentration at the K-25 site brings the total above the 150 $\mu g/m^3$ standard. The qualifications regarding the estimated PM_{10} concentrations and the likelihood for a need of mitigative measures discussed above for the Paducah site also apply to these K-25 results. As for Paducah, all other criteria pollutant concentrations at K-25 would be well below their respective standards, generally being between 1 to 3% of the standard. For years during which no construction activities are planned, the maximum pollutant concentrations should not exceed air quality standards (Tables D.13 and D.14).

The maximum annual and 24-hour average HF concentrations from hypothetical cylinder breaches at K-25 are estimated to be the highest of the three storage sites, as shown in Table D.15 (Tschanz 1997b). In large part, these high concentrations are a result of the distance to the nearest facility boundary from the modeled location, which for the majority of HF point source emissions is shorter at the K-25 site than at either of the other two facilities. The estimated maximum 24-hour HF concentrations would be 0.66 $\mu g/m^3$, which is 23% of the State of Tennessee standard of 2.9 $\mu g/m^3$. The highest monitored 7-day HF concentration at the Y-12 site in 1992 was 0.28 $\mu g/m^3$.

No quantitative estimate was made of the impacts on the criteria pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the K-25 site. Anderson and Roane Counties in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the continued storage options at the K-25 site would be HC and NO_x. The potential effects on ozone of those pollutants can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Anderson and Roane Counties, as recorded in the Tennessee Division of Air Pollution Control "Emissions Inventory" for 1995 (Conley 1996). The estimated HC and NO_x emissions of 3.03 and 1.24 tons/yr would be only 0.11 and 0.002%, respectively, of the 1995 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region. The HC and NO_x emissions would be even smaller during later continued storage periods.

D.2.4 Water and Soil

Potential water and soil impacts for continued storage of cylinders under the no action alternative were evaluated for surface water, groundwater, and soils at each of the three storage facilities. Impacts to water and soil quality were evaluated by comparisons with U.S. Environmental Protection Agency (EPA) guidelines.

Water use for construction under the no action alternative was estimated to be 2 million gal for the Paducah site and 0.81 million gal for the K-25 site (no construction would occur at the Portsmouth site). Operational water use was estimated as ranging from 0.12 to 0.16 million gal/yr at Paducah, 0.055 to 0.06 million gal/yr at Portsmouth, and 0.025 to 0.032 million gal/yr at K-25.

D.2.4.1 Surface Water

The estimated number of cylinder breaches assumed to occur under the no action alternative is given in Appendix B; these estimates were used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over a period of 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C and Tomasko (1997b).

The estimated maximum uranium concentrations in runoff water leaving the yards would be about 20, 19, and 52 µg/L (5, 5, and 13 pCi/L) for Paducah, Portsmouth, and K-25, respectively. These concentrations would occur in about 2002. The contaminated runoff was then assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentrations would be less than 0.7 µg/L (0.2 pCi/L) for all three sites (Table D.16). This concentration is less than the EPA proposed drinking water maximum contaminant level (MCL) for uranium of 20 µg/L, used here for comparison. The contaminated water would then mix with water in the Ohio River, Scioto River, or Clinch River, resulting in even greater dilution. Because of this mixing, impacts to the major rivers would not be measurable.

D.2.4.2 Groundwater

Groundwater impacts were assessed by assuming that water contaminated due to releases from hypothetical cylinder breaches would leave the yards as runoff and flow to the boundary of the nearest surface water (but not discharge to it), thereby creating a contaminated source on the ground surface. On the basis of the assumption that cylinder painting would control corrosion, the only impacts to groundwater would be to water quality; no impacts would occur to recharge, depth to water, or direction of flow (see Section D.3 for discussion of potential impacts based on assuming a greater number of breaches). Conservative estimates of the concentration of uranium in

TABLE D.16 Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage under the No Action Alternative

Site	Receiving Water	Dilution Factor	Maximum Concentration (µg/L)
Paducah	Little Bayou Creek	124	0.3
	Ohio River	43,600	0.000004
Portsmouth	Little Beaver Creek	26	0.7
	Scioto River	2,240	0.0004
K-25	Poplar Creek	2,550	0.02
	Clinch River	94	0.0002

groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 40 years. This duration corresponds to the time period for the no action alternative. Details on the methodology are given in Appendix C and Tomasko (1997b).

At the end of the no action period (2039), the concentrations of uranium in groundwater directly below the edge of the surface contamination at the Paducah, Portsmouth, and K-25 sites were estimated to be about 0.25, 0.1, and 0.6 µg/L, respectively (Table D.17), for a retardation factor of 5 (Tomasko 1997b). These concentrations are less than the EPA proposed drinking water MCL for uranium of 20 µg/L (EPA 1996). Maximum concentrations of 6, 5, and 7 µg/L would occur at the Paducah, Portsmouth, and K-25 sites, respectively, between 2070 and 2090 (Table D.17). For a retardation factor of 50 (relatively immobile uranium transport), maximum concentrations would be about 10 times less.

D.2.4.3 Soil

Estimated numbers of cylinder breaches assumed to occur under the no action alternative were used to calculate impacts to soil quality. Each breached cylinder was assumed to release a maximum of 1 lb/yr (0.45 kg/yr) for a maximum of 4 years. For soil, the only impacts would be to quality; there would be no impacts to topography, permeability, or erosion potential. Details on these calculations and methodology are presented in Appendix C and Tomasko (1997b).

At the Paducah site, the highest soil concentration of uranium would be 0.1 µg/g in about 2002 for a distribution coefficient (K_d) of 5 (relatively low sorption capacity). If the soil had a larger

TABLE D.17 Groundwater Concentrations for Continued Cylinder Storage for Two Soil Characteristics under the No Action Alternative[a]

	X = 0			X = 1,000 ft		
	Concentration		Time at Maximum	Concentration		Time at Maximum
Site/Parameter	pCi/L	µg/L	Concentration	pCi/L	µg/L	Concentration
Retardation Factor = 5						
Paducah						
Concentration at 40 years	0.07	0.25				
Maximum concentration	2	6.1	70 years	1.3	4.9	90 years
Portsmouth						
Concentration at 40 years	0.03	0.10				
Maximum concentration	1	5.1	80 years	1.1	4.1	96 years
K-25						
Concentration at 40 years	0.2	0.60				
Maximum concentration	2	7.3	60 years	1.5	5.7	80 years
Retardation Factor = 50						
Paducah						
Maximum concentration	0.2	0.7	585 years	0.1	0.5	770 years
Portsmouth						
Maximum concentration	0.1	0.5	670 years	0.1	0.4	860 years
K-25						
Maximum concentration	0.2	0.8	500 years	0.2	0.6	675 years

[a] Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

sorption capacity (K_d = 50), the maximum value would be 10 times greater (1.0 µg/g). At the Portsmouth site, the highest soil concentration of uranium would be 0.09 µg/g in about 2002 for a distribution coefficient of 5 (relatively low sorption capacity). If the soil had a larger sorption capacity (K_d = 50), the maximum value would be 10 times greater, 0.9 µg/g. At the K-25 site, the highest soil concentration of uranium would be 0.3 µg/g in about 2002 for a distribution coefficient of 5 (relatively low sorption capacity). If the soil had a larger sorption capacity (K_d = 50), the maximum value would be 3.0 µg/g. Even with the larger sorption, soil concentrations at the three sites would be below the recommended EPA guideline of 230 µg/g for residential soil and 6,100 µg/g for industrial soil (EPA 1995).

D.2.5 Socioeconomics

The impacts of continued storage on regional economic activity were estimated for a region of influence (ROI) at each of the three storage sites. Additional details regarding the assessment methodology are presented in Appendix C and Allison and Folga (1997).

Current storage activities at each site would likely have a small impact on socioeconomic conditions in the ROIs surrounding the three sites (see Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8). This is partly because a major proportion of expenditures associated with procurement for conducting continued storage activities would flow outside the ROI to other locations in the United States, thereby reducing the concentration of local economic effects of current storage activities at each site.

Slight changes in employment and income would occur in each ROI as a result of local spending derived from employee wages and salaries, local procurement of goods and services required to conduct continued storage activities, and other local investments associated with construction and operations. In addition to creating new (direct) jobs at each site, continued current storage would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at each site. Jobs and income created directly by continued storage, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding each site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of continued cylinder storage activities on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures are discussed in Sections D.2.5.1 through D.2.5.3. Impacts are presented for each storage site during the peak year of construction and the peak year of operations. The potential impacts of continued cylinder storage at the three sites are shown in Table D.18.

D.2.5.1 Paducah Site

During the peak year for construction and reconstruction of cylinder yards, 20 direct jobs would be created at the site and 60 additional jobs indirectly in the ROI (Table D.18) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 80 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $2.0 million of total income produced during the peak year. During the peak year of continued cylinder storage activities, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, at a total income of $2.3 million. Continued storage activities would result in an increase of 0.005 percentage points in the projected baseline compound annual average growth rate in ROI employment from 1999 through 2039.

Construction activities would be expected to generate direct in-migration of 20 in the peak year (Table D.18). Additional indirect job in-migration would also be expected, bringing the total

TABLE D.18 Potential Socioeconomic Impacts of Continued Cylinder Storage under the No Action Alternative

Parameter	Paducah Site		Portsmouth Site		K-25 Site	
	Impacts from Construction[a]	Impacts from Operations[b]	Impacts from Construction[c]	Impacts from Operations[b]	Impacts from Construction[a]	Impacts from Operations[b]
Economic activity in the ROI						
Direct jobs	20	60	–	20	10	30
Indirect jobs	60	30	–	10	50	50
Total jobs	80	90	–	30	60	90
Income ($ million)						
Direct income	1.0	1.8	–	0.6	0.4	2.7
Total income	2.0	2.3	–	0.7	1.5	3.7
Population in-migration into the ROI	70	30	–	10	20	30
Housing demand						
Number of units in the ROI	20	10	–	0	10	10
Public finances						
Change in ROI fiscal balance (%)	0.0	0.0	–	0.0	0.0	0.0

[a] Impacts for peak construction year. Construction activities were assumed to occur over 4 years at the Paducah site and over 1 year at the K-25 site (Parks 1997).

[b] Impacts for peak year of operations. Duration of operations was assumed to be 41 years (1999-2039).

[c] No construction activities are planned for continued cylinder storage at the Portsmouth site.

number of in-migrants to 70 in the peak year. Continued cylinder storage activities would be expected to generate direct and indirect job in-migration of 30 in the peak year of operations and would result in an increase of 0.001 percentage points in the projected baseline compound annual average growth rate in the ROI population from 1999 through 2039.

Continued cylinder storage activities would generate the demand for 20 additional rental housing units during the peak year of construction, representing an impact of 1.6% on the projected number of vacant rental housing units in the ROI (Table D.18). The demand for 10 additional owner-occupied housing units would be expected in the peak year of operations and would represent an impact of 0.3% on the number of vacant owner-occupied housing units.

During the peak year of construction, 70 persons would in-migrate into the ROI, which would lead to an increase of 0.04% over ROI-forecasted baseline revenues and expenditures (Table D.18). In the peak year of operations, 30 in-migrants would be expected, which would result in a 0.02% increase in local revenues and expenditures.

D.2.5.2 Portsmouth Site

During the peak year of continued cylinder storage activities, 20 direct jobs would be created at the site and 10 additional jobs indirectly in the ROI (Table D.18) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 30 jobs would be created. Operations would also produce direct and indirect income in the ROI surrounding the site, at a total income of $0.7 million during the peak year. Continued cylinder storage operations would result in an increase of 0.001 percentage points in the projected baseline compound annual average growth rate in ROI employment from 1999 through 2039.

Continued cylinder storage activities would be expected to generate direct in-migration of less than 10 in the peak year (Table D.18). Additional indirect job in-migration would also be expected and would bring the total number of in-migrants to 10 in the peak year. Operations would result in an increase of less than 0.001 percentage points in the projected baseline compound annual average growth rate in the ROI population from 1999 through 2039.

Continued cylinder storage activities would generate the demand for less than 10 additional rental housing units during the peak year of construction, thus representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table D.18).

During the peak year of operations, 10 persons would in-migrate into the ROI, thereby leading to an increase that rounds to 0.0% over ROI-forecasted baseline revenues and expenditures (Table D.18).

D.2.5.3 K-25 Site

During the single year during which construction activities are planned at the K-25 site, 10 direct jobs would be created at the site and 50 additional jobs indirectly in the ROI (Table D.18) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 60 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $1.5 million in income produced during the year. During the peak year of continued cylinder storage activities, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, at a total income of $3.7 million. Continued cylinder storage activities would result in an increase of less than 0.001 percentage points in the projected baseline compound annual average growth rate in ROI employment from 1999 through 2039.

Construction activities would be expected to generate direct in-migration of 10 in the construction year (Table D.18). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 20 in the peak year. Continued cylinder storage activities would be expected to generate direct and indirect job in-migration of 30 in the peak year of operations and would result in an increase of less than 0.001 percentage points in the projected baseline compound annual average growth rate in the ROI population from 1999 through 2039.

Continued cylinder storage activities would generate the demand for 10 additional rental housing units during the construction year and would represent an impact of 0.2% on the projected number of vacant rental housing units in the ROI (Table D.18). The demand for 10 additional owner-occupied housing units would be expected in the peak year of operations and would represent an impact of 0.1% on the number of vacant owner-occupied housing units.

During construction, 20 persons would in-migrate into the ROI, which would lead to an increase of less than 0.1% over ROI-forecasted baseline revenues and expenditures (Table D.18). In the peak year of operations, 30 in-migrants would be expected, which would result in a 0.01% increase in local revenues and expenditures.

D.2.6 Ecology

Impacts to ecological resources during continued cylinder storage would be expected to be negligible. Analysis of potential impacts was based on exposure to airborne contaminants or contaminants released to soil, groundwater, or surface water. Predicted concentrations of contaminants in environmental media were compared to benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. A detailed discussion of assessment methodology is presented in Appendix C.

At all three sites, atmospheric emissions of criteria pollutants from cylinder storage yard activities — including cylinder painting, cylinder relocation, and new yard construction (at the

Paducah and K-25 sites) — would be well below levels harmful to biota, and impacts to ecological resources would be negligible. (See Section D.2.3 for a discussion of air quality impacts and Appendix C for application of predicted values.)

The maximum annual average air concentration of HF at the site boundary, due to hypothetical cylinder breaches, would be very low, up to 0.08 $\mu g/m^3$ at the K-25 site and less for the other two sites (Section D.2.3). Resulting impacts to biota would be expected to be negligible. Potential impacts to ecological resources are shown in Table D.19.

Soil near the storage yards could become contaminated with uranium by surface runoff from the yards. Uptake of uranium-containing compounds can cause adverse effects to vegetation. The potential maximum uranium concentration in soil would be 1.0 µg/g at the Paducah site, 0.9 µg/g at the Portsmouth site, and 3.0 µg/g at the K-25 site (Section D.2.4.3). Because these estimated concentrations are below the lowest concentration known to produce toxic effects in plants, toxic effects on vegetation due to uranium uptake would not be expected (Table D.19).

Surface runoff from the storage yards would result in maximum (undiluted) uranium concentrations of 20, 19, and 52 µg/L (5.2, 4.8, and 13.4 pCi/L) at the Paducah, Portsmouth, and K-25 sites, respectively (Section D.2.4.1). Resulting dose rates to maximally exposed organisms in the nearest receiving surface water body at each site would be less than 0.016 rad/d, less than 2% of the dose limit of 1 rad/d for aquatic organisms, as specified in DOE Order 5400.5. These uranium concentrations are also considerably below 150 µg/L, which is the lowest concentration known to adversely affect aquatic biota. Therefore, impacts to aquatic biota would not be expected.

Surface runoff from the storage yards could infiltrate adjacent soil and become a source of groundwater contamination. Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium near the storage yards could range up to 6.1, 5.1, and 7.3 µg/L at the Paducah, Portsmouth, and K-25 sites, respectively; uranium activity could range up to 2, 1, and 2 pCi/L, respectively (Section D.2.4.2). Resulting toxic effects and dose rates to maximally exposed organisms would be negligible. Resulting impacts to aquatic biota would therefore be negligible (Table D.19).

Facility accidents (Section D.2.2) could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of the accident, season, and meteorological conditions.

D.2.7 Waste Management

The principal wastes expected to be generated by operations involving continued cylinder storage are low-level radioactive waste (LLW) and low-level mixed waste (LLMW). Impacts on waste management from wastes generated during the continued storage operations at the sites would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or

TABLE D.19 Potential Impacts to Ecological Resources from Continued Cylinder Storage under the No Action Alternative

Contaminant	Biota	Maximum Exposure	Effect
Paducah Site			
Hydrogen fluoride	Wildlife	0.009 µg/m^3	Negligible
Uranium in surface water	Aquatic	20 µg/L	Negligible
		5.2 pCi/L	Negligible
Uranium in groundwater	Aquatic	6.1 µg/L	Negligible
		1.6 pCi/L	Negligible
Uranium in soil	Plants	1.0 µg/g	Negligible
Portsmouth Site			
Hydrogen fluoride	Wildlife	0.01 µg/m^3	Negligible
Uranium in surface water	Aquatic	19 µg/L	Negligible
		4.8 pCi/L	Negligible
Uranium in groundwater	Aquatic	5.1 µg/L	Negligible
		2.1 pCi/L	Negligible
Uranium in soil	Plants	0.9 µg/g	Negligible
K-25 Site			
Hydrogen fluoride	Wildlife	0.08 µg/m^3	Negligible
Uranium in surface water	Aquatic	52 µg/L	Negligible
		13 pCi/L	Negligible
Uranium in groundwater	Aquatic	7.3 µg/L	Negligible
		1.9 pCi/L	Negligible
Uranium in soil	Plants	3.0 µg/g	Negligible

on a regional/national scale. Waste generated at the three sites from continued cylinder storage under the no action alternative are listed in Table D.20. Given the types and quantities of waste expected to be generated, there is little potential for impacts on regional or national waste treatment/disposal capabilities.

Only limited construction of additional facilities would be needed to support the operations involved in the continued storage and maintenance of cylinders. No waste management impacts resulting from construction-generated wastes would be expected.

The normal operations to maintain and store cylinders would consist of inspections, stripping and repainting of the cylinders, and disposal of scrap metal from breached cylinders that required emptying. These operations would generate two primary waste streams: (1) uranium-contaminated scrap metal LLW from breached cylinders and failed valves and (2) solid process residue LLMW from cylinder painting. In the event of cylinder failure, small amounts of additional LLMW could be generated due to releases from breached cylinders.

For all three current storage sites, the amount of LLW generated from continued storage would at most represent less than 1% of site LLW generation (see Appendix C, Section C.10.2). The maximum annual amount of LLW generated during the continued storage of cylinders at all three sites would represent less than 1% of the annual DOE LLW generation.

Continued storage would also generate LLMW at all three sites. At the Paducah site, stripping/painting operations would generate a maximum annual amount of 23 m^3 of LLMW, which

TABLE D.20 Waste Generated during Continued Cylinder Storage under the No Action Alternative

	Waste (m^3)	
Site	LLW[a]	LLMW[b]
Paducah	52	893
Portsmouth	23	418
K-25	10	157
Total (1999-2039)	85	1,468

[a] Contaminated scrap metal from empty cylinders.

[b] Inorganic process residues from cylinder painting.

would be about 20% of the site's total annual LLMW load, which represents a moderate impact to site waste management capabilities. At the Portsmouth site, the LLMW input would be less than 1% of the site load. At the K-25 site, continued cylinder storage would generate less than 1% of the total LLMW load at the Oak Ridge Reservation. Overall, the waste input resulting from continued cylinder storage would have negligible impacts on waste management capabilities at the Portsmouth and K-25 sites, but impacts from disposal of LLMW could have moderate impacts at the Paducah site. Impacts on national waste management capabilities would be negligible. The input of LLMW from continued cylinder storage at the three sites would represent less than 1% of the total nationwide LLMW load.

D.2.8 Resource Requirements

Material resources that could be consumed during continued cylinder storage include construction materials that could not be recovered or recycled, and materials consumed or reduced to unrecoverable forms of waste. Where construction is necessary, materials required could include concrete, sand, gravel, steel, and other metals. In general, none of the construction resources identified for continued cylinder storage are in short supply, and all would be readily available in the vicinity of the three sites. Energy resources during construction and operations would include the consumption of diesel fuel and gasoline for construction equipment and transportation vehicles. The anticipated utilities requirements would be within the supply capacities at each site. Detailed information relating to the methodology is presented in Appendix C.

Cylinder yard construction or reconstruction would occur only at the Paducah and K-25 sites. No reconstruction activities are anticipated at the Portsmouth site.

Continued cylinder storage would require materials such as 55-gal drums for containment of any generated waste, replacement cylinder valves for those found to be defective upon inspection, and diesel fuel and gasoline to operate equipment and on-site vehicles. In addition, two gallons of paint per cylinder would be required for cylinder painting. Potable water would be made available for the needs of the workforce.

Materials and utilities required for construction and operation activities for continued storage at the Paducah, Portsmouth, and K-25 sites are presented in Table D.21. The total quantities of commonly used construction materials are expected to be small compared to local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts of diesel fuel and gasoline are projected to be used. The required material resources during operations would be readily available.

D.2.9 Land Use

No construction activities are planned for the Portsmouth site. Other than disturbances to narrow strips of land along the outer perimeters of existing yards, no additional land clearing would

TABLE D.21 Resource Requirements of Construction and Operations for Continued Cylinder Storage under the No Action Alternative

		Consumption during 1999-2039		
Materials/Resource	Unit	Paducah Site	Portsmouth Site	K-25 Site
Construction				
Solids				
Concrete	yd^3	20,000	0	8,000
Construction aggregate	yd^3	29,000	0	12,000
Special coatings	yd^2	90,000	0	36,000
Liquids				
Gasoline	gal	3,100	0	1,300
Diesel fuel	gal	18,000	0	7,300
Operations[a]				
Solids				
55-gal drums	each	104 – 109	50	18 – 20
Cylinder valves (1-in.)	each	9	4	2
Liquids				
Gasoline	gal/yr	3,400 – 4,500	1,600 – 1,700	700 – 1,000
Diesel fuel	gal/yr	8,600 – 13,600	4,100	1,500 – 2,600
Zinc-based paint	gal/yr	5,700 – 6,000	2,700	1,000 – 1,100

[a] Values reported as ranges generally correspond to varying resource requirements during years for which construction activities are planned.

be necessary at the Paducah site. Construction activities at Paducah would consist of modifications to existing yards; no new construction would occur outside the footprints of existing yards. Although no location has been chosen for a new storage yard at K-25, the areal requirement of 6.7 acres (2.7 ha) would be very small and represent less than 1% of the land available for development on the site. Because the yard would be located in an area already dedicated to similar use, immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

During continued cylinder storage operations, land-use impacts at the three sites would be negligible and limited to potential minor disruptions on land parcels contiguous to the existing yards. No impacts would be expected for off-site land use.

D.2.10 Cultural Resources

Impacts to cultural resources are not likely at the Paducah or Portsmouth sites during continued cylinder storage. The existing and proposed storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources eligible for the *National Register of Historic Places*. No new storage yards are proposed at Portsmouth, so no cultural resources would be affected. A new storage yard is proposed at the K-25 site; however, the exact location is unknown. Impacts might result if the storage yard was constructed on or near an eligible resource.

D.2.11 Environmental Justice

The analysis of potential environmental justice impacts resulting from continued cylinder storage is based on the conclusions drawn in the assessment of impacts on human health (Sections D.2.1 and D.2.2) and a review of environmental impacts presented in discussions of other technical areas (Sections D.2.3 through D.2.10) such as air quality, water quality and soils, socioeconomics, and ecological resources. The analysis of health effects included an examination of risks to the general public associated with normal facility operations and accidents. A detailed description of the mapping procedures, screening criteria, calculational methods, and demographic sector analysis is presented in Appendix C, Section C.8.

Events occurring after 2039 could not be included in the analysis of potential environmental justice impacts because the composition of the population residing within 50 miles (80 km) of a site cannot be projected with accuracy over the long term. Current minority and low-income population proportions for each site were assumed out to the year 2039.

A review of potential human health impacts (Sections D.2.1 and D.2.2) indicated that no high and adverse human health effects or impacts would be expected from continued storage of cylinders at the Paducah, Portsmouth, and K-25 sites. Therefore, although minority and low-income populations reside within 50 miles (80 km) of the sites, no disproportionate impacts would be expected. The distributions of minority and low-income population census tracts within a 50-mile (80-km) radius of each site are shown in Appendix C, Figures C.1 through C.3. Screening criteria limits (Appendix C, Section C.8) for radiological and chemical sources under normal operations and accident conditions were not exceeded, and the risk of fatalities from operations and accidents from 1999 through 2039 would be considerably below one. Radiological releases from normal operations at the three sites would result in annual average doses to the MEI residing outside the facilities that would be considerably below the DOE regulatory limit of 100 mrem/yr for members of the public. Chemical impacts from routine operations under continued storage at all three sites would result in MEI hazard indices well below 1. Additionally, accidental chemical releases would not result in any expected fatalities or expected adverse human health effects for the general public (when considering risk, i.e., the product of the potential number of persons affected and the probability of the accident occurring).

A review of impact assessments for other technical areas (Sections D.2.3 through D.2.10) indicated that few or no impacts would be expected from continued storage of cylinders at any of the sites. Projected air emissions from construction activities and operations would be below federal and state regulatory limits and no impacts to water quality or soils are anticipated. Consequently, no segment of the population, including minorities or persons of low-income, would experience disproportionate impacts.

D.2.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur as a result of continued storage of depleted UF_6 cylinders at the three current storage sites include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the storage yards. These impacts, although considered, were not analyzed in detail because the impacts would be negligibly small or consideration of the impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS.

D.3 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE BASED ON UNCERTAINTIES IN CORROSION CONTROL

Under the no action alternative, it was assumed that cylinders would be painted every 10 years and that the paint would effectively stop any further corrosion of the cylinders (see introduction to this appendix). To address uncertainty in both the effectiveness of the painting in controlling further corrosion and uncertainties in the future painting schedule, a conservative assessment was made of the impacts assuming that painting would have no effect on corrosion. Under this assumption and using historical data from the three sites, the number of breaches that would occur at each site as a function of time were estimated (Lyon 1997). These conservative estimates indicate that the number of breaches that could occur prior to 2039 would be about 400 at Paducah, 74 at Portsmouth, and 210 at K-25 (see Appendix B).

If no credit were taken for corrosion reduction through painting, and if storage was continued at the three current storage sites indefinitely, calculations indicate that uranium releases from breaches occurring at the Paducah site prior to about the year 2020 could result in a sufficient amount of uranium in the soil column to bring the groundwater concentration of uranium to 20 µg/L in the future (about 2100) (Tomasko 1997a). The cylinders would have to undergo uncontrolled corrosion (without painting) until about 2050 at Portsmouth, and until about 2025 at the K-25 site before the same groundwater concentration guideline of 20 µg/L would be a concern. Again, the groundwater concentration would not actually reach 20 µg/L at these sites until about 2100 or later.

Also, if no credit were taken for corrosion reduction through painting, air quality concerns might arise. Calculations indicate that breaches occurring at the K-25 site by around the year 2020

could result in maximum 24-hour average HF concentrations at the site boundary approximately equal to 2.9 $\mu g/m^3$ (3.5 ppb). This level corresponds to the primary standard for the State of Tennessee. For comparison, the maximum estimated 24-hour average HF concentration at the Paducah and Portsmouth sites through the year 2039 would be 2 $\mu g/m^3$ and 0.6 $\mu g/m^3$, considerably below the 2.9 $\mu g/m^3$ level (the State of Kentucky primary standard for HF is much higher [816 $\mu g/m^3$ maximum 24-hour average]; the State of Ohio does not have standards for HF).

A painting program for the cylinders, designed to control further corrosion, has been initiated at the three sites. Therefore, the assumption of uncontrolled corrosion is not a reasonable assumption. The painting program is expected to eliminate or substantially reduce the corrosion of cylinders at the sites. DOE will continue to monitor its cylinders and is committed to maintain the safety basis of continued cylinder storage. If the conditions became substantially different from what is assumed under the no action alternative, DOE would take the appropriate action(s) to maintain the safety basis.

D.4 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE ACTION ALTERNATIVES

For the action alternatives considered in this PEIS — long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal as uranium oxide — continued storage could be necessary for some portion of the DOE-generated cylinders at the current storage sites through approximately 2028. This 30-year storage period would correspond to the period during which construction of conversion, long-term storage, and/or disposal facilities would occur and during which the cylinders would be transported from the current locations to the processing locations. For analyses in this PEIS, the cylinder removal period was assumed to take place between 2009 and 2028; the number of cylinders at each site would decrease by 5% annually during that time.

Potential environmental impacts associated with continued cylinder storage for the action alternatives were assessed with essentially the same methodology used to estimate impacts for the no action alternative (see Section D.2 and Appendix C). Through the year 2008, the number of maintenance activities (such as inspections, yard reconstruction, and painting) was assumed to be the same as for the no action alternative (Parks 1997). From 2009 through 2028, the number of maintenance activities was assumed to decrease by 5% annually, to correspond to the reduction in cylinder inventory that would be occurring. Impacts associated with maintenance activities (e.g., radiation doses to involved workers) would, therefore, generally be reduced for the action alternatives.

A key difference between the assessment of continued storage impacts conducted for the action alternatives and the assessment conducted for the no action alternative was in the assumptions made regarding potential numbers of breached cylinders. Because of impending cylinder movement or content transfer, cylinder yard improvement and cylinder painting might not occur at the same rate

under the action alternatives as they would under the no action alternative. Because the painting schedule that would be followed under the action alternatives is not known, and to present reasonable upper bound estimates of impacts, no credit was taken for the effectiveness of cylinder yard improvements and painting in reducing cylinder corrosion rates. Therefore, the number of hypothetical cylinder breaches assumed for the action alternatives was estimated by assuming that painting and improved storage conditions were not effective in arresting continued corrosion of the cylinders (i.e., assuming that corrosion continued at historical rates; see Appendix B) and by assuming that the population of cylinders at each site was decreasing at an annual rate of 5% between the years 2009 and 2028. These assumptions led to a higher number of assumed breaches for continued storage under the action alternatives than under the no action alternative, even though the number of years of storage would be lower. The assumptions for releases of uranium and HF from breached cylinders, as well as for methods to estimate water and soil impacts, were identical to those used for the assessment of impacts for the no action alternative. However, the outcome of the increased number of assumed cylinder breaches was a slightly higher estimate of impacts on groundwater, air quality, and human health and safety for the action alternatives, although the estimated impacts are still within applicable standards or guidelines (see Table D.1). The impacts of continued cylinder storage under the action alternatives for the various technical areas of interest are discussed in Sections D.4.1 through D.4.11. Assessment methods are described in Appendix C and in Section D.2.

D.4.1 Human Health — Normal Operations

D.4.1.1 Radiological Impacts

Estimated radiation doses and latent cancer risks for each of the three storage sites are presented in Tables D.22 and D.23. Long-term radiological impacts (based on groundwater contamination) are provided in Table D.24.

D.4.1.1.1 Paducah Site

During the continued cylinder storage period, the average annual collective dose for involved workers would be about 15 person-rem/yr for an average of 23 workers, assuming the workers work 5 hours per day in the cylinder yard. The individual dose for involved workers would average 650 mrem/yr for this period of time. The maximum dose for noninvolved workers would be less than 0.3 mrem/yr, well below the regulatory limit of 10 mrem/yr. For the general public, the maximum dose would be approximately 0.1 mrem/yr, with 0.03 mrem/yr from airborne pathways and 0.07 mrem/yr from groundwater pathways.

Long-term radiation exposure after year 2028 from use of contaminated groundwater would result in a maximum dose of 1.3 mrem/yr, which is a small fraction of the DOE dose limit of 100 mrem/yr for the general public.

TABLE D.22 Radiological Doses from Continued Cylinder Storage under Normal Operations for the Action Alternatives

	Annual Dose to Receptor					
	Involved Workers[a]		Noninvolved Workers[b]		General Public	
Site	Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[c] (mrem/yr)	Collective Dose[d] (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
Paducah	650	15	0.26	0.012	0.031 (< 0.072)	0.017
Portsmouth	450	6.0	0.057	0.00040	0.017 (< 0.0051)	0.0017
K-25	260	3.0	0.17	0.0031	0.37 (< 0.085)	0.017

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999-2028. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

[d] The reported collective doses are averages over the time periods considered. Population size of the noninvolved workers was assumed to be about 2,000 for Paducah, 2,700 for Portsmouth, and 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective dose was estimated for the population within a radius of 50 miles (80 km) around the three sites. The reported values are averages over the time period considered. The off-site populations are 500,000 persons for Paducah, 605,000 for Portsmouth, and 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE D.23 Latent Cancer Risks from Continued Cylinder Storage under Normal Operations for the Action Alternatives

	Annual Risk of Latent Cancer Fatality to Receptor					
	Involved Worker[a]		Noninvolved Worker[b]		General Public	
Site	Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[c] (risk/yr)	Collective Risk[d] (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
Paducah	3×10^{-4}	6×10^{-3}	1×10^{-7}	5×10^{-6}	2×10^{-8} ($< 7 \times 10^{-9}$)	8×10^{-6}
Portsmouth	2×10^{-4}	2×10^{-3}	2×10^{-8}	2×10^{-7}	8×10^{-9} ($< 5 \times 10^{-10}$)	8×10^{-7}
K-25	1×10^{-4}	1×10^{-3}	7×10^{-8}	1×10^{-6}	2×10^{-7} ($< 8 \times 10^{-9}$)	9×10^{-6}

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999-2028.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

[d] The reported collective risks are averages over the time period considered. Population size of the noninvolved workers was assumed to be about 2,000 for Paducah, 2,700 for Portsmouth, and 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective risk was estimated for the population within a radius of 50 miles (80 km) around the three sites. The reported values are averages over the time period considered. The off-site populations are 500,000 persons for Paducah, 605,000 for Portsmouth, and 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE D.24 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage under the Action Alternatives[a,b]

	Impact to MEI of General Public	
Storage Location	Radiation Dose[c] (mrem/yr)	Latent Cancer Risk[c] (risk/yr)
Paducah site	0.13 – 1.3	$6 \times 10^{-8} - 7 \times 10^{-7}$
Portsmouth site	0.021 – 0.21	$1 \times 10^{-8} - 1 \times 10^{-7}$
K-25 site	0.077 - 0.64	$4 \times 10^{-8} - 3 \times 10^{-7}$

[a] Long-term impacts correspond to the time after the year 2028.

[b] Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

[c] Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2028, assuming no mitigation action was taken.

D.4.1.1.2 Portsmouth Site

During the cylinder storage period (1999-2028), the average annual collective dose for involved workers would be 6.0 person-rem/yr for approximately 14 workers, resulting in an average individual dose of 450 mrem/yr. The doses for the MEIs of noninvolved workers and members of the general public would be less than 0.06 and 0.02 mrem/yr, respectively, from airborne emission of UO_2F_2. Additional exposure of the general public could be caused by use of contaminated groundwater; the maximal dose would be about 0.005 mrem/yr by the end of the cylinder storage period. The radiation exposure of involved workers would be much less than the regulatory limit of 5,000 mrem/yr; exposure of noninvolved workers and members of the general public would be quite small compared with the regulatory limits of 10 mrem/yr for airborne emissions and 100 mrem/yr for all exposure pathways for the general public.

Long-term radiation exposure after the year 2028 from the use of contaminated groundwater would result in a maximum dose of 0.21 mrem/yr.

D.4.1.1.3 K-25 Site

Radiation exposures of involved workers at the K-25 site would be less than those at the Paducah and Portsmouth sites because fewer cylinders would be managed at the K-25 site. During continued cylinder storage, involved workers would receive an average dose of 260 mrem/yr from performing cylinder maintenance activities. The average annual collective dose for involved workers would be 3.0 person-rem/yr for approximately 12 workers. Radiation exposures of noninvolved workers and members of the general public would be less than 0.17 and 0.37 mrem/yr, respectively, from airborne emission of UO_2F_2. The dose for the general public MEI would be greater than that for the noninvolved worker MEI because of the close proximity from the assumed emissions point to the site boundary. Potential radiation exposure from the use of contaminated groundwater would result in a dose of less than 0.081 mrem/yr at the end of this period.

Long-term radiation exposure after the year 2028 from the use of contaminated groundwater would result in a maximal dose of 0.64 mrem/yr.

D.4.1.2 Chemical Impacts

Chemical impacts associated with continued cylinder storage could result primarily from exposure to uranium compounds and HF released from hypothetical cylinder breaches. Estimated impacts for each of the three storage sites are given in Table D.25. The highest hazard quotients result when the use of contaminated groundwater is considered in addition to exposures through inhalation, soil ingestion, and surface water ingestion (i.e., maximum hazard quotient of 0.17 at the Paducah site). Adverse health effects would not be expected from exposure to chemical contaminants associated with continued cylinder storage (that is, the estimated hazard indices would all be less than the threshold value of 1).

D.4.2 Human Health — Accident Conditions

The assessment of impacts conducted for potential accidents associated with continued cylinder storage under the action alternatives was similar to that for the no action alternative (Section D.2.2) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring would therefore be somewhat lower under the action alternatives.

TABLE D.25 Chemical Impacts to Human Health from Continued Cylinder Storage under Normal Operations for the Action Alternatives

Site/Time Period	Impacts to Receptor: Noninvolved Workers[a] Hazard Index[c] for MEI	Noninvolved Workers[a] Population Risk[d] (ind. at risk/yr)	General Public[b] Hazard Index[c] for MEI	General Public[b] Population Risk[d] (ind. at risk/yr)
Paducah site				
1999-2028	1.6×10^{-3}	–	5.2×10^{-3} (9.0×10^{-3})	–
Long-term impacts[e]	NA[f]	–	0.02 – 0.17	–
Portsmouth site				
1999-2028	3.9×10^{-5}	–	3.0×10^{-3} (6.4×10^{-4})	–
Long-term impacts[e]	NA	–	0.003 – 0.03	–
K-25 site				
1999-2028	1.1×10^{-3}	–	6.5×10^{-2} (1.1×10^{-2})	–
Long-term impacts[e]	NA	–	0.01 – 0.08	–

[a] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

[b] The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values for the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999-2028 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[e] Long-term impacts would result from using contaminated groundwater.

[f] NA = not applicable; workers were assumed not to ingest groundwater.

D.4.2.1 Radiological Impacts

The accidents that might be associated with continued cylinder storage under the action alternatives are identical to those addressed under the no action alternative. See Section D.2.2.1 for the discussion of potential human health impacts associated with radiological exposures from accidental releases.

D.4.2.2 Chemical Impacts

The accidents that might be associated with continued cylinder storage under the action alternatives are identical to those addressed under the no action alternative. See Section D.2.2.2 for the discussion of potential human health impacts associated with chemical exposures from accidental releases.

D.4.2.3 Physical Hazards

The activities considered in calculating the physical hazards associated with continued cylinder storage were routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers of breached cylinders. The annual labor requirements and the corresponding fatality and injury risks to all workers for these activities were estimated to be less than 1 (0.07) for the total three-site fatality risk and about 90 injuries for the total three-site injury risk (see Table D.26).

D.4.3 Air Quality

The assessment of air quality impacts from construction, relocating cylinders, and painting cylinders conducted for the no action alternative would also be applicable for the action alternatives because the assessment was based on maximum annual impacts (i.e., the same construction activities were assumed, as well as the same levels of relocating and painting cylinders during the initial years of continued storage). Potential impacts on air quality from these activities are discussed in Section D.2.3.

The estimated HF emissions for the action alternatives would differ from those for the no action alternative because different numbers of breached cylinders were assumed (see Appendix B). The numbers of hypothetical breaches and estimated resulting HF concentrations at the three current storage sites are given in Table D.27. The estimated 0.27 $\mu g/m^3$ maximum 24-hour average HF concentration for the Paducah site is considerably below the Kentucky primary annual standard for HF of 400 $\mu g/m^3$ (0.5 ppm). The estimated 2.7 $\mu g/m^3$ maximum 24-hour average HF concentration for the K-25 site is below the Tennessee 24-hour average standard of 2.9 $\mu g/m^3$.

TABLE D.26 Estimated Impacts to Human Health from Physical Hazards under Continued Cylinder Storage for the Action Alternatives[a,b]

Impacts to All Workers (Involved and Noninvolved)[c]							
Fatality Incidence				Injury Incidence			
Paducah Site	Portsmouth Site	K-25 Site	Total, 3 Sites	Paducah Site	Portsmouth Site	K-25 Site	Total, 3 Sites
0.03	0.02	0.02	0.07	41	26	23	90

[a] Potential impacts are based on continued storage activities, which would include routine inspections, ultrasonic inspections, valve monitoring and maintenance, cylinder relocations, cylinder yard construction and reconstruction, cylinder painting, and patching and content transfers for breached cylinders for the time period 1999-2028.

[b] Risk estimates include reconstruction of L-, M-, N-, and P-yards at Paducah and construction of a new yard at K-25.

[c] Injury and fatality rates used in the calculations were taken from National Safety Council (1995).

TABLE D.27 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the Existing Storage Sites for the Action Alternatives

Site	Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration ($\mu g/m^3$)	
			24-Hour Average	Annual Average
Paducah	4	16	0.27	0.03
Portsmouth	1	4	0.14	0.015
K-25	3	8	2.7	0.34

D.4.4 Water and Soil

D.4.4.1 Surface Water

The estimated numbers of cylinder breaches assumed to occur during continued cylinder storage for the action alternatives are given in Appendix B. These estimates were used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C and Tomasko (1997b).

The estimated maximum uranium concentrations in runoff water leaving the yards would be about 121, 25, and 130 µg/L (31, 6, and 34 pCi/L) for the Paducah, Portsmouth, and K-25 sites, respectively. These concentrations would occur in about the year 2018. After leaving the yards, the contaminated runoff was assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentrations would be less than 2 µg/L (0.5 pCi/L) for all three sites (see Table D.28). This concentration is less than the EPA proposed drinking water MCL for uranium of 20 µg/L, used here for comparison. The contaminated water would then mix with water in the Ohio River, Scioto River, or Clinch River, which would result in even greater dilution. Because of this mixing, impacts to the major rivers would not be measurable.

TABLE D.28 Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage under the Action Alternatives

Site	Receiving Water	Dilution Factor	Maximum Concentration (µg/L)
Paducah	Big Bayou Creek	124	1.7
	Ohio River	43,600	0.00002
Portsmouth	Little Beaver Creek	26	1
	Scioto River	2,240	0.0005
K-25	Poplar Creek	2,550	0.05
	Clinch River	94	0.0005

D.4.4.2 Groundwater

Methods for estimating groundwater impacts were the same as those used for the no action alternative (Section D.2.4.2); however, a larger number of cylinder breaches was assumed to occur. Conservative estimates of the concentrations of uranium in groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 20 years; this time interval corresponds to the time over which the concentration in surface water would be higher than half of its maximum value.

At the end of the time period considered for the action alternatives (1999-2028), the concentration of uranium in groundwater directly below the edge of the surface contamination at the Paducah, Portsmouth, and K-25 sites is estimated to be about 1.1, 0.09, and 1.3 μg/L (0.3, 0.02, and 0.3 pCi/L), respectively, for a retardation factor of 5 (Table D.29) (Tomasko 1997b). These concentrations are less than the proposed EPA drinking water MCL for uranium of 20 μg/L, used here for comparison (EPA 1996).

Maximum concentrations of about 20, 4, and 9 μg/L (5, 1, and 3 pCi/L) would occur between the years 2070 and 2080 at Paducah, Portsmouth, and K-25, respectively, assuming a retardation factor of 5. The maximum concentration would only equal the EPA proposed drinking water guideline at Paducah; this guideline is not directly applicable because the groundwater directly at the boundary of the nearest surface water is unlikely to be used as a drinking water source. For a retardation factor of 50 (relatively immobile uranium transport), maximum concentrations would be about 10 times less. These concentrations would occur between the years 2500 and 2700.

Assuming a retardation factor of 5 and a distance of 1,000 ft (300 m) from the edge of the source area, the maximum concentration of uranium would range from about 9 μg/L (3 pCi/L at the K-25 site to 16 μg/L (4 pCi/L) at the Paducah site. For less mobile conditions (retardation of 50), the maximum concentrations would be about 10 times less.

D.4.4.3 Soil

Maximum uranium concentrations in soil for a distribution coefficient of 50 (relatively high sorption capacity) would range from 1.2 μg/g for the Portsmouth site to 6.5 μg/g for the K-25 site. If the soil had a lower sorption capacity (distribution coefficient of 5), the soil concentrations would be 10 times lower. These maximum soil concentrations associated with continued cylinder storage under the action alternatives are much lower than the recommended EPA guideline levels of 230 μg/g for residential soil or 1,000 μg/g for industrial soil (EPA 1995).

TABLE D.29 Groundwater Concentrations for Continued Cylinder Storage for Two Soil Characteristics under the Action Alternatives[a]

Site/Parameter	X = 0 Concentration pCi/L	X = 0 Concentration µg/L	X = 0 Time to Maximum Concentration	X = 1,000 ft Concentration pCi/L	X = 1,000 ft Concentration µg/L	X = 1,000 ft Time to Maximum Concentration
Retardation Factor = 5						
Paducah						
Concentration at 30 years	0.28	1.1				
Maximum concentration	5.2	20	> 70 years	4.0	16	> 70 years
Portsmouth						
Concentration at 30 years	0.02	0.09				
Maximum concentration	0.8	3.5	> 70 years	0.7	2.8	> 70 years
K-25						
Concentration at 30 years	0.33	1.3				
Maximum concentration	2.5	9.4	> 70 years	2.0	7.7	> 70 years
Retardation Factor = 50						
Paducah						
Maximum concentration	0.5	2.1	> 500 years	0.4	1.6	> 500 years
Portsmouth						
Maximum concentration	0.08	0.4	> 500 years	0.07	0.3	> 500 years
K-25						
Maximum concentration	0.3	1.1	> 500 years	0.2	0.8	> 500 years

[a] Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

D.4.5 Socioeconomics

The methods used to assess socioeconomic impacts of continued cylinder storage for the action alternatives were the same as those used for the no action alternative (Section D.2.5). Impacts are presented in Table D.30. Construction impacts would be identical to those estimated for the no action alternative because all construction would take place during the time period 1999-2008, when identical activities are assumed. For K-25, the estimated impacts from operations under the action alternatives are slightly higher than those estimated for the no action alternative, primarily because of the increased number of cylinder breaches assumed, which would require increased levels of activities for repairs, thus leading to increased employment. Under the action alternatives,

TABLE D.30 Potential Socioeconomic Impacts of Continued Cylinder Storage under the Action Alternatives

Parameter	Paducah Site		Portsmouth Site		K-25 Site	
	Impacts from Construction[a]	Impacts from Operations[b]	Impacts from Construction[c]	Impacts from Operations[b]	Impacts from Construction[a]	Impacts from Operations[b]
Economic activity in the ROI						
Direct jobs	20	60	–	20	10	40
Indirect jobs	60	30	–	10	50	70
Total jobs	80	90	–	30	60	110
Income ($ million)						
Direct income	1.0	1.7	–	0.5	0.4	3.8
Total income	2.0	2.2	–	0.6	1.5	5.1
Population in-migration into the ROI	70	30	–	10	20	30
Housing demand						
Number of units in the ROI	20	10	–	0	10	10
Public finances						
Change in ROI fiscal balance (%)	0.0	0.0	–	0.0	0.0	0.0

[a] Impacts for peak construction year. Construction activities were assumed to occur over 4 years (1999-2002) at the Paducah site and over 1 year (1999) at the K-25 site.

[b] Impacts for peak year of operations. Duration of operations was assumed to be 30 years (1999-2028).

[c] No construction activities are planned for continued cylinder storage at the Portsmouth site.

continued storage activities would still have a negligible impact on socioeconomic conditions in the ROIs surrounding the three sites.

D.4.6 Ecology

For continued cylinder storage under the action alternatives, the maximum annual average HF concentrations would be 0.009 $\mu g/m^3$, 0.015 $\mu g/m^3$, and 0.081 $\mu g/m^3$ for the Paducah, Portsmouth, and K-25 sites, respectively (Section D.4.3). Resulting impacts to biota would be expected to be negligible. Contamination of soils near the storage yards by surface runoff could result in maximum uranium concentrations of 6.1 $\mu g/g$ at the Paducah site, 1.2 $\mu g/g$ at the Portsmouth site, and 6.5 $\mu g/g$ at the K-25 site (Section D.4.4). The predicted concentrations for the Paducah and K-25 sites are approximately the same as the lowest uranium concentration reported to produce toxic effects in plants (5 $\mu g/kg$). The extent of vegetation affected would be restricted to the area of surface runoff from the yards. Therefore, impacts to vegetation would be expected to be negligible to low. Surface runoff from the storage yards would have a maximum uranium concentration of 121 $\mu g/L$ (31 pCi/L) at the Paducah site, 25 $\mu g/L$ (6 pCi/L) at the Portsmouth site, and 130 $\mu g/L$ (34 pCi/L) at the K-25 site (Section D.4.4). Resulting impacts to maximally exposed organisms in the nearest receiving surface water body at each site would be expected to be negligible. Uranium concentrations in groundwater would be considerably less and resulting impacts to aquatic biota would be negligible.

Uranium concentrations in groundwater following the cylinder removal period would be very low, and long-term impacts to aquatic biota would not be expected. Contaminants associated with cylinder storage would not occur in other environmental media following the cylinder removal period.

D.4.7 Waste Management

As for the no action alternative, the principal wastes that are expected to be generated during continued cylinder storage are uranium-contaminated scrap metal from breached cylinders and failed valves, assumed to be LLW, and solid process residue from cylinder painting, assumed to be LLMW. The amounts of these waste types estimated to be generated for continued cylinder storage under the action alternatives is given in Table D.31. The annual amount of LLW generated would be less than 2% of site LLW generation for all three sites. The maximum annual amount of LLW generated during continued cylinder storage at all three sites would represent less than 1% of the annual DOE LLW generation.

For the Portsmouth and K-25 sites, the annual amount of LLMW generation would be less than 1% of site LLMW generation. However, for the Paducah site, the annual amount of LLMW generated during the initial years of evaluation, when painting of the entire inventory was assumed

TABLE D.31 Waste Generated during Continued Cylinder Storage under the Action Alternatives

Site	Waste (m^3)	
	LLW[a]	LLMW[b]
Paducah	792	440
Portsmouth	350	204
K-25	206	45
Total (1999-2028)	1,348	689

[a] Contaminated scrap metal from empty cylinders.

[b] Inorganic process residues from cylinder painting.

to occur (23 m^3/yr), would represent about 20% of the site's total annual LLMW load, a moderate impact on site waste management capabilities. The input of LLMW from continued storage would represent less than 1% of the total nationwide LLMW load.

Overall, the waste input resulting from the continued storage of cylinders under the action alternatives would have negligible impacts on waste management capabilities at the Portsmouth and K-25 sites. Impacts from disposal of LLMW could have moderate impacts at the Paducah site. Impacts on national waste management capabilities would be negligible.

D.4.8 Resource Requirements

Resource requirements for continued cylinder storage under the action alternatives are summarized in Table D.32. The resource requirements for construction would be identical to those for the no action alternative. The upper end of the range of annual requirements shown in Table D.32 generally corresponds to the upper end of the range estimated for the no action alternative; these requirements represent the early years of continued cylinder storage when some construction activities are planned. The lower end of the range of annual resource requirements is lower than the lower values for the no action alternative because maintenance of the decreasing cylinder inventory would require fewer resources.

The total quantities of commonly used construction materials needed for continued storage under the action alternatives are expected to be small compared with local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts

TABLE D.32 Resource Requirements of Construction and Operations for Continued Cylinder Storage under the Action Alternatives

Materials/Resource	Unit	Consumption during 1999-2028		
		Paducah Site	Portsmouth Site	K-25 Site
Construction				
Solids				
Concrete	yd^3	20,000	0	8,000
Construction aggregate	yd^3	29,000	0	12,000
Special coatings	yd^2	90,000	0	36,000
Liquids				
Gasoline	gal	3,100	0	1,300
Diesel fuel	gal	18,000	0	7,300
Operations[a]				
Solids				
55-gal drums	each	53 – 109	26 – 50	10 – 18
Cylinder valves (1-in.)	each	4 – 9	2 – 4	1 – 2
Liquids				
Gasoline	gal/yr	2,000 – 4,500	810 – 1,600	450 – 1,000
Diesel fuel	gal/yr	4,300 – 13,600	2,100 – 4,100	800 – 2,600
Zinc-based paint	gal/yr	2,900 – 6,000	1,400 – 2,700	470 – 1,000

[a] Values reported as ranges generally correspond to varying resource requirements during years for which construction activities are planned.

of diesel fuel and gasoline are projected to be used. The required material resources during operations would appear to be readily available.

D.4.9 Land Use

Construction activities assumed for continued storage under the action alternatives are identical to those assumed for the no action alternative. Therefore, potential land-use impacts would be the same as those discussed in Section D.2.9.

D.4.10 Cultural Resources

Potential impacts to cultural resources under the action alternatives would be identical to those discussed in Section D.2.10.

D.4.11 Environmental Justice

Because no screening criteria limits for radiological and chemical sources under normal operations were exceeded under the action alternatives, no disproportionate impacts to minority and low-income populations would be associated with normal operations for continued cylinder storage. The assessment of impacts for potential accidents associated with continued cylinder storage under the action alternatives is similar to that for the no action alternative (Section D.2.11) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring is somewhat lower. However, the conclusion that no disproportionate impacts would be associated with continued cylinder storage under the no action alternative is still applicable for the action alternatives because risks are lower for these alternatives.

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APPENDIX E:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE

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NOTATION (APPENDIX E)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MCL	maximum contaminant level
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 µm or less
ROI	region of influence

Chemicals

CO	carbon monoxide
HC	hydrocarbons
HF	hydrogen fluoride
NaOH	sodium hydroxide
NO_x	nitrogen oxides
UF_6	uranium hexafluoride
UO_2F_2	uranyl fluoride
$UO_2(OH)_2$	uranyl hydroxide

UNITS OF MEASURE

Ci	curie(s)
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
gal	gallon(s)
gpm	gallon(s) per minute
GWh	gigawatt-hour(s)
ha	hectare(s)
kg	kilogram(s)
L	liter(s)
lb	pound(s)
µg	microgram(s)
µm	micrometer(s)
m	meter(s)
m^3	cubic meter(s)
min	minute(s)
mrem	millirem(s)
pCi	picocurie(s)
rem	roentgen equivalent man
s	second(s)
scf	standard cubic foot (feet)
ton(s)	short ton(s)
yd^3	cubic yard(s)
yr	year(s)

APPENDIX E:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the cylinder preparation options considered in the PEIS. The discussion provides background information for these options, as well as a summary of the estimated environmental impacts associated with each option.

Cylinder Preparation Options

Cylinder preparation refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. However, after several decades in storage, some cylinders no longer meet these requirements. Two options for preparing these cylinders for shipment are considered in the PEIS.

Cylinder Overcontainers. Cylinders that do not meet DOT requirements could be placed inside protective metal "overcontainers" for shipment. These reusable overcontainers, which would be slightly larger than a cylinder, would be designed to meet all DOT requirements.

Cylinder Transfer. In this option, the depleted UF_6 in cylinders that do not meet DOT requirements would be transferred to new cylinders capable of being transported.

Note: For both options, cylinders that meet DOT shipment requirements would be shipped directly.

The term "cylinder preparation" refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Under the PEIS alternative management strategies, transportation of depleted UF_6 cylinders was assumed to be required from the three current cylinder storage sites to either (1) a conversion facility or (2) a long-term storage site (for long-term storage of UF_6). UF_6 cylinders have been transported safely by truck and rail between DOE facilities, electric utilities, reactor fuel fabricators, and research nuclear reactors for about 40 years.

Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. The DOT requirements, specified in Title 49 of the *Code of Federal Regulations* (CFR), are intended to maintain the safety of shipments during both routine and accident conditions. Cylinders meeting the DOT requirements could be loaded directly onto specially designed truck trailers or railcars for shipment. However,

after several decades in storage, some cylinders no longer meet the DOT requirements. Two cylinder preparation options, which address different approaches that could be used to transport the depleted UF_6 stored in these cylinders, are considered in the PEIS. These two options, discussed in detail in Section E.2, are a cylinder overcontainer option and a cylinder transfer option.

It is unknown exactly how many of the depleted UF_6 cylinders currently do not meet the DOT transportation requirements. The potential problems with cylinders are related to three DOT requirements that must be satisfied before shipment: (1) cylinders must be filled to less than 62% of the maximum capacity (the fill-limit was reduced to 62% from 64% around 1987); (2) the pressure within cylinders must be less than atmospheric pressure; and (3) cylinders must be free of damage or defects, such as dents, and have a specified minimum wall thickness. Cylinders not meeting these requirements are referred to as overfilled, overpressurized, and substandard, respectively. Some cylinders may fail to meet more than one requirement.

The assessment of cylinder preparation options in the PEIS considers the environmental impacts of preparing the entire DOE-generated depleted UF_6 cylinder inventory for shipment over a 20-year period. Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment. If a cylinder failed the inspection, it would be prepared using one of the two cylinder preparation options (see Section E.2).

If cylinder shipment was necessary under the alternative selected, this activity would occur at each site (e.g., cylinders might be shipped to a conversion facility or to a long-term storage facility, assuming that the site(s) selected for these facilities were not the current storage locations). Therefore, the assessment of cylinder preparation options in this PEIS was designed to address the entire range of potential cylinder preparation needs at each of the three sites, as follows:

- ***Paducah Site:*** The estimated number of cylinders not meeting DOT requirements at the Paducah site would range from 9,600 to 28,351 (the entire Paducah inventory of DOE-generated cylinders). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 480 to 1,420 cylinders annually and, conversely, to prepare from 0 to 940 standard cylinders per year for shipment.

- ***Portsmouth Site:*** The estimated number of cylinders not meeting DOT requirements at the Portsmouth site would range from 2,600 to 13,388 (the entire Portsmouth inventory of DOE-generated cylinders). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 130 to 670 cylinders annually and to prepare from 0 to 540 standard cylinders per year for shipment.

- ***K-25 Site:*** The estimated number of cylinders not meeting DOT requirements at the K-25 site would range from 2,342 to 4,683 (the entire K-25 inventory). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 120 to 234 cylinders annually and to prepare from 0 to 120 standard cylinders per year for shipment.

The environmental impacts from the cylinder preparation options were evaluated on the basis of information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997), i.e., preconceptual design data for each option, including descriptions of facility layouts; resource requirements; estimated effluents, wastes, and emissions; and potential accident scenarios. In the engineering analysis report, estimates for cylinder transfer operations ranged in capacity from 320 to 1,600 cylinders processed per year; whereas overcontainer and standard cylinder operations were addressed on a site-specific basis for a reference case for each site (i.e., 960 cylinders/yr with overcontainers for the Paducah site, 260 cylinders/yr with overcontainers for the Portsmouth site, and 234 cylinders/yr with overcontainers for the K-25 site), with some information provided on scaling up or down from the reference case (LLNL 1997). Supporting data for the overcontainer and transfer facility analyses were derived by Folga (1996b) using information provided in the engineering analysis report (LLNL 1997).

For assessment purposes, it was assumed that all cylinders would require transportation. However, the actual need for transportation of cylinders would depend on site selection and other considerations to be addressed in the second tier of the *National Environmental Policy Act* (NEPA) process.

E.1 SUMMARY OF CYLINDER PREPARATION OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in Section E.3.

Potential environmental impacts are summarized in Tables E.1, E.2, and E.3 for the Paducah, Portsmouth, and K-25 sites, respectively. Ranges of impacts are presented for the overcontainer option, the cylinder transfer option, and the preparation of standard cylinders (which is required for either option). Based on the information in Tables E.1 through E.3 and Section E.3, the following general conclusions may be drawn:

- For the cylinder overcontainer option and preparation of standard cylinders, impacts during normal operations would be small and limited to involved workers. No impacts to the off-site public or the environment would occur because no releases would be expected and no construction activities would be required.

TABLE E.1 Summary of Cylinder Preparation Impacts for the Paducah Site

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 170 – 510 person-rem Total number of LCFs: 0.07 – 0.2 LCF	**Involved Workers:** Total collective dose: 610 – 1,000 person-rem Total number of LCFs: 0.2 – 0.4 LCF	**Involved Workers:** Total collective dose: 0 – 220 person-rem Total number of LCFs: 0 – 0.09 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $1.9 \times 10^{-6} - 4.9 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $8 \times 10^{-13} - 2 \times 10^{-12}$ per year Total collective dose: $5.1 \times 10^{-5} - 1.3 \times 10^{-4}$ person-rem Total number of LCFs: $2 \times 10^{-8} - 5 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $6.8 \times 10^{-6} - 1.7 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: $3 \times 10^{-12} - 9 \times 10^{-12}$ per year Total collective dose to population within 50 miles: $1.1 \times 10^{-3} - 2.9 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $6 \times 10^{-7} - 1 \times 10^{-6}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 15 person-rem	Collective dose: 15 person-rem	Collective dose: 15 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 28 person-rem	Collective dose to population within 50 miles: 28 person-rem	Collective dose to population within 50 miles: 28 person-rem
Number of LCFs in population within 50 miles: 0.01 LCF	Number of LCFs in population within 50 miles: 0.01 LCF	Number of LCFs in population within 50 miles: 0.01 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 910 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 450 persons	Number of persons with potential for adverse effects: 910 persons
Number of persons with potential for irreversible adverse effects: 300 persons	Number of persons with potential for irreversible adverse effects: 330 persons	Number of persons with potential for irreversible adverse effects: 300 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,900 persons	Number of persons with potential for adverse effects: 2,500 persons	Number of persons with potential for adverse effects: 1,900 persons
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 1 person

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health — Accidents: Physical Hazards		
Operations: **All Workers:** Less than 1 (0.029 – 0.087) fatality, approximately 39 – 115 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.31 – 0.34) fatality, approximately 210 – 250 injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.043) fatality, approximately 0 – 87 injuries
Air Quality		
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 62% of standard. Concentrations of other criteria pollutants all below 15% of respective standards.	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.08% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.08% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.03% of respective standards.
Water		
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
Soil		
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
	Land Use	
No impacts	Use of approximately 21 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

TABLE E.2 Summary of Cylinder Preparation Impacts for the Portsmouth Site

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 47 – 240 person-rem Total number of LCFs: 0.02 – 0.1 LCF	**Involved Workers:** Total collective dose: 410 – 690 person-rem Total number of LCFs: 0.2 – 0.3 LCF	**Involved Workers:** Total collective dose: 0 – 120 person-rem Total number of LCFs: 0 – 0.05 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $1.9 \times 10^{-6} - 7.9 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $7 \times 10^{-13} - 3 \times 10^{-12}$ per year Total collective dose: $2.6 \times 10^{-5} - 1.1 \times 10^{-4}$ person-rem Total number of LCFs: $1 \times 10^{-8} - 4 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $3.3 \times 10^{-5} - 4.4 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: 2×10^{-11} per year Total collective dose to population within 50 miles: $3.1 \times 10^{-4} - 1.3 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $2 \times 10^{-7} - 7 \times 10^{-7}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 16 person-rem	Collective dose: 16 person-rem	Collective dose: 16 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 32 person-rem	Collective dose to population within 50 miles: 32 person-rem	Collective dose to population within 50 miles: 32 person-rem
Number of LCFs in population within 50 miles: 0.02 LCF	Number of LCFs in population within 50 miles: 0.02 LCF	Number of LCFs in population within 50 miles: 0.02 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,000 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 520 persons	Number of persons with potential for adverse effects: 1,000 persons
Number of persons with potential for irreversible adverse effects: 110 persons	Number of persons with potential for irreversible adverse effects: 440 persons	Number of persons with potential for irreversible adverse effects: 110 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 650 persons	Number of persons with potential for adverse effects: 580 persons	Number of persons with potential for adverse effects: 650 persons
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 1 person

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health — Accidents: Physical Hazards		
Operations: **All Workers:** Less than 1 (0.007 – 0.041) worker fatality, approximately 10 – 54 worker injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.22 – 0.31) worker fatality, approximately 110 – 240 worker injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.025) worker fatality, approximately 0 – 33 worker injuries
Air Quality		
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 36% of standard. Concentrations of other criteria pollutants all below 7% of respective standards.	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.02% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.04% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.01% of respective standards.
Water		
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
Soil		
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use	
No impacts	Use of approximately 14 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 µm or less; ROI = region of influence.

TABLE E.3 Summary of Cylinder Preparation Impacts for the K-25 Site

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 42 – 85 person-rem Total number of LCFs: 0.02 – 0.03 LCF	**Involved Workers:** Total collective dose: 410 – 480 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 0 – 27 person-rem Total number of LCFs: 0 – 0.01 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $2.0 \times 10^{-6} - 3.7 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $8 \times 10^{-13} - 2 \times 10^{-12}$ per year Total collective dose: $3.1 \times 10^{-5} - 5.6 \times 10^{-5}$ person-rem Total number of LCFs: $1 \times 10^{-8} - 2 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $2.4 \times 10^{-5} - 2.9 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: 1×10^{-11} per year Total collective dose to population within 50 miles: $9.8 \times 10^{-4} - 1.8 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $5 \times 10^{-7} - 9 \times 10^{-7}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 16 person-rem	Collective dose: 16 person-rem	Collective dose: 16 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 63 person-rem	Collective dose to population within 50 miles: 63 person-rem	Collective dose to population within 50 miles: 63 person-rem
Number of LCFs in population within 50 miles: 0.03 LCF	Number of LCFs in population within 50 miles: 0.03 LCF	Number of LCFs in population within 50 miles: 0.03 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 500 persons	Number of persons with potential for adverse effects: 770 persons
Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 140 persons	Number of persons with potential for irreversible adverse effects: 190 persons	Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 140 persons

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health – Accidents: Chemical (Cont.)		
General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 980 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards		
Operations: **All Workers:** Less than 1 (0.007 – 0.014) worker fatality, approximately 9 – 18 worker injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.17 – 0.21) worker fatality, approximately 94 – 140 worker injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.006) worker fatality, approximately 0 - 7 worker injuries
Air Quality		
Construction: Not applicable **Operations:** Concentrations of all criteria pollutants below 0.01% of respective standards.	**Construction:** 24-hour PM_{10} impacts potentially as large as 87% of standard. Concentrations of other criteria pollutants all below 11% of respective standards. **Operations:** Concentrations of all criteria pollutants below 0.07% of respective standards.	**Construction:** Not applicable **Operations:** Concentrations of all criteria pollutants below 0.004% of respective standards.
Water		
Construction: Not applicable **Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Construction:** Negligible impacts to surface water and groundwater **Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Construction:** Not applicable **Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
Soil		
Construction: Not applicable **Operations:** No impacts	**Construction:** Negligible, but temporary, impacts **Operations:** No impacts	**Construction:** Not applicable **Operations:** No impacts

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
	Socioeconomics	
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use	
No impacts	Use of approximately 12 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

- For the cylinder transfer option, impacts during construction and normal operations would generally be small and limited primarily to involved workers. Some small off-site releases of hazardous and nonhazardous materials would occur, although these would have negligible impacts on the off-site public and environment. Construction activities could temporarily impact air quality, but concentrations of criteria pollutants would all be within standards.

- For both options, there is a potential for low-probability accidents (UF_6 cylinders engulfed in a fire) that could have large consequences. The accident impacts would be limited primarily to workers, but off-site impacts are possible.

E.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the cylinder preparation options considered in the assessment of impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment.

The preparation of standard cylinders for shipment (cylinders that meet DOT requirements) would include inspection activities, unstacking, on-site transfer, and loading onto a truck trailer or railcar. The cylinders would be secured using the appropriate tiedowns, and the shipment would be labeled in accordance with DOT requirements. Handling and support equipment and procedures for on-site movement and loading the cylinders would be of the same type currently used for cylinder management activities at the three storage sites.

E.2.1 Cylinder Overcontainers

Cylinder overcontainers are one option for transporting cylinders that do not meet DOT requirements. An overcontainer is simply a container into which a cylinder would be placed for shipment. The metal overcontainer would be designed, tested, and certified to meet all DOT shipping

requirements. The overcontainer would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. In addition, the overcontainers could be designed as pressure vessels, enabling the withdrawal of the depleted UF_6 from the cylinder in an autoclave (a device used to heat cylinders using hot air).

The type of overcontainer evaluated in the PEIS, shown in Figure E.1, is a horizontal "clamshell" vessel (LLNL 1997). For transportation, a cylinder not meeting DOT requirements would be placed into an overcontainer already on a truck trailer or railcar. The overcontainer would be closed, secured, and the shipment would be labeled in accordance with DOT requirements. The handling and support equipment for on-site movement and loading the cylinder into the

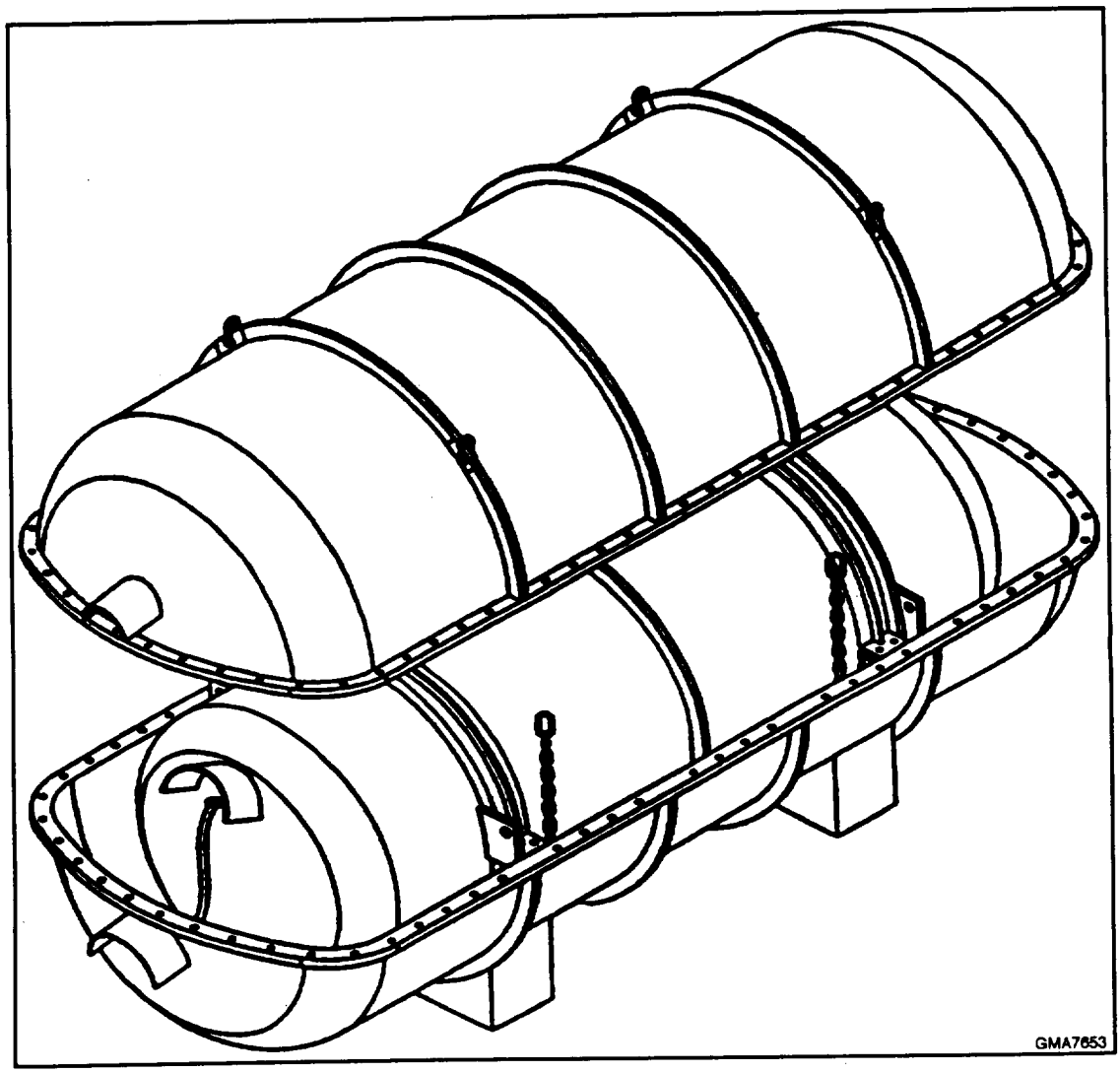

FIGURE E.1 Horizontal "Clamshell" Overcontainer for Transportation of Cylinders Not Meeting DOT Requirements (Source: LLNL 1997)

overcontainer would be of the same type currently used for cylinder management activities at the three DOE sites. The overcontainers could be reused following shipment. The overcontainer option would not require the construction of new facilities.

E.2.2 Cylinder Transfer

A second option for transporting cylinders that do not meet DOT requirements would be to transfer the depleted UF_6 from substandard cylinders to new cylinders that meet all DOT requirements. This option would require the construction of a new facility. A representative transfer facility is shown in Figure E.2. The transfer facility would be a stand-alone facility capable of receiving cylinders, storing a small number of cylinders, and transferring the contents to new cylinders. The transfer of depleted UF_6 would take place in a process building by placing substandard cylinders into autoclaves. The autoclaves would be used to heat the contents of the cylinder (using hot air), forming UF_6 gas which then would be piped to a new cylinder. The new cylinders could be shipped by placing them directly on appropriate trucks or railcars. The empty cylinders would be cleaned and treated with other scrap metals. (See Appendix F for details on the treatment of empty cylinders.)

E.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options, including impacts from construction (of a cylinder transfer facility), and during operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C.

The environmental impacts from the cylinder preparation options were evaluated on the basis of the information described in the engineering analysis report (LLNL 1997) and Folga (1996a). The following general assumptions apply to the assessment of impacts:

- The assessment considers preparation of cylinders that meet DOT requirements (standard cylinders), as well as those cylinders that do not meet the requirements.

- Evaluation of standard cylinder preparation and the cylinder overcontainer option includes only an operational phase — no construction activities would be required. Additionally, these options would not generate emissions of uranium compounds or hydrogen fluoride (HF) during normal operations.

- The evaluation of the cylinder transfer option includes construction of a facility in addition to operations. The operation of a cylinder transfer facility would involve small releases of uranium compounds and HF as air and water effluents during normal operations.

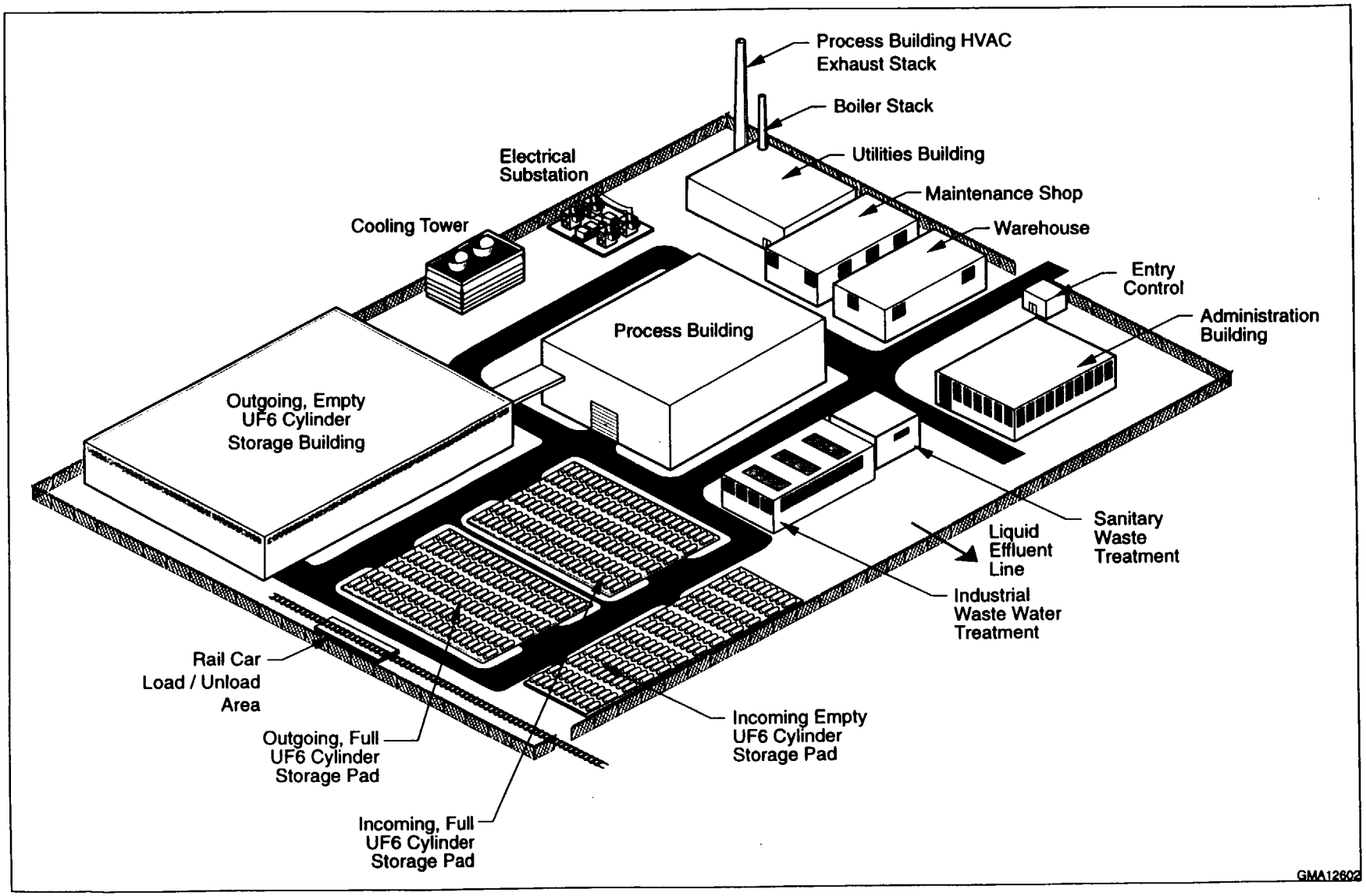

FIGURE E.2 Representative Layout of a Transfer Facility Site (Source: LLNL 1997)

- Impacts were evaluated separately for the three current storage sites, assuming a range in annual processing requirements at each site, because the actual number of cylinders that would not meet DOT requirements at the time of shipment cannot be determined. The ranges of problem cylinders at each site are discussed in the opening section of this appendix. The remaining cylinders were assumed to be standard cylinders that could be shipped directly.

- Cylinder preparation activities would take place over a 20-year period, from 2009 through 2028, for all alternatives except the no action alternative, which does not involve cylinder preparation.

E.3.1 Human Health — Normal Operations

E.3.1.1 Radiological Impacts

Potential radiological impacts for the cylinder preparation options were assessed for involved workers, noninvolved workers, and the general public. Detailed discussions of the methodologies used in the radiological impact analyses are provided in Appendix C and Cheng et al. (1997).

Impacts to involved workers would result primarily from external radiation and would depend only on the number of cylinders handled. The estimated collective doses to involved workers are presented in Figures E.3, E.4, and E.5 for the overcontainer option, cylinder transfer option, and preparation of standard cylinders, respectively. The collective dose is presented as a solid line, with three dashed lines above or below showing the corresponding segments representative for the three cylinder storage sites. Because no airborne or waterborne releases of uranium would be generated for the overcontainer option and preparation of standard cylinders, no radiological impacts would be expected to noninvolved workers or members of the general public. Impacts to these two receptors for the cylinder transfer option are presented in Figures E.6 through E.9. The ranges of impacts for the three cylinder storage sites are different because of the different numbers of cylinder handled and different site characteristics; the ranges are presented by three separate solid lines in the figures.

In general, impacts for the overcontainer option would be less than those for the cylinder transfer option. The average doses to involved workers for all cylinder preparation activities would be less than 660 mrem/yr, which is less than the regulatory limit of 5,000 mrem/yr (10 CFR Part 835). Exposure of noninvolved workers and members of the general public would be extremely small, less than 3.0×10^{-5} mrem/yr.

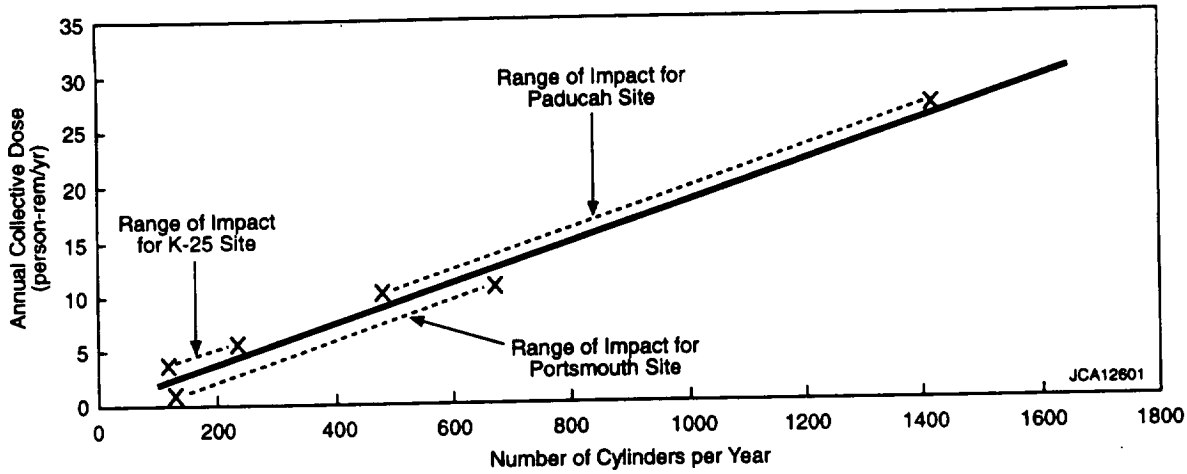

FIGURE E.3 Annual Collective Dose to Involved Workers from Preparing Problem Cylinders for Shipment Using Overcontainers

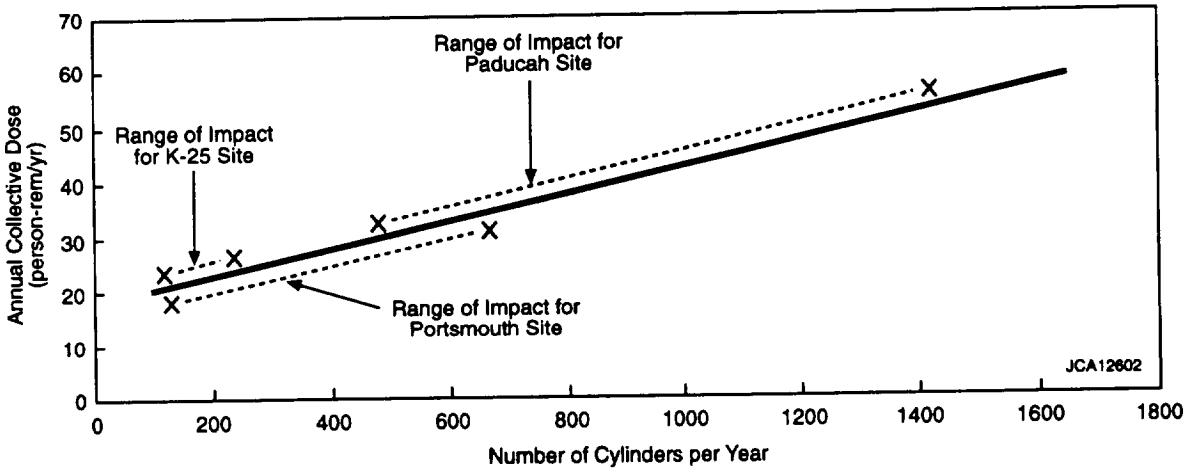

FIGURE E.4 Estimated Annual Collective Dose to Involved Workers from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

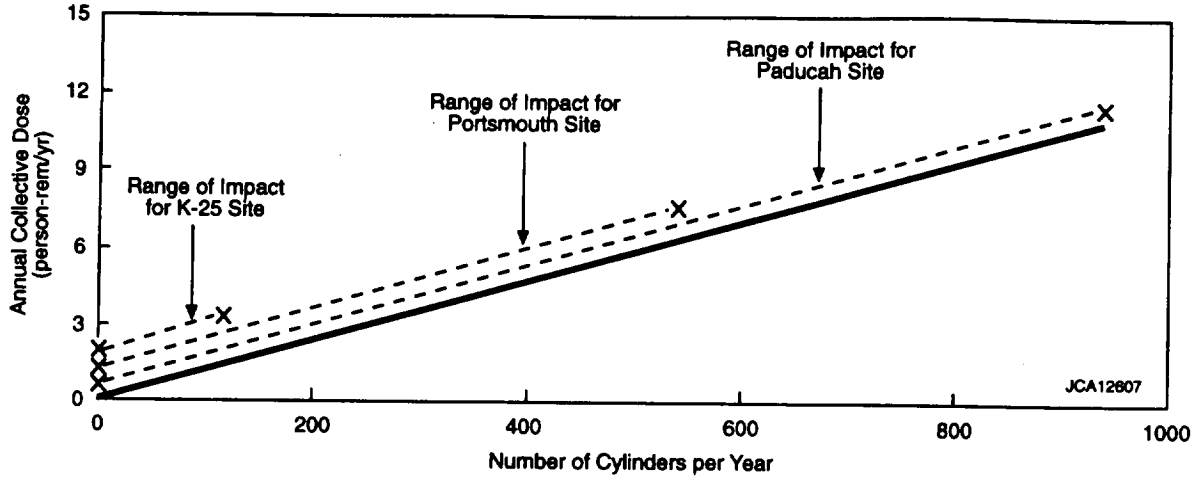

FIGURE E.5 Annual Collective Dose to Involved Workers from Preparing Standard Cylinders for Shipment

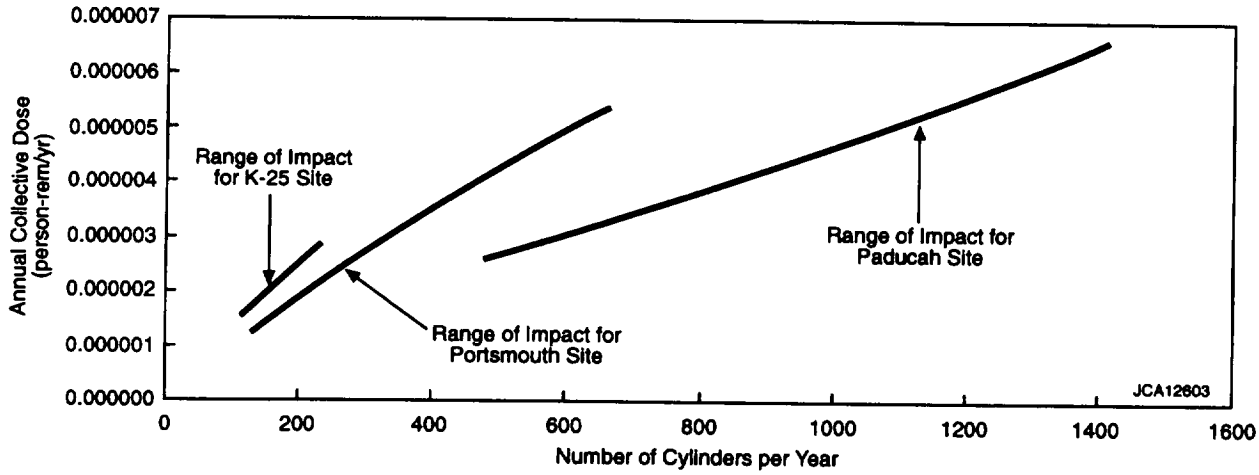

FIGURE E.6 Estimated Annual Collective Dose to Noninvolved Workers from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (population size of noninvolved workers: about 2,000 at Paducah; 2,700 at Portsmouth; and 3,500 at the K-25 Site)

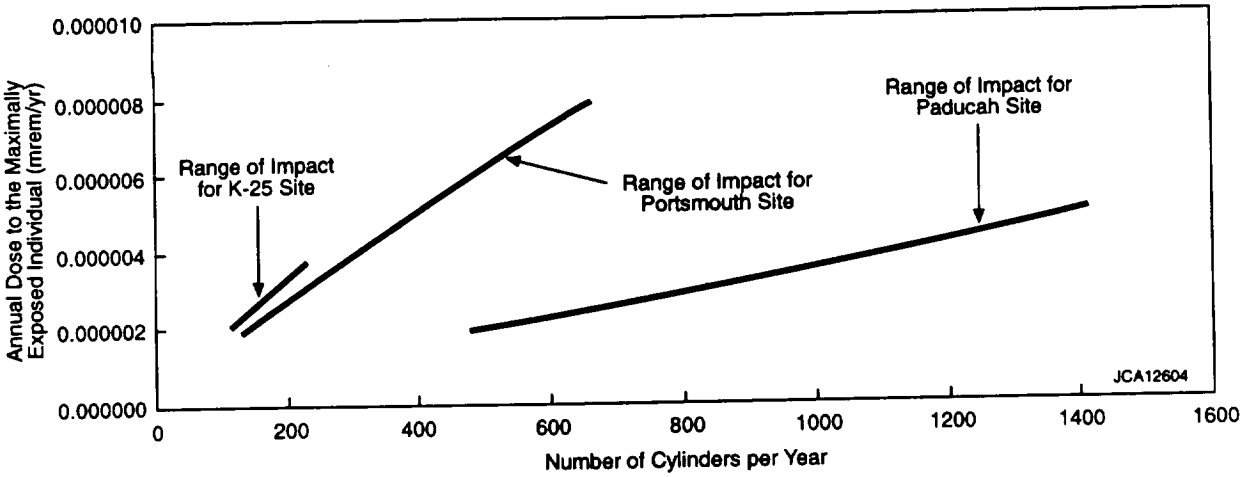

FIGURE E.7 Estimated Annual Dose to the Noninvolved Worker MEI from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

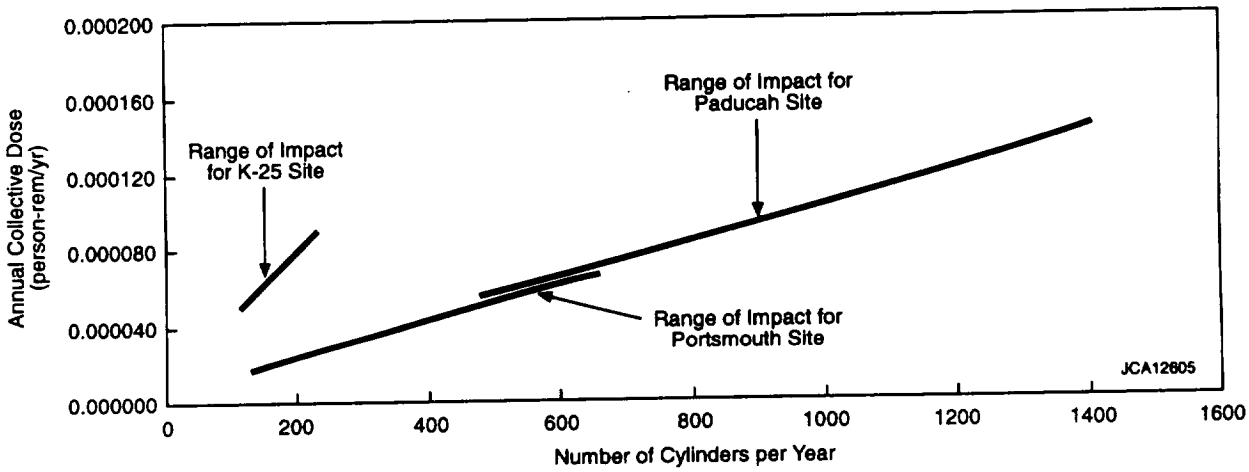

FIGURE E.8 Estimated Annual Collective Dose to the General Public from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposure to airborne emissions; population size of general public: about 500,000 at Paducah; 605,000 at Portsmouth; and 877,000 at the K-25 Site)

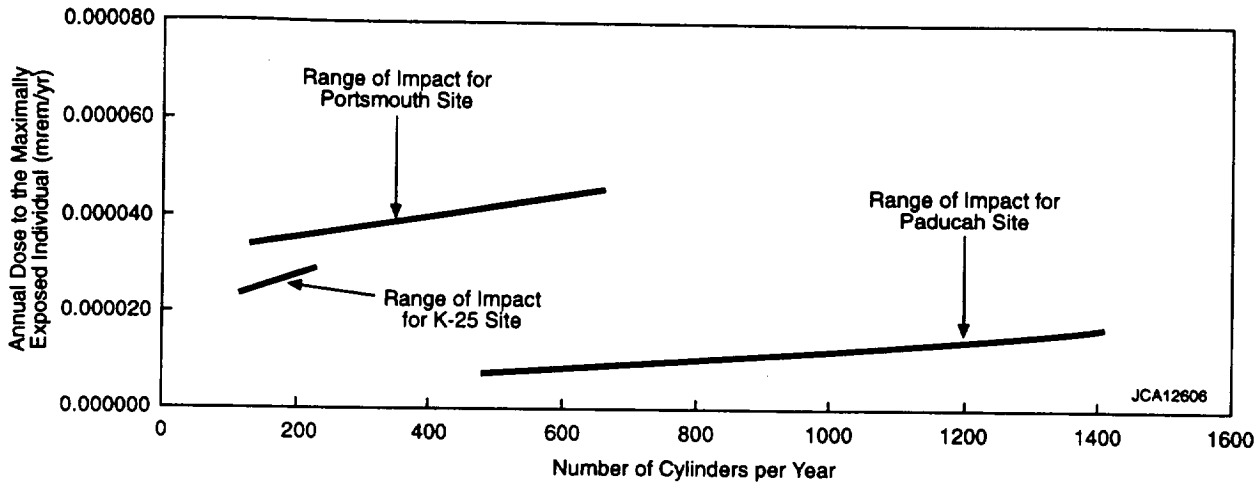

FIGURE E.9 Estimated Annual Dose to the General Public MEI from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposures would result from airborne emissions and discharge of wastewater)

E.3.1.1.1 Overcontainer Option

Potential external radiation exposures of involved workers would occur from preshipment inspection, testing, and surveying of cylinders; unstacking and retrieving cylinders; on-site transportation of cylinders by straddle buggy; loading cylinders into overcontainers placed on trucks or railcars; and packaging cylinders. The annual collective dose to involved workers was estimated to be approximately 2.1 to 4.3 person-rem/yr for about 4 to 8 workers at the K-25 site, 2.4 to 12.2 person-rem/yr for about 5 to 22 workers at the Portsmouth site, and 8.7 to 26 person-rem/yr for about 16 to 47 workers at the Paducah site. Assuming that the workers would work 5 hours per day with an availability factor of 75%, i.e., 3.75 hours per day for cylinder preparation activities (Folga 1996c), the average individual involved worker dose would be approximately 540 mrem/yr. The corresponding average cancer risk would be approximately 0.0002 per year (i.e., an individual's chance of developing a latent fatal cancer would be less than 1 in 5,000 per year).

E.3.1.1.2 Cylinder Transfer Option

The collective dose to involved workers would range from 20 to 24 person-rem/yr for approximately 31 to 42 workers at the K-25 site, 21 to 34 person-rem/yr for approximately 32 to 62 workers at the Portsmouth site, and 30 to 52 person-rem/yr for approximately 52 to 94 workers at the Paducah site. The average individual dose to involved workers would be less than 660 mrem/yr, corresponding to a risk of latent cancer fatality (LCF) of 3×10^{-4} per year (one chance in 3,300 per year).

Radiation doses to noninvolved workers vary from site to site depending on the processing rate of cylinders, site-specific meteorological conditions, and distribution and population of the on-site workers (for collective doses). The estimated radiation dose to the maximally exposed individual (MEI) would be extremely small, less than 8×10^{-6} mrem/yr, due to the small airborne emission rates of uranium. Impacts to the off-site public would also depend on the factors discussed for noninvolved workers, but instead of the distribution and population of the on-site workers, the impacts would be determined by the distribution and population of the off-site public (for collective dose).

The radiation dose to the MEI of the off-site public would be greater than that for the MEI of the noninvolved workers because of the additional exposure from drinking surface water. The radiation dose from drinking surface water would be greater than that from airborne emissions. As a result, the MEI dose for the Paducah site would be less than the doses for the Portsmouth and K-25 sites because surface water around the Paducah site would have the largest dilution capability. The radiation doses to the off-site public MEI from normal operations of the cylinder transfer facility were estimated to be less than 4.4×10^{-5} mrem/yr for all three cylinder storage sites, which is extremely small compared with the regulatory limit of 100 mrem/yr.

E.3.1.1.3 Preparation of Standard Cylinders

The collective radiation exposures to involved workers were estimated to range from 0 to 1.4 person-rem/yr for the K-25 site. The lower range results from the assumption that all the cylinders at the K-25 sites would be problem cylinders. A maximum of four workers would be required for the preparation activities. Radiation doses to involved workers at the Portsmouth site would range from 0 to 6.2 person-rem/yr, with a maximum requirement of 11 workers. At the Paducah site, the collective doses were estimated to range from 0 to 11 person-rem/yr, with a maximum requirement of 18 workers. The average individual dose to involved workers was estimated to be less than 600 mrem/yr for all three cylinder storage sites.

E.3.1.2 Chemical Impacts

The only potential chemical impacts that could be associated with cylinder preparation options would be from exposure to emissions from a cylinder transfer facility; no impacts during normal operations would be expected for the cylinder overcontainer option or preparation of standard cylinders because no releases would occur. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses, and calculational methods used in the chemical impact analysis is provided in Appendix C and Cheng et al. (1997).

During cylinder transfer operations, very small quantities of uranyl fluoride (UO_2F_2) effluent would be discharged into the air and surface water. Estimates of the hazardous chemical

human health impacts resulting from cylinder transfer operations were calculated for the range of cylinders that might require processing at each of the three storage sites (i.e., up to 1,420 annually at Paducah, 670 annually at Portsmouth, and 234 annually at K-25). Inhalation of HF was not included in the hazard index calculations because HF emissions from the cylinder transfer facility would be hundreds of times lower than HF emissions from conversion facilities (see Appendix F), for which no chemical impacts were predicted.

No impacts to noninvolved workers or the general public would be expected from normal transfer facility operations. The maximum (high case) hazard indices for chemical impacts to the noninvolved worker MEI working at the cylinder transfer facility would be less than or equal to 3.2×10^{-8}, 3.0×10^{-8}, and 1.1×10^{-8} at the Paducah, Portsmouth, and K-25 sites, respectively. These values are considerably below the threshold for adverse effects (i.e., the ratio of intake to reference dose is much less than 1). The maximum (high case) hazard indices for chemical impacts to the general public MEI would be less than or equal to 2.8×10^{-6}, 6.1×10^{-6}, and 3.6×10^{-6} at the Paducah, Portsmouth, and K-25 sites, respectively; these values are also considerably below the threshold for adverse effects.

E.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table E.4. The results for the radiological and chemical health impacts of the maximum-consequence accident in each frequency category are presented in Sections E.3.2.1 and E.3.2.2. The bounding accidents are the same for both the cylinder overcontainer option and the cylinder transfer option. Results for all accidents listed in Table E.4 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C and Policastro et al. (1997).

E.3.2.1 Radiological Impacts

Table E.5 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table E.6. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions were considered for each cylinder preparation option (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

TABLE E.4 Accidents Considered for the Cylinder Preparation Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Overcontainers					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 time in 1 million years)					
Small plane crash, two full 48G cylinders[b]	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Cylinder Transfer					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
UF_6 vapor leak	A UF_6 transfer line leaks 5% of its flowing contents for 10 minutes due to potential compressor or pipe leakage.	UO_2F_2 HF	0.009 2.4	30	Stack
UF_6 liquid leak	A drain line from the UF_6 condensers leaks 5% of its flowing contents due to potential condenser or pipe leakage.	UO_2F_2 HF	0.0045 1.2	30	Stack
Loss of off-site electrical power	Off-site power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Loss of cooling water	Cooling water flow to the UF_6 condenser is lost, and UF_6 vapor is released.	UO_2F_2 HF	0.009 2.4	2	Stack

TABLE E.4 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Transfer (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
UF_6 cold trap rupture	A UF_6 cold trap is overfilled with UF_6 and ruptures during heating, releasing UF_6 into the process building.	UO_2F_2 HF	0.13 34	30	Stack
Extremely Unlikely Accidents (frequency: from 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Earthquake	A UF_6 compressor discharge pipe is cleanly sheared during a design-basis earthquake and leaks for 1 minute.	UO_2F_2 HF	0.018 4.7	30	Stack
Tornado	A design-basis tornado does not result in significant releases because UF_6 is a solid at ambient conditions.	No release	NA	NA	NA
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude flooding.	No release	NA	NA	NA
Small plane crash, two full 48G cylinders[b]	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,192	0 to 30 30 to 121.4	Ground

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

[b] The frequency range of a small plane crash would be a function of site: extremely unlikely for the Paducah site, and incredible for the Portsmouth and K-25 sites.

TABLE E.5 Estimated Radiological Doses per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options

Site/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Paducah Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.4	2.3×10^{-3}	2.6×10^{-1}	3.3×10^{-3}	6.3×10^{-2}	9.8×10^{-5}	3.0×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.5×10^{-4}	1.1×10^{-7}	5.6×10^{-4}	2.1×10^{-8}	2.8×10^{-5}	8.6×10^{-8}	2.3×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.5×10^{1}	1.5×10^{-2}	2.8×10^{1}	3.7×10^{-3}	1.3	1.9×10^{-3}	1.1
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	4.9	4.9×10^{-3}	3.7×10^{-1}	8.7×10^{-4}	6.4×10^{-1}	6.2×10^{-4}	5.2×10^{-2}
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	2.2	2.2×10^{-3}	2.1×10^{-1}	3.3×10^{-3}	9.5×10^{-2}	9.3×10^{-5}	2.8×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.5×10^{-4}	1.1×10^{-7}	7.1×10^{-4}	2.1×10^{-8}	1.5×10^{-5}	8.6×10^{-8}	2.5×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	3.2×10^{1}	3.7×10^{-3}	2.0	1.9×10^{-3}	1.6
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.3	4.3×10^{-3}	5.5×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	6.2×10^{-4}	7.6×10^{-2}
K-25 Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.3	2.7×10^{-3}	4.3×10^{-1}	3.3×10^{-3}	6.0×10^{-2}	1.1×10^{-4}	5.9×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.8×10^{-4}	1.1×10^{-7}	1.2×10^{-3}	2.1×10^{-8}	3.6×10^{-5}	8.6×10^{-8}	5.0×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	6.3×10^{1}	3.7×10^{-3}	2.4	1.9×10^{-3}	2.2
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.4	4.3×10^{-3}	7.4×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	7.1×10^{-4}	1.0×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

[d] Applicable only to the cylinder transfer option.

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TABLE E.6 Estimated Radiological Health Risks per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options[a]

Site/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Paducah Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	6×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	3×10^{-5}	5×10^{-8}	1×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	6×10^{-8}	4×10^{-11}	3×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	1×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	1×10^{-2}	1×10^{-6}	5×10^{-4}	1×10^{-6}	5×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	2×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	3×10^{-5}
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	9×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	4×10^{-5}	5×10^{-8}	1×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	6×10^{-8}	6×10^{-11}	4×10^{-7}	8×10^{-12}	6×10^{-9}	4×10^{-11}	1×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	6×10^{-6}	2×10^{-2}	1×10^{-6}	8×10^{-4}	1×10^{-6}	8×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	3×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	4×10^{-5}
K-25 Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	5×10^{-4}	1×10^{-6}	2×10^{-4}	1×10^{-6}	2×10^{-5}	6×10^{-8}	3×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	7×10^{-8}	6×10^{-11}	6×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	3×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	9×10^{-4}	1×10^{-6}	1×10^{-3}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	4×10^{-4}	3×10^{-7}	3×10^{-4}	4×10^{-7}	5×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.0001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] Applicable only to the cylinder transfer option.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table E.6] by the annual probability of occurrence by the number of years of operation) would be less than 1 for all of the accidents.

E.3.2.2 Chemical Impacts

The accidents considered for the cylinder preparation options are listed in Table E.4. The results of the accident consequence modeling for chemical impacts are given in Tables E.7 and E.8. The results are presented as the (1) number of persons with potential for adverse effects and (2) the number of persons with potential for irreversible adverse effects. The results are given for the accident within each accident frequency category that would affect the largest number of persons (total of workers and off-site population) (Policastro et al. 1997). The impacts presented here are based on the assumption that the accidents would occur. The accidents listed in Tables E.7 and E.8 are not identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The following general conclusions may be drawn from the chemical accident assessment:

- If the accidents identified in Table E.7 and E.8 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 1,900 (maximum corresponding to the vehicle-induced fire scenario at the Paducah site), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1 (maximum corresponding to the corroded cylinder spill with pooling scenario at the Portsmouth site).

- If the accidents identified in Tables E.7 and E.8 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 1,000 (maximum corresponding to the vehicle-induced fire scenario at the Portsmouth site), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 300 (maximum corresponding to the corroded cylinder spill with pooling scenario at the Paducah site).

TABLE E.7 Number of Persons with Potential for Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options[a]

Site/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah Site									
Corroded cylinder spill, dry conditions	L	Yes	10	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	690	Yes	14	Yes	7	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	910	Yes	1,900	Yes	4	Yes	3
Small plane crash, 2 full 48G cylinders	I	Yes	67	Yes	18	Yes[f]	0	No	0
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	Yes	48	Yes[f]	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	850	Yes	12	Yes	2	Yes[f]	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	1,000	Yes	650	Yes	160	Yes	4
Small plane crash, 2 full 48G cylinders	I	Yes	700	Yes	22	No	0	No	0
K-25 Site									
Corroded cylinder spill, dry conditions	L	Yes	69	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	700	Yes	18	Yes	47	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	770	Yes	550	No	0	Yes	12
Small plane crash, 2 full 48G cylinders	I	Yes	420	Yes	34	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE E.8 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options[a]

Site/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah Site									
Corroded cylinder spill, dry conditions[f]	L	Yes[g]	0	No[g]	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	130	Yes[g]	0	Yes	1	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	300	Yes	1	Yes	1	No	0
Small plane crash, 2 full 48G cylinders	I	No	0	No	0	No	0	No	0
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	Yes[g]	0	No	0	No[g]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	90	Yes	1	Yes[g]	0	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	110	Yes	1	Yes[g]	0	No	0
Small plane crash, 2 full 48G cylinders[f]	I	No	0	No	0	No	0	No	0
K-25 Site									
Corroded cylinder spill, dry conditions	L	Yes	3	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	140	Yes	0	Yes	2	No	0
Vehicle-induced fire, 3 full 48G cylinders[f]	EU	No	0	No	0	No	0	No	0
Small plane crash, 2 full 48G cylinders[f]	I	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] These accidents would result in the largest plume size for the frequency category, although no people would be affected.

[g] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

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- Accidents resulting in a vehicle-induced fire involving three 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009-2028). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

  - *Potential Adverse Effects and Irreversible Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely):
    Workers at the Paducah, Portsmouth, and K-25 sites

    Corroded cylinder spill, wet conditions – rain (U, unlikely):
    Workers at the Paducah, Portsmouth, and K-25 sites

  These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible effects was estimated. All the bounding-case accidents shown in Table E.8 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures could be high enough to result in death for up to 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 300 irreversible adverse effects, approximately 0 to 3 deaths would be expected. Similarly, of the general public experiencing a range of 0 to 1 irreversible adverse effects, less than 1 death would be expected. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from the assumption of worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

E.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for involved and noninvolved workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the construction and operational phases of the cylinder transfer facility

lifetime; manufacturing fatality and injury rates were used for standard cylinder shipping preparation and overcontainer activities.

Figure E.10 shows the fatality and injury incidences for all workers associated with packaging cylinders in overcontainers across the ranges that might be required at the three current storage sites (i.e., ranges of 480 to 1,420 cylinders/yr at the Paducah site; 130 to 670 cylinders/yr at the Portsmouth site; and 120 to 234 cylinders/yr at the K-25 site). The impacts would increase directly as a function of the numbers of cylinders placed in overcontainers annually. Fatality incidences over the 20-year period of operations would all be less than 1 — ranging from about 0.029 to 0.087 at Paducah, about 0.007 to 0.041 at Portsmouth, and about 0.007 to 0.014 at K-25. On the basis of the ranges given for overcontainer requirements, the corresponding estimated injury incidence over the 20-year operations period would be from about 39 to 115 at Paducah, about 10 to 54 at Portsmouth, and about 9 to 18 at K-25.

Figures E.11 and E.12 give the fatality and injury incidences for all workers associated with transferring cylinder contents to new cylinders across the same potential range requirements as discussed above. It was assumed that any transfer facility would be constructed with a capacity near to or somewhat greater than the maximum number of cylinders expected to require processing (the actual numbers would not be determined until the time of cylinder shipment). Thus, the fatality and injury incidence estimates for construction of the transfer facility remain constant for each site across the range of annual cylinder processing requirements. However, data in the engineering analysis report (LLNL 1997) also showed that the relationship between number of cylinders processed annually and number of employees required per cylinder processed would not increase linearly. For example, more employees per cylinder would be required to process 100 cylinders than to process 1,000 cylinders. Therefore, the fatality and injury incidences would be lower at the K-25 and Portsmouth sites than at the Paducah site because of lower processing requirements; however, the fatality and injury incidences would also increase much more rapidly over the range processed annually at these sites, whereas the estimates for the Paducah site would remain relatively constant. Once the processing rate was above about 500 cylinders per year, fatality and injury incidences

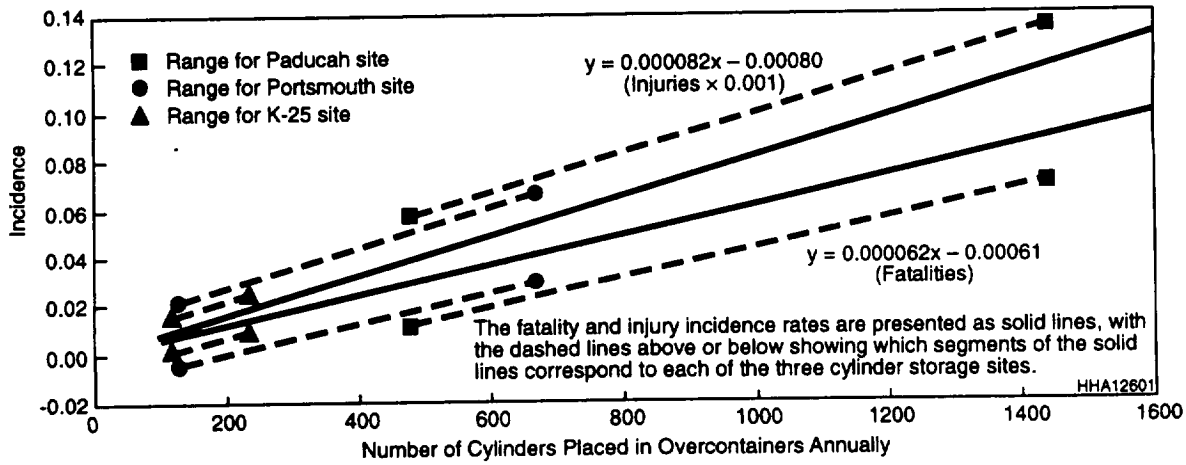

FIGURE E.10 Worker Fatality and Injury Incidence for Cylinder Overcontainer Activities

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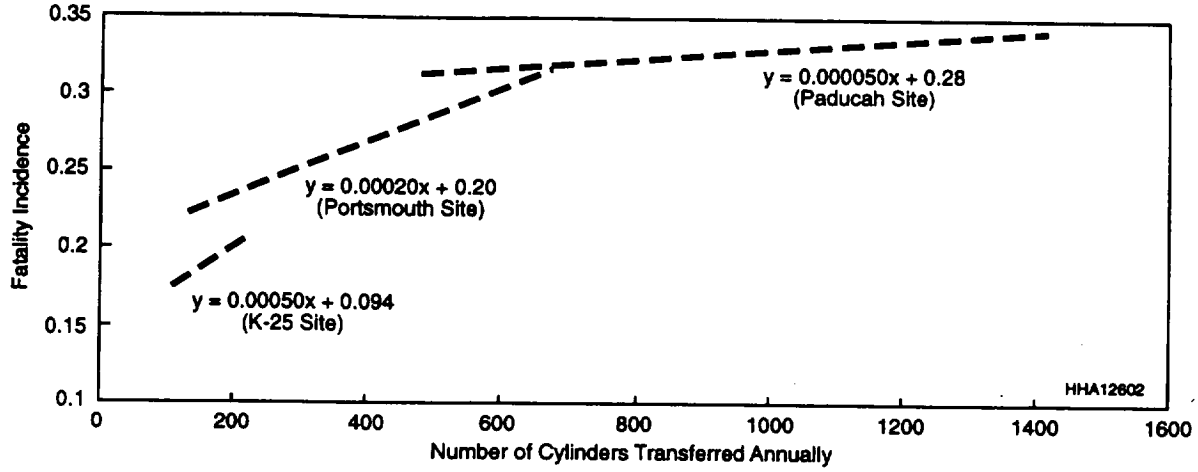

FIGURE E.11 Worker Fatality Incidence for Cylinder Transfer Activities

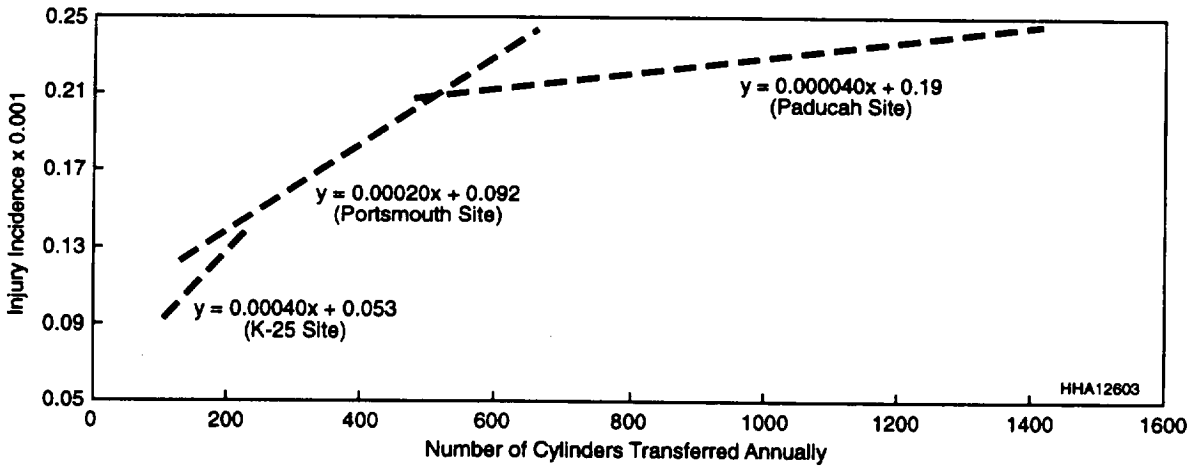

FIGURE E.12 Worker Injury Incidence for Cylinder Transfer Activities

would increase very little up to the maximum rate examined of about 1,600 cylinders per year. Fatality incidences for transfer facility construction and operation would all be less than 1, ranging from about 0.31 to 0.34 at Paducah, about 0.22 to 0.31 at Portsmouth and about 0.17 to 0.21 at K-25. On the basis of the assumed range in cylinder transfer requirements given above, the corresponding injury incidence would range from about 210 to 250 at Paducah, about 110 to 240 at Portsmouth, and about 94 to 140 at K-25.

Figure E.13 gives the fatality and injury incidences for all workers associated with preparation of standard cylinders for transport across the ranges that might be required at the three current storage sites (i.e., ranges from 0 to 940 cylinders/yr at Paducah, 0 to 540 cylinders/yr at Portsmouth, and 0 to 120 cylinders/yr at K-25). The impacts would increase directly as a function of the numbers of cylinders prepared annually. Fatality incidences would all be less than 1, ranging from 0 to about 0.043 at Paducah, 0 to about 0.025 at Portsmouth, and 0 to about 0.006 at K-25. The corresponding injury incidence would range from 0 to about 87 at Paducah, 0 to about 33 at Portsmouth, and 0 to about 7 at K-25.

E.3.3 Air Quality

Air quality impacts would result from the emissions associated with two distinct cylinder preparation options: (1) movement of cylinders in preparation for transportation, both those cylinders requiring overcontainers and standard cylinders, and (2) construction and operation of facilities to transfer contents from substandard cylinders to new ones. These two options are referred to in the following discussion as "overcontainer" and "transfer facility." No construction would be required for the overcontainer option. Descriptions of the methodology and assumptions are provided in Appendix C and Tschanz (1997).

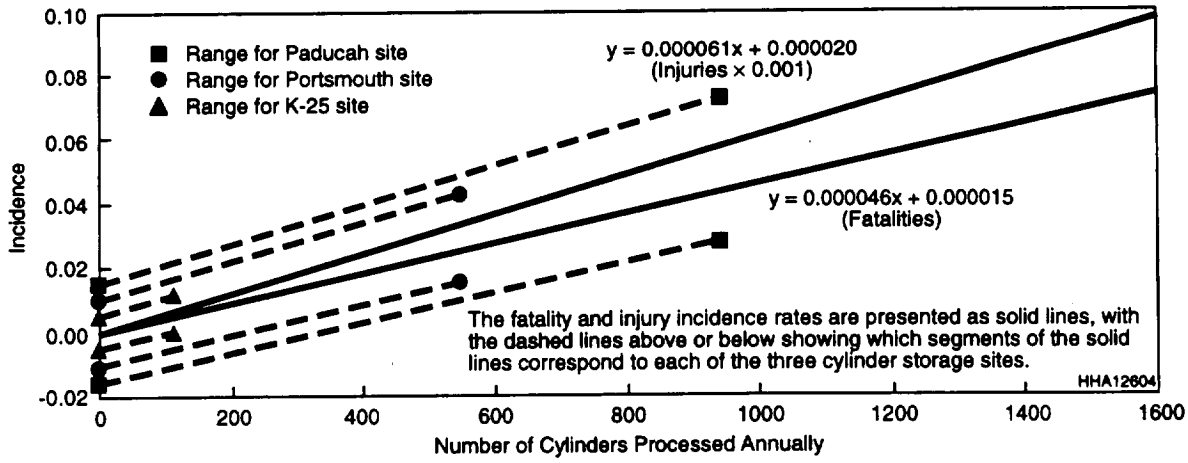

FIGURE E.13 Worker Fatality and Injury Incidence for Standard Cylinder Preparation

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E.3.3.1 Paducah Site

Potential air quality impacts for carbon monoxide (CO), nitrogen oxides (NO_x), and PM_{10} (particulate matter with a mean diameter of 10 μm or less) from implementation of the overcontainer and transfer facility options at the Paducah site are presented in Table E.9. Ranges of impacts for the overcontainer option represent the assumptions of low to high numbers of cylinders that might be substandard at the time of transportation. All of the impacts for the overcontainer option would be negligible.

Construction of a transfer facility with a capacity to handle 1,600 cylinders per year would cause larger impacts than operation of the facility. The construction impacts would all be less than the applicable air quality standards. The largest impact, 62% of the standard, would occur for the 24-hour PM_{10} concentration (Table E.9). The PM_{10} concentrations would occur primarily as a result of fugitive dust from land disturbance. The estimated fugitive dust emissions from construction activities were based on a general emission factor that considers only the size of the disturbed area and, therefore, might be overestimated relative to the actual use of construction equipment. Mitigative measures, such as spraying water, would be expected to reduce the PM_{10} concentrations. More detailed information about the construction activities would be required to accurately assess the likely actual impacts.

Criteria pollutant concentrations during operations would be less than 2% of the values estimated to occur during construction, making all impacts negligible. Process stack emissions during operations would produce an annual average HF concentration of 3.1×10^{-5} μg/m^3 and UO_2F_2 concentration of 2.1×10^{-6} μg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Paducah site. McCracken County in the Paducah-Cairo Interstate Air Quality Control Region is currently in attainment for all criteria pollutant standards, including ozone. The pollutants most related to ozone formation that could result from the cylinder preparation options at the Paducah site would be hydrocarbons (HC) and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in McCracken County, as recorded in the Kentucky Division of Air Quality Control "Emissions Inventory" for 1995 (Hogan 1996). The estimated HC and NO_x emissions of 0.20 and 2.19 tons/yr during operation of the cylinder transfer facility would be only 0.034 and 0.006%, respectively, of the 1995 McCracken County emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the county. Emissions of HC and NO_x from the overcontainer option would be even smaller.

TABLE E.9 Air Quality Impacts of Cylinder Preparation Options at the Paducah Site

	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]
CO	23 – 31	0.00078	3.0 – 4.0	0.00040	1.2 – 1.6	–	0.048 – 0.063	–
NO_x	3.5 – 4.7	–	0.46– 0.62	–	0.18 – 0.24	–	0.0073 – 0.0098	0.000098
PM_{10}	0.69 – 0.93	–	0.091 – 0.12	–	0.036 – 0.048	0.00032	0.0014 – 0.0019	0.000038

	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]
CO	3,200	0.080	1,400	0.14	540	–	50	–
NO_x	450	–	200	–	77	–	7.2	0.072
PM_{10}	550	–	250	–	93	0.62	8.7	0.17

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

E.3.3.2 Portsmouth Site

The air quality impacts of cylinder preparation options at the Portsmouth site are shown in Table E.10. All impacts from construction of a transfer facility with a capacity for 960 cylinders per year at the Portsmouth site would be less than applicable air quality standards.

The impacts of criteria pollutant emissions during operation of the transfer facility would be negligible. Process stack emissions during operations would produce an annual average HF concentration of 1.9×10^{-5} μg/m^3 and UO_2F_2 concentration of 1.5×10^{-6} μg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Portsmouth site. Pike and Scioto Counties in the Wilmington-Chillicothe-Logan Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the cylinder preparation options at the Portsmouth site would be HC and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Pike and Scioto Counties, as recorded in the Ohio Environmental Protection Agency "Emissions Inventory" for 1990 (Juris 1996). The estimated HC and NO_x emissions of 0.18 and 1.65 tons/yr from operation of the cylinder transfer facility would be only 0.011 and 0.069%, respectively, of the 1990 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region. Emissions of HC and NO_x from the overcontainer option would be even smaller.

E.3.3.3 K-25 Site

The air quality impacts of cylinder preparation options at the K-25 site are shown in Table E.11. The NO_x and PM_{10} impacts from construction of a transfer facility with a capacity for 320 cylinders per year at the K-25 site would be larger in comparison with applicable air quality standards than would the impacts from a 1,600/yr cylinder transfer facility at the Paducah site. In part, this would be due to the fact that construction emissions would not decrease in proportion to the reduction in transfer capacity. Emissions of PM_{10} were assumed to be the same at all three sites.

The impacts of criteria pollutant emissions during operation of the transfer facility would be negligible. Process stack emissions during operations would produce an annual average HF concentration of 1.3×10^{-5} μg/m^3 and UO_2F_2 concentration of 1.0×10^{-6} μg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the K-25 site. Anderson and Roane Counties in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the cylinder preparation

TABLE E.10 Air Quality Impacts of Cylinder Preparation Options at the Portsmouth Site

	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]
CO	5.4 – 7.7	0.00019	0.91 – 1.3	0.00013	0.36 – 0.52	–	0.029 – 0.042	–
NO_x	0.81 – 1.2	–	0.14– 0.20	–	0.054– 0.079	–	0.0044 – 0.0064	0.000064
PM_{10}	0.16 – 0.23	–	0.027 – 0.040	–	0.011 – 0.016	0.00011	0.00088 – 0.0013	0.000026

	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]
CO	2,600	0.065	660	0.066	250	–	29	–
NO_x	390	–	97	–	38	–	4.3	0.043
PM_{10}	560	–	140	–	54	0.36	6.2	0.12

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

TABLE E.11 Air Quality Impacts of Cylinder Preparation Options at the K-25 Site

	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]
CO	3.6 – 4.5	0.00011	0.54 – 0.67	0.00007	0.23 – 0.29	–	0.017 – 0.021	–
NO_x	0.56 – 0.70	–	0.083– 0.10	–	0.036– 0.044	–	0.0026 – 0.0033	0.00003
PM_{10}	0.11 – 0.14	–	0.016 – 0.020	–	0.0071 – 0.0088	0.00006	0.00052 – 0.00064	0.00001

	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]
CO	2,200	0.055	1,100	0.11	470	–	61	–
NO_x	320	–	160	–	69	–	8.9	0.089
PM_{10}	590	–	300	–	130	0.87	16	0.32

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

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options at the K-25 site would be HC and NO_x. The potential effects on ozone of those pollutants can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Anderson and Roane Counties, as recorded in the Tennessee Division of Air Pollution Control "Emissions Inventory" for 1995 (Conley 1996). The estimated HC and NO_x emissions of 0.14 and 1.20 tons/yr during operation of the cylinder transfer facility would be only 0.005 and 0.002%, respectively, of the 1995 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region. Emissions of HC and NO_x from the overcontainer option would be even smaller.

E.3.4 Water and Soil

The cylinder preparation options were assessed for potential impacts on surface water, groundwater, and soils. Details on the methodology and assumptions are presented in Appendix C and Tomasko (1997).

E.3.4.1 Surface Water

Potential impacts to surface water for the cylinder preparation options could occur during construction, normal operations, and postulated accident scenarios. For the cylinder overcontainer option and preparation of standard cylinders, however, there would be no impacts to surface water because no liquid wastes would be produced during construction and operations (LLNL 1997) and no accident scenarios were identified in the engineering analysis report that would directly release contaminated material to surface water (LLNL 1997). Secondary impacts to surface water would also be negligible because of the small concentrations associated with air deposition.

For the cylinder transfer facility, potential impacts to surface water during construction, normal operations, and accident scenarios would include changes in runoff, changes in quality, and floodplain encroachment.

E.3.4.1.1 Construction

Paducah Site. Construction of a cylinder transfer facility with a capacity for 1,600 cylinders per year at the Paducah site would increase runoff because about 15 acres (6.1 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.4% of the land available).

TABLE E.12 Summary of Environmental Parameters for the Cylinder Transfer Facility

		Requirements per Site		
Option	Unit	Paducah	Portsmouth	K-25
Disturbed land area	acres	21	14	12
Paved area	acres	15	10	8
Construction water	million gal/yr	10	8	6.5
Construction wastewater	million gal/yr	5	4	3.3
Operations water	million gal/yr	9	7	6
Operations wastewater	million gal/yr	7.1	5.7	4.4
Radioactive release	Ci/yr	0.00078	0.00063	0.00049

Construction of the cylinder transfer facility would require about 10 million gal/yr (19 gpm) of water. This withdrawal would correspond to less than 0.000016% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, the quality of nearby surface water could be affected by releases of wastewater containing small quantities of contaminants such as construction chemicals, organics, and suspended solids. About 5 million gal/yr (9.5 gpm) of construction wastewater would be discharged to nearby surface waters or to an appropriate wastewater sewer under a National Pollutant Discharge Elimination System (NPDES) permit. Once released, the wastewater would eventually be discharged to the Ohio River, resulting in dilution in excess of 12 million:1. All contaminant concentrations would be considerably below regulatory standards.

Portsmouth Site. Construction of a cylinder transfer facility with a capacity of 960 cylinders per year at the Portsmouth site would increase runoff because about 10 acres (4.1 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.3% of the land available).

Construction of the cylinder transfer facility would require about 8 million gal/yr of water (15 gpm). Following usual practice at the Portsmouth site, this water would be withdrawn from wells, and there would be no impact to surface water. During construction, about 4 million gal/yr (8 gpm) of wastewater would be discharged to the river. Because of dilution (260,000:1), contaminant concentrations would be reduced to considerably below regulatory standards.

K-25 Site. Construction of a cylinder transfer facility with a capacity of 320 cylinders per year at the K-25 site would increase runoff because about 8 acres (4 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.5% of the land available).

Construction of the cylinder transfer facility would require about 6.5 million gal/yr (12 gpm) of water. This withdrawal would correspond to about 0.00059% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, about 3.3 million gal/yr (6 gpm) of wastewater would be discharged to the river. Because of dilution (340,000:1), contaminant concentrations would be reduced to considerably below regulatory standards.

E.3.4.1.2 Operations

Paducah Site. For normal operations of the 1,600/yr cylinder transfer facility at the Paducah site, approximately 9 million gal/yr (17.1 gpm) of water would be withdrawn from surface water (Table E.12). This withdrawal would represent less than 0.000014% of the average river flow and would produce a negligible impact on water levels and floodplains.

About 7.1 million gal/yr (14 gpm) of wastewater would be discharged to the river during normal operations. This water would consist of sanitary wastewater, blowdown water from the cooling tower, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.000012% of the average river flow and would produce a negligible impact on water levels and floodplains.

In addition to producing physical impacts to surface water, normal operations would also impact surface water quality. Approximately 0.00078 Ci/yr (about 112 µg/L) of uranium would be released to the river at the point of discharge (LLNL 1997). Although the concentration at the outfall would exceed the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 20 µg/L (EPA 1996) used as a guideline, the resulting uranium concentration (as well as the concentrations of other chemicals) in the river would be less than 20 µg/L because of dilution (9 million:1).

Portsmouth Site. For normal operations of the 960/yr cylinder transfer facility at the Portsmouth site, about 7 million gal/yr (13 gpm) of water would be required (Table E.12). Because this water would be withdrawn from wells, there would be no surface water impacts.

About 5.7 million gal/yr (11 gpm) of wastewater would be discharged to the river. This water would consist of sanitary wastewater, blowdown water, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.00052% of the average river flow and would produce a negligible impact on water levels and floodplains.

Normal operations would also impact surface water quality. Approximately 0.00063 Ci/yr of uranium would be released to surface water (about 112 µg/L at the point of discharge). Although the concentration of uranium at the outfall would exceed the 20 µg/L guideline (EPA 1996), the resulting uranium concentration (as well as other chemicals) in the river would be less 20 µg/L because of dilution (200,000:1).

K-25 Site. For normal operation of the 320/yr cylinder transfer facility at the K-25 site, about 6 million gal/yr (11 gpm) of water would be required (Table E.12). This rate of withdrawal would represent about 0.00054% of the average river flow and would produce a negligible impact on water levels and floodplains.

About 4.4 million gal/yr (8 gpm) of wastewater would be discharged to the river. This water would consist of sanitary wastewater, blowdown water, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.00038% of the average river flow and would produce a negligible impact on water levels and floodplains.

Normal operations would also impact surface water quality. Approximately 0.00049 Ci/yr of uranium would be released to surface water (about 112 µg/L at the point of discharge). Although the concentration of uranium at the outfall would exceed the 20 µg/L guideline (EPA 1996), the resulting uranium concentration (as well as other chemicals) in the river would be less than 20 µg/L because of dilution (255,000:1).

E.3.4.1.3 Accident Scenarios

No accidents are identified in LLNL (1997) that would directly affect surface water at any of the three storage sites. Secondary impacts resulting from deposition of airborne contaminants would not be measurable because of low concentrations in the deposited material.

E.3.4.2 Groundwater

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to groundwater for any of the sites because there would be no discharges to the surface (LLNL 1997). For the cylinder transfer facility, impacts could occur during construction and normal operations; however, there would be no impacts from potential accidents because no accidents were identified in the engineering analysis report (LLNL 1997) that would release

contaminants to the ground. Secondary impacts from air deposition would not be measurable because of the small concentrations of deposited material.

E.3.4.2.1 Construction

Paducah Site. Construction of the cylinder transfer facility at the Paducah site would result in decreased permeability of about 15 acres (6.1 ha) of land (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.4% of the land available), the impacts would be local and negligible.

During construction, groundwater quality would also be impacted. For example, stockpiled chemicals could be mobilized by precipitation and infiltrate the surficial aquifer. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rain, promptly cleaning up any spills, and providing retention basins to catch and hold contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

Portsmouth Site. Construction of the cylinder transfer facility at the Portsmouth site would decrease the permeability of about 10 acres (4.1 ha) (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.3% of the land available), the impacts would be local and negligible.

Construction of the cylinder transfer facility would require extracting 4 million gal/yr (8 gpm) from wells. This extraction would increase the daily withdrawal by less than 0.1% and would produce a negligible impact on depth to groundwater and direction of groundwater flow. Construction could also impact groundwater quality. By following good engineering and construction practices, groundwater concentrations would be less than the EPA guidelines.

K-25 Site. Construction of the cylinder transfer facility would decrease the permeability of about 8 acres (3.2 ha) (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.5% of the land available), the impacts would be local and negligible. During construction, groundwater quality would also be impacted. By following good engineering and construction practices, groundwater concentrations would be less than the EPA guidelines.

E.3.4.2.2 Operations

Paducah Site. No impacts to groundwater would occur during normal operations at the Paducah site because no groundwater would be used and there would be no discharges to the ground.

Portsmouth Site. Normal operation of the cylinder transfer facility at the Portsmouth site would required an additional 7 million gal/yr of withdrawal from wells (Table E.12). This rate of withdrawal would represent an increase in daily extraction of about 0.1%. Because the rate of increased use would be small, impacts to the depth to the groundwater and its flow direction would be negligible. No impacts would occur to groundwater quality because there would be no direct discharges to the ground.

K-25 Site. No impacts to groundwater would occur during normal operations at the K-25 site because no groundwater would be used and there would be no discharges to the ground.

E.3.4.3 Soil

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to soils from any of the three cases because there would be no discharges to the ground. For the cylinder transfer facility, the only impacts to the three sites would occur during construction; for normal operations, there would be no discharges to the ground, and there are no accidents identified in the engineering analysis report (LLNL 1997) that would lead to direct contamination of the soil. Secondary impacts to the soil from air deposition would be negligible because of the small concentrations of contaminants in the deposited material. Impacts from construction of the cylinder transfer facility include changes in topography, permeability, quality, and erosion potential.

E.3.4.3.1 Paducah Site

At the Paducah site, construction of a cylinder transfer facility with a capacity of 1,600 cylinders per year would disturb 21 acres (8.5 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.6% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these physical changes, construction could also have a chemical impact on soil. By following good engineering and construction practices (e.g., covering chemicals with tarps, cleaning up spills as soon as they occur, and providing retention basins to catch and hold surface runoff), impacts to soil quality would be negligible.

E.3.4.3.2 Portsmouth Site

At the Portsmouth site, construction of a cylinder transfer facility with a capacity for 960 cylinders per year would disturb 14.3 acres (5.8 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.4% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these physical changes, construction could also have a chemical impact on soil. By following good engineering and construction practices, impacts to soil quality would be negligible.

E.3.4.3.3 K-25 Site

At the K-25 site, construction of a cylinder transfer facility with a capacity for 320 cylinders per year would disturb 12 acres (4.9 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.7% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these changes, construction could also have a chemical impact on soil. By following good engineering and construction practices, impacts to soil quality would be negligible.

E.3.5 Socioeconomics

The impacts of cylinder preparation on socioeconomic activity were estimated for a region of influence (ROI) at the three storage sites. Additional details regarding the assessment methodology is presented in Appendix C and Allison and Folga (1997).

Cylinder preparation would likely have a small impact on socioeconomic conditions in the ROIs surrounding the three sites described in Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8. This is partly because a major proportion of expenditures associated with procurement for the preoperation and operation of each preparation option would flow outside the ROI to other locations in the United States, reducing the concentration of local economic effects of each facility.

Slight changes in employment and income would occur in each ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required for cylinder preparation activities, and other local investment associated with preoperations and operations. In addition to creating new (direct) jobs at each site, cylinder preparation would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at each site. Jobs and income created directly by cylinder preparation, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding each site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of preoperating and operating cylinder preparation on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures are discussed in Sections E.3.5.1 through E.3.5.3. Impacts are presented for cylinder preparation at each of the storage sites for the peak year of preoperations and the first year of operations. The impacts of cylinder preparation at the three storage sites are given in Table E.13.

E.3.5.1 Paducah Site

E.3.5.1.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 230 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $9 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.02 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational

TABLE E.13 Potential Socioeconomic Impacts of the Cylinder Preparation Options at the Three Sites

Site/Parameter	Cylinder Overcontainers		Cylinder Transfer Facility		Standard Cylinder Preparation	
	Preoperation[a]	Operations[b]	Construction[a]	Operations[b]	Preoperation[a]	Operations[b]
Paducah Site						
Economic activity in the ROI						
Direct jobs	<5	120	260	200	<5	60
Indirect jobs	<5	110	130	170	<5	60
Total jobs	<5	230	390	370	<5	120
Direct income ($ million)	0.1	8	12	10	0.1	4
Total income ($ million)	0.2	9	14	13	0.1	5
Population in-migration into the ROI	<5	230	440	390	<5	100
Housing demand						
Number of units in the ROI	<5	80	160	140	<5	40
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.3	0.3	0	0.1
Portsmouth Site						
Economic activity in the ROI						
Direct jobs	<5	100	190	160	<5	50
Indirect jobs	<5	80	90	180	<5	40
Total jobs	<5	180	280	350	<5	90
Direct income ($ million)	0.1	6	8	8	0.1	3
Total income ($ million)	0.2	7	10	11	0.1	4
Population in-migration into the ROI	<5	200	320	330	<5	100
Housing demand						
Number of units in the ROI	<5	80	120	120	<5	40
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.2	0.2	0	0.1

TABLE E.13 (Cont.)

Site/Parameter	Cylinder Overcontainers		Cylinder Transfer Facility		Standard Cylinder Preparation	
	Preoperation[a]	Operations[b]	Construction[a]	Operations[b]	Preoperation[a]	Operations[b]
K-25 Site						
Economic activity in the ROI						
Direct jobs	<5	80	130	130	<5	40
Indirect jobs	<5	120	160	380	<5	60
Total jobs	<5	200	290	510	<5	100
Direct income ($ million)	0.1	5	6	7	0.1	2
Total income ($ million)	0.2	6	9	13	0.1	3
Population in-migration into the ROI	<5	190	220	240	<5	80
Housing demand						
Number of units in the ROI	<5	70	80	90	<5	30
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.04	0.04	0	0.01

[a] Impacts are for peak year of preoperation or construction, 2007. The preoperational (construction) phase was assessed from 1999 through 2008.

[b] Impacts are the annual averages for operations for the period 2009 through 2028.

activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 230 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 80 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 1.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 230 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.1.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 260 direct jobs would be created at the site and 130 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 390 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $14 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 370 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.04 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 360 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 440 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 390 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.02 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 160 additional rental housing units during the peak year of construction, representing an impact of 10.4% on the projected number of vacant rental housing units in the ROI (Table E.13). The demand for 140 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 3.0% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 440 people would be expected to in-migrate into the ROI, leading to an increase of 0.3% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 390 in-migrants would be expected, leading to an increase of 0.3% in local revenues and expenditures.

E.3.5.1.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 120 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $5 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for standard cylinder preparation would be expected to generate direct and indirect job in-migration of 100 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.0% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 100 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.2 Portsmouth Site

E.3.5.2.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperation for standard cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperation activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 180 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $7 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.02 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 200 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing unit during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 80 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 1.6% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 200 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.2.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 190 direct jobs would be created at the site and 90 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 280 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $10 million of total income produced during the peak year. During the first

year of operations of the cylinder transfer facility, 350 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $11 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.03 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 260 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 320 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 330 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 120 additional rental housing units during the peak year of construction, representing an impact of 5.9% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 120 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.2% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 320 people would be expected to in-migrate into the ROI, leading to an increase of 0.2% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 330 in-migrants would be expected, leading to an increase of 0.2% in local revenues and expenditures.

E.3.5.2.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $4 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for standard cylinder preparation would be expected to generate direct and

indirect job in-migration of 100 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.004 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing essentially no impact on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.7% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 100 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.3 K-25 Site

E.3.5.3.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 200 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $6 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 190 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.03 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 70 additional

owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.6% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 190 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.3.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 130 direct jobs would be created at the site and 160 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 290 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $9 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 510 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 170 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 220 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 240 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.004 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 80 additional rental housing units during the peak year of construction, representing an impact of 1.5% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 90 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 220 people would be expected to in-migrate into the ROI, leading to an increase of 0.04% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 240 in-migrants would be expected, leading to an increase of 0.04% in local revenues and expenditures.

E.3.5.3.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 100 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $3 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder preparation would be expected to generate direct and indirect job in-migration of 80 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.001 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing unit during the peak year of preoperations, representing essentially no impact on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 30 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.3% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 80 in-migrants would be expected, leading to an increase of 0.01% in local revenues and expenditures.

E.3.6 Ecology

Predicted concentrations of contaminants in environmental media were compared with benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. Discussion of assessment methodology is presented in Appendix C.

No ecological impacts would be expected during preparation of standard cylinders. Under the cylinder overcontainer option, no site preparation or construction would occur. Normal operations would not result in impacts to surface water, groundwater, or soil (Section E.3.4). Atmospheric releases of contaminants would include only criteria pollutants, and emission levels

would be expected to be extremely low (Section E.3.3). Therefore, impacts of the cylinder overcontainer option to ecological resources would be negligible.

Impacts to ecological resources could result from construction of a cylinder transfer facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a cylinder transfer facility could result from exposure to airborne contaminants or contaminants released to soils, groundwater, or surface waters or changes in surface water or groundwater quality or flow rates.

E.3.6.1 Paducah Site

Site preparation for the construction of a cylinder transfer facility at the Paducah site would require the disturbance of approximately 21 acres (9 ha), including the permanent replacement of approximately 15 acres (6 ha), primarily with structures and paved areas. Existing vegetation would be destroyed during land clearing activities. Determination of the vegetation communities that would be eliminated by site preparation would depend on the exact location of the facility. Communities occurring on undeveloped land at the site are relatively common and well represented in the vicinity of the site; however, impacts to high quality native plant communities might occur if facility construction required disturbance to vegetation communities outside of the currently fenced site area (see Section E.3.9 for a discussion of land use). Construction of the transfer facility would not be expected to threaten the local population of any species. The loss of up to 21 acres (9 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Erosion of exposed soil at the construction site could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table E.14.

TABLE E.14 Potential Impacts to Ecological Resources from Construction of the Cylinder Transfer Facility at the Paducah Site

Resource	Type of Impact	Degree of Impact
Vegetation	Loss of 21 acres	Moderate adverse impact
Wildlife	Loss of 15 to 21 acres	Moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land-clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to quickly recolonize replanted areas near the facility following completion of construction. The permanent loss of 15 to 21 acres (6 to 9 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. Construction of a cylinder transfer facility would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section E.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be impacted by filling or draining during construction. In addition, impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Air Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any federal- or state-listed threatened or endangered species at the Paducah site. Prior to construction of the transfer facility, a survey would be conducted for federal- and state-listed threatened, endangered, or candidate species, or species of special concern. Impacts to these species could thus be avoided or, when impacts were unavoidable, appropriate mitigation could be developed.

Water withdrawal from surface waters or groundwater, as well as wastewater discharge, during facility construction and operation could potentially alter water levels. The changes in water levels could in turn affect aquatic ecosystems, including wetlands, such as those located along the periphery of these surface water bodies. However, water-level changes due to water withdrawal and wastewater discharge would be negligible (Section E.3.4). Therefore, impacts to wetlands and aquatic communities would be expected to be negligible.

Ecological resources in the vicinity of the transfer facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section E.3.3.1), well below concentrations known to adversely affect biota. Resulting impacts to biota would be expected to be negligible. Impacts due to facility operation are shown in Table E.15.

TABLE E.15 Potential Impacts to Ecological Resources from Operation of the Cylinder Transfer Facility at the Paducah Site

Contaminant	Biota	Maximum Exposure	Impact
HF	Wildlife	3.1×10^{-5} µg/m^3	Negligible
UO_2F_2 in air	Wildlife	2.1×10^{-6} µg/m^3	Negligible
Uranium in surface water	Aquatic	112 µg/L	Negligible

Effluent discharges to surface waters could contain a number of chemical contaminants. Facility wastewater would have a uranium concentration of about 112 µg/L in the undiluted effluent (Section E.3.4.1). Dilution of the discharge in the receiving stream by a factor in excess of 150,000 would result in negligible concentrations (Section E.3.4.1). Thus, impacts to aquatic biota in the vicinity of the outfall would be negligible.

Facility accidents, as discussed in Section E.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors such as location of the accident, season, and meteorological conditions.

E.3.6.2 Portsmouth Site

Construction of a cylinder transfer facility at the Portsmouth site would result in the types of impacts associated with the Paducah facility. However, a smaller area would be required. Facility construction would disturb approximately 14 acres (6 ha), including the permanent replacement of 10 acres (4 ha), primarily with structures and paved areas. Construction of the transfer facility would not be expected to threaten the local population of any species. In addition to site-specific surveys for protected species, avoidance of wooded areas would reduce the potential for impacts to the sharp-shinned hawk (state-listed as endangered) and Indiana bat (federal- and state-listed as endangered). The loss of up to 14 acres (6 ha) of undeveloped land and 10 to 14 acres (4 to 6 ha) of habitat would constitute a moderate adverse impact to vegetation and wildlife.

Operation of a cylinder transfer facility at the Portsmouth site would result in lower atmospheric emissions of contaminants than predicted for the Paducah facility. Resulting impacts to biota would, therefore, also be negligible. Uranium concentrations in discharges to surface water would be slightly lower than predicted for the Paducah facility. Resulting impacts to aquatic biota would also be negligible.

E.3.6.3 K-25 Site

Construction of a cylinder transfer facility at the K-25 site would result in the types of impacts associated with the Paducah and Portsmouth facilities. However, a smaller area would be required. Facility construction would disturb approximately 12 acres (5 ha), including the permanent replacement of 8 acres (3 ha), primarily with structures and paved areas. Construction of the transfer facility would not be expected to threaten the local population of any species. The loss of up to 12 acres (5 ha) of undeveloped land and 9 to 12 acres (4 to 5 ha) of habitat would constitute a moderate adverse impact to vegetation and wildlife.

Operation of a cylinder transfer facility at the K-25 site would result in lower atmospheric emissions of contaminants than predicted for the Paducah or Portsmouth facilities. Resulting impacts to biota would, therefore, also be negligible. Uranium concentrations in discharges to surface water would be slightly lower than predicted for the Paducah or Portsmouth facilities. Resulting impacts to aquatic biota would also be negligible.

E.3.7 Waste Management

Estimates of waste generation were based on the total number of cylinders at each site. No liquid wastes would be expected at the sites as a result of cylinder shipment activities from either standard cylinders or cylinders in overcontainers. The only solid waste generated in these activities would be personal protective equipment and wipes and rags that would be used to remove surface contamination on the cylinders. These wastes are categorized as combustible solid low-level radioactive waste (LLW) and are shown in Table E.16 for each of the three sites. It was assumed that the LLW would be generated during removal of surface contamination and would be independent of the cylinders being standard or substandard. Thus, the amount of waste in this operation would be proportional to the total number of cylinders at the site. It was assumed that no cylinder breaches would occur inside the overcontainers during transportation.

The waste input resulting from the cylinder overcontainer operations would have minimal impact on radioactive waste management capabilities at any of the three sites or on a national level. The impact on site nonradiological waste management would also be negligible.

The estimated total quantities of solid and liquid wastes generated from activities associated with the construction of the cylinder transfer facility are shown in Table E.17. The type and quantity of solid and liquid waste expected to be generated from the operation of the cylinder transfer facility are shown in Table E.18, based on a throughput cylinder capacity of 5% of the total cylinder inventory at each site. The different types of waste generated during the operation of this facility would include LLW, low-level mixed waste (LLMW), hazardous waste, and nonhazardous waste.

TABLE E.16 Waste Generated with Activities for Cylinder Overcontainers or Standard Cylinder Preparation[a]

	Waste Generated		
Site	Waste Type[b]	Annual Volume (m^3/yr)	Uranium Form
Paducah	LLW (combustible solids)	12.7	UO_2F_2
Portsmouth	LLW (combustible solids)	7.0	UO_2F_2
K-25	LLW (combustible solids)	2.8	UO_2F_2

[a] Decontamination of the overcontainer surfaces was assumed to be performed at the conversion/storage facility prior to the overcontainer being sent back to the site for reuse.

[b] It was assumed that the low-level waste would be generated during removal of surface contamination and would be independent of the cylinder being standard or substandard.

TABLE E.17 Total Wastes Generated during Construction of the Cylinder Transfer Facility: Base Case

Waste Category	Quantity
Hazardous solids	38 m^3
Hazardous liquids	20,000 gal
Nonhazardous solids	
Concrete	76 m^3
Steel	30 tons
Other	612 m^3
Nonhazardous liquids	
Sanitary	3 million gal
Other	1 million gal

TABLE E.18 Estimated Annual Radioactive, Hazardous, and Nonhazardous Wastes Generated during Operation of the Cylinder Transfer Facility at the Three Sites

Type of Waste	Description of Waste	Annual Volume (m^3)			Contaminants
		Paducah	Portsmouth	K-25	
Low-Level Waste					
Combustible solids	Gloves, wipes, clothing, etc.	91	43	15	17 lb UO_2F_2
Metal, surface-contaminated	Failed equipment	12	5.3	2.2	16 lb UO_2F_2
Noncombustible compactible solids	HEPA filters	46	11	8.0	54 lb UO_2F_2
	Grouted waste	2.8	1.3	0.44	135 lb $UO_2(OH)_2$
Other	Lab packs (chemicals)	0.5	0.27	0.11	0.75 lb UO_2F_2
Low-Level Mixed Waste					
Lab packs	Chemicals	0.3	0.13	0.04	0.37 lb UO_2F_2
Inorganic process debris	Failed equipment	0.3	0.13	0.04	0.37 lb UO_2F_2
Combustible debris	Wipes, etc.	0.3	0.13	0.04	0.07 lb UO_2F_2
Hazardous Waste					
Organic liquids	Solvents, oil, paint, thinner	0.8	0.35	0.18	
Inorganic process debris	Failed equipment	1.2	0.6	0.26	1.5 lb HF, 2 lb NaOH
Combustible debris	Wipes, etc.	1.2	0.6	0.26	0.75 lb HF, 1 lb NaOH
Nonhazardous Waste					
Nonhazardous solid waste	Nonhazardous solid waste	87	46	20	
Nonhazardous liquid waste	Cooling tower blowdown process water, etc.	460	220	76	
Recyclable waste	Recyclable waste	180	85	30	

Notation: HEPA = high-efficiency particulate air (filters); HF = hydrogen fluoride; NaOH = sodium hydroxide; UO_2F_2 = uranyl fluoride; $UO_2(OH)_2$ = uranyl hydroxide.

The primary waste produced in the transfer process would be empty UF_6 cylinders and grouted waste drums. Radioactive or hazardous liquid materials would include decontamination liquids, laboratory liquid wastes, contaminated cleaning solution, lubricants, and paints. Radioactive or hazardous solid wastes would include failed process equipment, HEPA filters, laboratory wastes, wipes, rags, and operator-contaminated clothing. The LLW would be shipped off-site for disposal, and the LLMW and hazardous waste would be shipped off-site for both treatment and disposal. The total volume of crushed, empty UF_6 cylinders would be about 125,000 m^3. For the PEIS analysis, it was assumed that the treated cylinders would become part of the DOE scrap metal inventory. If a disposal decision were made, the treated cylinders could be disposed of as LLW, representing a 3% addition to the total projected DOE complex-wide LLW disposal volume.

Overall, the waste input resulting from construction and operation of a transfer facility would add about 7% to the Paducah site LLW generation and less at the Portsmouth and K-25 sites

(see Appendix C, Table C.3), based on the different-sized treatment facilities at each site. The input of LLMW and nonhazardous wastes from the transfer facility would represent less than 1% of each site's LLMW or nonhazardous waste loads.

The waste input resulting from the construction and operation of the transfer facility would have minimal impact on radioactive waste management capabilities at any of the three sites. The impact on nonradiological site waste management would also be negligible. The impacts of waste resulting from the operation of the depleted UF_6 transfer facility on national waste management capabilities would be negligible.

E.3.8 Resource Requirements

Cylinder overcontainers would be constructed primarily from steel purchased from existing steel vendors. The preliminary overcontainer design requires approximately 8,000 lb (3,600 kg) of steel per overcontainer (LLNL 1997). Resources would be required only for the construction of overcontainers. No substantial resources would be required for the use of the overcontainers. Because the overcontainers would be reusable, it is estimated that the total number of overcontainers required would be approximately 581 (LLNL 1997). This total assumes a 10% contingency for spares, unforeseen delays, and the few overcontainers that might be needed at the cylinder treatment facility. The total amount of steel required for the overcontainers would be about 4,640,000 lb (2,110,000 kg). Based upon the total steel required for construction of overcontainers, no impact on local or national steel availability or production would be expected (Standard & Poor's 1996; U.S. Bureau of the Census 1996). No other materials of significant quantity would be required.

Resource needs for the cylinder transfer facility are presented in Table E.19 as utilities consumed during construction and operations at the three sites. The facility was assumed to operate 24 hours per day, 7 days per week, and 292 days per year for an 80% plant availability during operations.

The process equipment would be purchased from equipment vendors. The total quantities of commonly used construction material (i.e., steel) for equipment would be minor as compared to the quantities for construction. The primary specialty material used for equipment fabrication is at most approximately 7 tons of Monel. The material quantities required for construction and operation of the cylinder transfer facility would be minor compared to local and national supplies.

E.3.9 Land Use

No impacts to land use from cylinder overcontainer operations at any of the current cylinder storage sites would be expected. No additional land would be required, and no new construction

TABLE E.19 Resource Requirements for Construction and Operation of the Cylinder Transfer Facility

Material/Resource	Unit	Total Requirement		
		Paducah	Portsmouth	K-25
Construction				
Utilities				
Electricity	GWh	40	35	25
Solids				
Concrete	yd^3	23,000	20,000	16,000
Steel	tons	9,000	8,000	6,000
Liquids				
Fuel	million gal	1.8	1.5	1.2
Gases				
Industrial gases	gal	5,000	4,400	3,500
Specialty material (Monel)	tons	7	5	4
Operations				
Utilities				
Electricity	GWh/yr	14.6	10.8	7.1
Solids				
Cement	lb	2,700	1,600	530
Potassium hydroxide	lb	4,600	2,700	930
Liquids				
Sulfuric acid	lb/yr	2,400	1,400	470
Hydrochloric acid	lb/yr	1,900	1,300	970
Sodium hydroxide	lb/yr	1,500	1,100	770
Liquid fuel	gal/yr	6,000	5,500	4,800
Gases				
Natural gas	million scf/yr	48.5	35	26

would be necessary. Existing handling and support equipment would be utilized with no modifications required (LLNL 1997). No off-site traffic impacts would be encountered during operations because the required labor force would not appreciably affect local traffic patterns or flows.

Impacts to land use from the construction and operation of a cylinder transfer facility would be negligible and limited to temporary disruptions to contiguous land parcels and potential minor traffic disruptions from peak year construction activities. Areal requirements would be small (approximately 21 acres or less), regardless of whether or not the facility were located at one or all of the current cylinder storage sites.

The peak construction labor force for the cylinder transfer facility could result in potential off-site traffic impacts in the vicinity of the three sites, although such impacts would be negligible and would ease as construction neared completion.

E.3.10 Cultural Resources

No impacts to cultural resources would be expected at the Paducah, Portsmouth, and K-25 sites as a result of the cylinder overcontainer option for cylinder preparation. Impacts could result from the cylinder transfer option during construction of the transfer facility at one of the sites. Specific impacts cannot be determined at this time and would depend on the exact location of a facility within each site and whether eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources.

E.3.11 Environmental Justice

The analysis of human health and environmental impacts associated with the cylinder overcontainer operations (Sections E.3.1 through E.3.9) indicates that no high and adverse human health effects would be expected at any of the current cylinder storage sites during normal operations. Consequently, no particular segment of the population, including minority and low-income persons, would be disproportionately affected. The results of accident analyses for cylinder preparation did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1).

The construction and operation of a cylinder transfer facility at any or all of the three storage sites would not result in disproportionate effects on minority or low-income populations. The analysis of human health effects and environmental impacts associated with a cylinder transfer facility (Sections E.3.1 through E.3.9) indicates that no high and adverse human health effects or environmental impacts would be expected.

E.3.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the cylinder preparation options considered in this PEIS were implemented include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the cylinder transfer facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS; or

- Impacts to the visual environment, recreational resources, and noise levels would be expected to stay the same as they are because cylinder preparation activities would be similar to the cylinder management activities currently ongoing at the three sites.

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APPENDIX F:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR CONVERSION OF UF_6 TO OXIDE OR METAL

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NOTATION (APPENDIX F)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LCF	latent cancer fatality
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 μm or less
ROI	region of influence

Chemicals

AlF_3	aluminum trifluoride
CaF_2	calcium fluoride
CO	carbon monoxide
Fe	iron
HC	hydrocarbons
HF	hydrogen fluoride
HNO_3	nitric acid
Mg	magnesium
MgF_2	magnesium fluoride
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
TCE	trichloroethylene
SO_2	sulfur dioxide
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride

UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

°F	degree(s) Fahrenheit	µg	microgram(s)
Ci	curie(s)	m	meter(s)
cm	centimeter(s)	m^3	cubic meter(s)
cm^3	cubic centimeter(s)	mg	milligram(s)
d	day(s)	min	minute(s)
ft	foot (feet)	mrem	millirem(s)
ft^2	square foot (feet)	MW	megawatt(s)
g	gram(s)	MWh	megawatt hour(s)
gal	gallon(s)	pCi	picocurie(s)
gpm	gallon(s) per minute	ppm	part(s) per million
GWh	gigawatt hour(s)	psia	pound(s) per square inch absolute
ha	hectare(s)	rad	radiation absorbed dose(s)
in.	inch(es)	rem	roentgen equivalent man
kg	kilogram(s)	s	second(s)
km	kilometer(s)	scf	standard cubic foot (feet)
L	liter(s)	ton(s)	short ton(s)
lb	pound(s)	yr	year(s)

APPENDIX F:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR CONVERSION OF UF_6 TO OXIDE OR METAL

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the conversion options considered in the PEIS. The discussion provides background information for the conversion options, as well as a summary of the estimated environmental impacts associated with each option.

Conversion Options

Conversion of depleted UF_6 to another chemical form is required for a number of storage, use, and disposal management alternatives. The principal conversion options considered in the PEIS are as follows:

Conversion to U_3O_8. This chemical form is a stable, low-solubility oxide considered for storage and disposal. Two different technologies were considered for conversion to U_3O_8.

Conversion to UO_2. This stable, low-solubility oxide is considered for storage, disposal, and potential use as shielding material. Three different technologies were considered for conversion to UO_2.

Conversion to Metal. Metallic depleted uranium is considered for use as shielding material. Two different technologies were considered for conversion to metal.

Conversion of depleted UF_6 to another chemical form is required for most alternative management strategies. Three different conversion options have been considered in the PEIS: (1) conversion to triuranium octaoxide (U_3O_8), (2) conversion to uranium dioxide (UO_2), and (3) conversion to uranium metal. The specific conversion option considered under each of the alternatives is shown in Table F.1. Because of their high chemical stability and low solubility, uranium oxides (i.e., U_3O_8 and UO_2) are considered for the storage and disposal alternatives. High-density UO_2 and uranium metal are considered for the use alternatives (e.g., spent nuclear fuel radiation shielding applications). Other details concerning the characteristics of the different chemical forms of uranium are given in Appendix A.

Conversion of depleted UF_6 to another chemical form would take place at a stand-alone industrial plant dedicated to the conversion process. A representative conversion plant layout is shown in Figure F.1; the actual plant layout would depend on the specific conversion option and technology selected, as well as on certain site characteristics. In general, the plant would be capable of receiving depleted UF_6 cylinders on trucks or railcars, temporarily storing a small inventory of

TABLE F.1 Summary of the Conversion Options Considered for Each Programmatic Management Alternative

	Option Considered for Management Alternative[a]					
		Long-Term Storage		Use		
Option	No Action	UF_6	Oxide	Uranium Oxide	Uranium Metal	Disposal
Conversion to U_3O_8	–	–	X	–	–	X
Conversion to UO_2	–	–	X	X	–	X
Conversion to metal	–	–	–	–	X	–

[a] X = option considered; – = option not considered.

full cylinders, processing the depleted UF_6 to another chemical form, and storing the converted uranium product and any other products until shipment off-site. The empty cylinders would be stored until transfer to a cylinder treatment facility, which is assumed to be located at the conversion plant site. It is estimated that a typical conversion plant would cover an area of approximately 20 acres (8 ha) (Lawrence Livermore National Laboratory [LLNL] 1997).

In general, potential environmental impacts would occur (1) during construction of a conversion facility, (2) during operations of the facility, and (3) during postulated accidents. The potential impacts associated with facility construction would result from typical land-clearing and construction activities. Potential impacts during operations would occur primarily to workers during handling operations and to the public as a result of routine releases of small amounts of contaminants through exhaust stacks and treated liquid effluent discharges. In addition, potential impacts to workers and the public from processing or storage might occur as a result of accidents that release hazardous materials.

The environmental impacts from the conversion options were evaluated based on the information described in the engineering analysis report (LLNL 1997). For each of the three conversion options (conversion to U_3O_8, UO_2, or metal), the engineering analysis report provides preconceptual facility design data, including descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and estimates of potential accident scenarios. Within each conversion option, several technologies or chemical processes that could be used to produce the same uranium end product are described (two are considered for conversion to U_3O_8, three for conversion to UO_2, and two for conversion to metal). Some of these technologies have not been demonstrated on a commercial scale but were considered to provide an estimate of the range of the

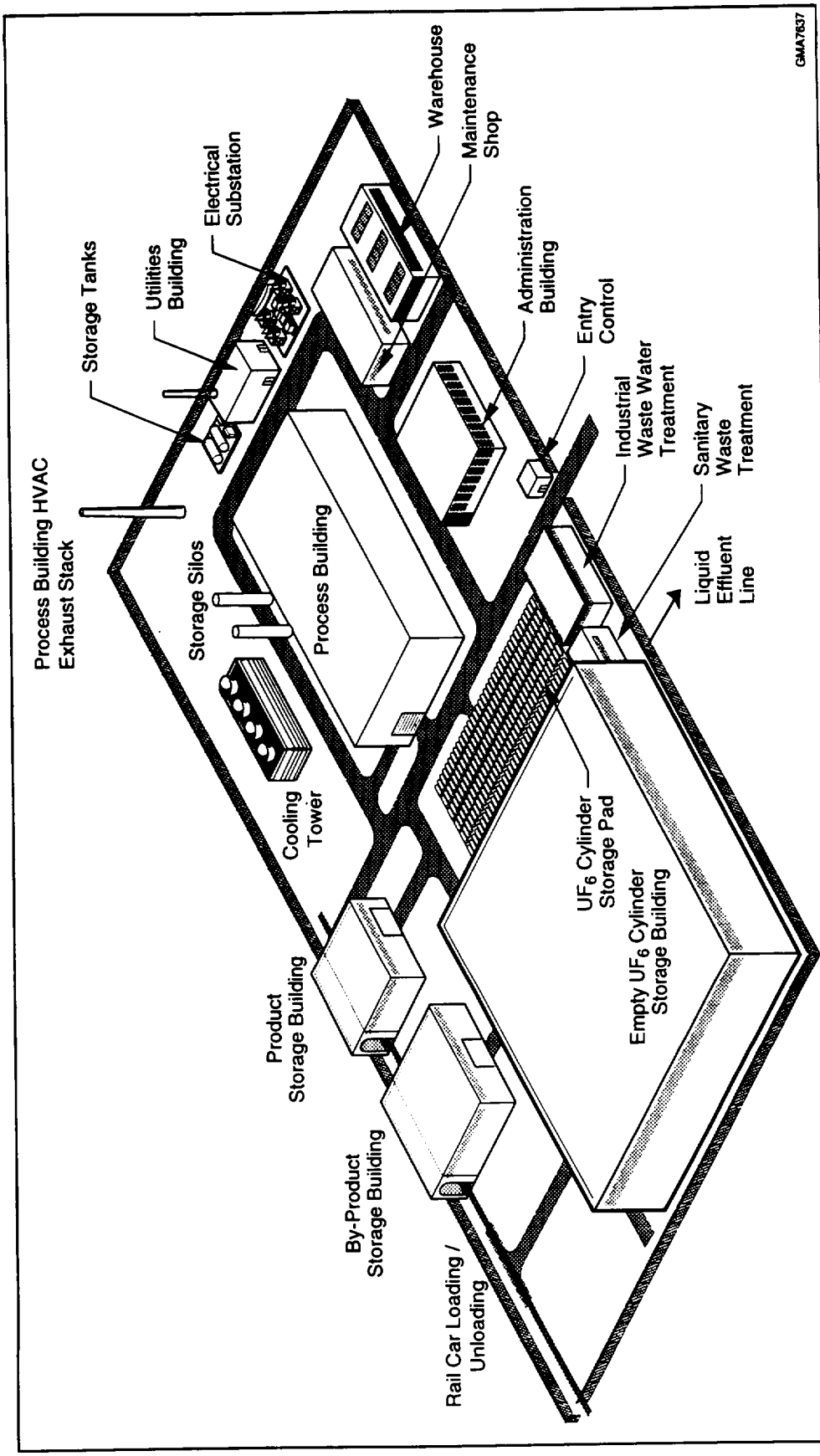

FIGURE F.1 Representative Site Layout for a Conversion Facility

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environmental impacts that might be associated with each of the conversion options. All facility designs were based on a single plant sized to process the entire inventory of DOE-generated depleted UF_6 cylinders over a 20-year period (approximately 2,300 cylinders per year).

F.1 SUMMARY OF CONVERSION OPTION IMPACTS

A summary of the potential environmental impacts associated with the conversion options is provided in this section. These potential impacts are not site-specific because the location of a conversion facility, if required at all, would not be decided until some time in the future. For assessment purposes, the environmental impacts were determined for a range of environmental conditions represented by those at the three current depleted UF_6 storage sites.

The potential environmental impacts for the three conversion options are compared in Table F.2. For each conversion option, the potential environmental impacts are presented as a range within each area of impact. This range is intended to provide a reasonable estimate of the magnitude of impacts, taking into account the uncertainty relative to the specific technologies and sites that could ultimately be selected for conversion. The range of impacts results from two factors: (1) fundamental differences among the technologies within each conversion option; and (2) differences in the conditions at the three representative sites that were evaluated. A more detailed assessment of specific technologies and site conditions will be conducted, as appropriate, as part of the second phase (tier) of the programmatic *National Environmental Policy Act* (NEPA) approach. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in the remaining sections of this appendix.

F.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the different conversion options considered in the assessment of conversion impacts (Table F.3). The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, such as descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and estimates of potential accident scenarios.

All of the conversion options would involve the removal of depleted UF_6 from the storage cylinders, resulting in a large number of empty cylinders. These empty cylinders would contain approximately 22 lb (10 kg) of depleted UF_6 (Charles et al. 1991), called "heels." For assessment purposes, it has been assumed that a cylinder treatment facility would be constructed to wash the empty cylinders. This facility has been assumed to be an independent, or "stand-alone," facility, although it could be integrated directly into the design of the conversion plant. The facility would be co-located with the conversion plant.

TABLE F.2 Summary of Conversion Option Impacts

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
Human Health – Normal Operations: Radiological			
Involved Workers: Total collective dose: 820 person-rem Total number of LCFs: 0.3 LCF	**Involved Workers:** Total collective dose: 980 – 1,100 person-rem Total number of LCFs: 0.4 LCF	**Involved Workers:** Total collective dose: 650 – 1,300 person-rem Total number of LCFs: 0.3 – 0.5 LCF	**Involved Workers:** Total collective dose: 320 person-rem Total number of LCFs: 0.1 LCF
Noninvolved Workers: Annual dose to MEI: $1.6 \times 10^{-3} - 5.8 \times 10^{-3}$ mrem/yr Annual cancer risk to MEI: $6 \times 10^{-10} - 2 \times 10^{-9}$ per year Total collective dose: 0.043 – 0.09 person-rem Total number of LCFs: $2 \times 10^{-5} - 4 \times 10^{-5}$ LCF	**Noninvolved Workers:** Annual dose to MEI: $3.2 \times 10^{-3} - 2.2 \times 10^{-2}$ mrem/yr Annual cancer risk to MEI: $1 \times 10^{-9} - 9 \times 10^{-9}$ per year Total collective dose: 0.084 – 0.34 person-rem Total number of LCFs: $3 \times 10^{-5} - 1 \times 10^{-4}$ LCF	**Noninvolved Workers:** Annual dose to MEI: $6.8 \times 10^{-4} - 1.7 \times 10^{-2}$ mrem/yr Annual cancer risk to MEI: $3 \times 10^{-10} - 7 \times 10^{-9}$ per year Total collective dose: 0.018 – 0.27 person-rem Total number of LCFs: $7 \times 10^{-6} - 1 \times 10^{-4}$ LCF	**Noninvolved Workers:** Annual dose to MEI: $4.9 \times 10^{-6} - 1.8 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: $2 \times 10^{-12} - 7 \times 10^{-12}$ per year Total collective dose: $1.3 \times 10^{-4} - 2.7 \times 10^{-4}$ person-rem Total number of LCFs: $5 \times 10^{-8} - 1 \times 10^{-7}$ LCF
General Public: Annual dose to MEI: $4.9 \times 10^{-3} - 8.8 \times 10^{-3}$ mrem/yr Annual cancer risk to MEI: $2 \times 10^{-9} - 4 \times 10^{-9}$ per year Total collective dose to population within 50 miles: 0.79 – 2.7 person-rem Total number of LCFs in population within 50 miles: 0.0004 – 0.001 LCF	**General Public:** Annual dose to MEI: $9.7 \times 10^{-3} - 3.3 \times 10^{-2}$ mrem/yr Annual cancer risk to MEI: $5 \times 10^{-9} - 2 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 1.6 – 10 person-rem Total number of LCFs in population within 50 miles: 0.0008 – 0.005 LCF	**General Public:** Annual dose to MEI: $2.1 \times 10^{-3} - 2.6 \times 10^{-2}$ mrem/yr Annual cancer risk to MEI: $1 \times 10^{-9} - 1 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.34 – 8.0 person-rem Total number of LCFs in population within 50 miles: 0.0002 – 0.004 LCF	**General Public:** Annual dose to MEI: $1.5 \times 10^{-5} - 2.7 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: $8 \times 10^{-12} - 1 \times 10^{-11}$ per year Total collective dose to population within 50 miles: 0.0024 – 0.0082 person-rem Total number of LCFs in population within 50 miles: $1 \times 10^{-6} - 4 \times 10^{-6}$ LCF

TABLE F.2 (Cont.)

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
Human Health – Normal Operations: Chemical			
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts	**General Public:** No impacts
Human Health – Accidents: Radiological			
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 9.2 rem Risk of LCF to MEI: 4×10^{-3} Collective dose: 840 person-rem Number of LCFs: 0.3	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 2.3 rem Risk of LCF to MEI: 9×10^{-4} Collective dose: 210 person-rem Number of LCFs: 0.08	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 7.5 person-rem Number of LCFs: 3×10^{-3}	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.43 rem Risk of LCF to MEI: 2×10^{-4} Collective dose: 38 person-rem Number of LCFs: 0.02
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 20 person-rem Number of LCFs in population within 50 miles: 0.01 LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.068 rem Risk of LCF to MEI: 3×10^{-5} Collective dose to population within 50 miles: 5.1 person-rem Number of LCFs in population within 50 miles: 0.003 LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 56 person-rem Number of LCFs in population within 50 miles: 0.03 LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.013 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 2.5 person-rem Number of LCFs in population within 50 miles: 0.001 LCF

TABLE F.2 (Cont.)

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
Human Health – Accidents: Chemical			
Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: less than once in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,100 persons	Number of persons with potential for adverse effects: 1,100 persons	Number of persons with potential for adverse effects: 1,100 persons	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 10,000 years to 1 in 1 million years): 440 persons	Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 10,000 years to 1 in 1 million years): 440 persons	Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 10,000 years to 1 in 1 million years): 440 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 41,000 persons	Number of persons with potential for adverse effects: 41,000 persons	Number of persons with potential for adverse effects: 41,000 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 1,700 persons	Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards			
Construction and Operations: **All Workers:** Less than 1 (0.35) fatality, approximately 290 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.59) fatality, approximately 490 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.55) fatality, approximately 490 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.19) fatality, approximately 170 injuries

TABLE F.2 (Cont.)

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
		Air Quality	
Construction: 24-hour PM_{10} concentration potentially as large as 65% of standard. Concentrations of other criteria pollutants all below 15% of respective standards.	**Construction:** 24-hour PM_{10} concentration potentially as large as 90% of standard. Concentrations of other criteria pollutants all below 30% of respective standards.	**Construction:** 24-hour PM_{10} concentration potentially as large as 90% of standard. Concentrations of other criteria pollutants all below 20% of respective standards.	**Construction:** 24-hour PM_{10} concentration potentially as large as 25% of standard. Concentrations of other criteria pollutants all below 10% of respective standards.
Operations: 8-hour CO concentration potentially as large as 3% of standard.	**Operations:** 8-hour CO concentration potentially as large as 5% of standard.	**Operations:** 8-hour CO concentration potentially as large as 5% of standard.	**Operations:** Concentrations of all criteria pollutants below 0.06% of respective standards.
		Water	
Construction: None to negligible physical impacts; concentrations less than applicable standards	**Construction:** None to negligible physical impacts; concentrations less than applicable standards	**Construction:** None to negligible physical impacts; concentrations less than applicable standards	**Construction:** None to negligible physical impacts; concentrations less than applicable standards
Operations: None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	**Operations:** None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	**Operations:** None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards	**Operations:** None to negligible physical impacts to surface water and groundwater; concentrations less than applicable standards
		Soil	
Construction: None to negligible impacts	**Construction:** None to negligible impacts	**Construction:** None to negligible impacts	**Construction:** None to negligible impacts
Operations: None to negligible physical impacts; concentrations less than applicable guidelines	**Operations:** None to negligible physical impacts; concentrations less than applicable guidelines	**Operations:** None to negligible physical impacts; concentrations less than applicable guidelines	**Operations:** None to negligible physical impacts; concentrations less than applicable guidelines

TABLE F.2 (Cont.)

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
		Socioeconomics	
Construction: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Negligible to low impacts to ROI employment and population growth rates and to public finances; potential moderate impacts to vacant housing	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Operations:** Negligible to low impacts to ROI employment and population growth rates and to public finances; potential moderate impacts to vacant housing	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
		Ecology	
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** Negligible impacts	**Operations:** Negligible impacts
		Waste Management	
Potential moderate impacts to site, regional, or national waste management operations	Potential moderate impacts to site, regional, or national waste management operations	Potential moderate impacts to site, regional, or national waste management operations	Potential moderate impacts to national waste management operations

TABLE F.2 (Cont.)

Impacts from Conversion to U_3O_8	Impacts from Conversion to UO_2	Impacts from Conversion to Metal	Impacts from Cylinder Treatment[a]
	Resource Requirements		
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use[b]		
Construction: Use of approximately 20 acres; negligible impacts	**Construction:** Use of approximately 22 to 31 acres; negligible impacts	**Construction:** Use of approximately 23 to 26 acres; negligible impacts	**Construction:** Use of approximately 9 acres; negligible impacts
Operations: Use of approximately 13 acres; negligible impacts	**Operations:** Use of approximately 14 to 20 acres; negligible impacts	**Operations:** Use of approximately 15 to 16 acres; negligible impacts	**Operations:** Use of approximately 5 acres; negligible impacts

[a] These impacts must be added to those for each of the conversion options.

[b] Land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

Notation: CO = carbon monoxide; LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

TABLE F.3 Summary of Technologies Considered under Each Conversion Option

Conversion Option	Technologies
Conversion to U_3O_8	- Defluorination with anhydrous HF production - Defluorination with HF neutralization
Conversion to UO_2	- Dry process with anhydrous HF production - Dry process with HF neutralization - Gelation process
Conversion to metal	- Batch metallothermic reduction - Continuous metallothermic reduction

Following removal of the depleted UF_6, the emptied cylinders containing "heels" would be stored for about 3 months to allow the level of radioactivity associated with the decay products of uranium that remained after UF_6 withdrawal to decrease to acceptable levels. Subsequently, in the proposed cylinder treatment facility, the emptied cylinders are first washed with water and the resulting aqueous wash solution is evaporated and converted to solid U_3O_8 and hydrogen fluoride (HF). The U_3O_8 would be packaged and sent either for disposal or storage. The HF would be neutralized to calcium fluoride (CaF_2) and separately packaged for disposal or sale.

It was assumed that the treated cylinders with a very low residual radiation level would become part of the DOE scrap metal inventory. A report by Nieves et al. (1997) analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle into low-level radioactive waste (LLW) disposal containers, reuse as LLW containers, free release for remelting, and disposal (i.e., burial) as LLW. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. The estimated total health risks over 20 years of processing ranged from 0.1 to 0.8 total fatality for the various options. The potential health impacts were similar for each of the options; however, the disposal option was considered to have the greatest adverse environmental impacts because it would require land allocations and removal of the metal mass from any further usefulness.

F.2.1 Conversion to U_3O_8

A "dry" process, referred to as defluorination, is well established and currently used by industry. It is also practiced on a large-scale industrial basis by Cogema in France. In this process, UF_6 is chemically decomposed with steam and heat to produce U_3O_8 and concentrated HF. The

U_3O_8 would then be compacted to achieve a bulk density of about 3 g/cm^3 prior to storage or disposal.

Two technologies were considered for management of the HF following conversion of UF_6 to U_3O_8. The first process would upgrade the concentrated HF to anhydrous HF for sale. Anhydrous HF is a valuable product; one potential use for HF is in the production of UF_6 from natural uranium ore for feedstock to the gaseous diffusion process. The second process would neutralize the HF to CaF_2 for disposal or sale, depending on whether the CaF_2 with trace amounts of uranium could be marketed.

Because of the considerable market for anhydrous HF, the technology of defluorination with anhydrous HF production would minimize waste and increase product value. However, the handling, storage, and transportation of large quantities of anhydrous HF pose a potential hazard to both workers and the public. During the conversion process, the HF would be upgraded to anhydrous HF by distillation, a common industrial process. Based on historical experience, it is anticipated that the anhydrous HF would contain only trace amounts of depleted uranium (less than 1 ppm, or 0.4 pCi/g) (LLNL 1997). Thus, it was assumed that the anhydrous HF could be sold commercially for unrestricted use.

The process of HF neutralization with lime would convert the concentrated HF to CaF_2 for disposal or possible sale. This step would avoid the potential hazards associated with the processing, general handling, storage, and transportation of large quantities of anhydrous HF. However, the value of CaF_2 is significantly less than that of anhydrous HF, and large quantities of lime are required for neutralization, which would add to the cost of the neutralization option. It is also unknown whether the CaF_2 produced would be sold, disposed of as nonhazardous solid waste, or disposed of as LLW. If disposal were required, there could be moderate impacts to waste management (see Section F.3.7).

F.2.2 Conversion to UO_2

The conversion of UF_6 to UO_2 is used in the nuclear fuel fabrication industry. The UF_6 is converted to a low-density UO_2 powder by either a "wet" or "dry" process. "Wet" processes are based upon separation of solid UO_2 from an aqueous solution, whereas "dry" processes are based upon decomposing and reducing the UF_6. The resulting powder is pressed into a pellet under high pressure, and the pellet is sintered (agglomerated) at high temperatures to yield a dense solid. Depending on the shape, size, and size distribution, the bulk density of UO_2 will generally be 6 to 9 g/cm^3.

Three technologies were considered for the conversion of UF_6 to UO_2. A generic industrial dry process with conversion to produce centimeter-sized pellets is the basis for the first two technologies. The first process would upgrade the concentrated HF to anhydrous HF for sale, similar to the U_3O_8 process. The second process would neutralize the HF to CaF_2 for disposal or sale. The third process is a "wet" process, based on pilot-scale studies, and is referred to as the gelation process.

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In the dry process, gaseous UF_6 would be chemically reacted with steam to produce solid uranyl fluoride (UO_2F_2) and HF. The UO_2F_2 would then be converted to UO_2 powder through a combination of chemical reactions. Using standard physical treatment operations (milling, compacting, and screening) and the addition of a dry lubricant, the UO_2 powder would be pressed into dense pellets with a bulk density of about 6 g/cm^3. The HF would be upgraded to anhydrous HF for commercial resale, as described in Section F.2.1. In the other dry process, the HF would be neutralized to CaF_2 rather than upgraded to anhydrous HF.

In the gelation process, small, dense spheres of UO_2 would be produced through a combination of chemical processes beginning with the conversion of UF_6 to UO_2F_2 and anhydrous HF. The solid UO_2F_2 would then be reacted with steam to produce U_3O_8 and additional anhydrous HF. The U_3O_8 would be dissolved in nitric acid, mixed with other chemicals, and chilled to form a feed broth. This broth would be formed into droplets and fed into a column of hot chlorinated hydrocarbon liquid. Once these droplets formed into spheres, they would be removed from the hot liquid and washed. The droplets would then be dried and converted by heating to dense uranium oxide. The final sintered uranium dioxide spheres are expected to have a density of about 95% or greater of the theoretical maximum density of uranium dioxide, resulting in a bulk density of about 9 g/cm^3. The gelation process has not been demonstrated on a commercial scale.

F.2.3 Conversion to Metal

The conversion of UF_6 to uranium metal would use a commercial process called metallothermic reduction. During this process, UF_6 would react with both hydrogen and magnesium metal to produce uranium metal, anhydrous HF, and magnesium fluoride ($MgFl_2$; slag). Two technologies were considered: a batch reduction process, which is the method used to date, and a continuous reduction process, which is under development and has not been demonstrated on a commercial scale.

In the batch metallothermic reduction process, the UF_6 would be mixed with hydrogen gas in a vertical reaction vessel to form uranium tetrafluoride (UF_4) and HF. The anhydrous HF would be recovered and stored for sale. The UF_4 powder and an excess of magnesium would be contained in a sealed metal vessel and preheated. Once initiated, the reaction would produce molten uranium metal (collecting at the bottom of the reactor) and less dense molten MgF_2 slag. The cycle time per batch (about 12 hours total) would be dominated by the heating and cooling periods. A large number of reactors would be required because of the long cycle time. The slag would be ground, screened, and prepared for disposal. Any metal pellets would be recovered for recycle.

In the continuous metallothermic reduction process, the UF_6 would be mixed with hydrogen gas in a vertical reaction vessel to form UF_4 and HF. The anhydrous HF would be recovered and stored for sale. A mixture of UF_4, magnesium (Mg), iron (Fe), and salt would be continuously fed into the top of a heated reactor. The more dense molten uranium/iron compound would settle to the bottom of the reactor where it would be continuously withdrawn. The lower density MgF_2/salt

mixture would float on top and be separately withdrawn. The molten uranium/iron compound would then be cast into ingots or the end-product form if the manufacturing function was integrated into the conversion facility. The molten salt mixture would be cooled and ground and the water-soluble salt dissolved. After evaporation and drying, the salt would be recycled to the reactor. The insoluble MgF_2 would be drummed for disposal. The annual throughput of the continuous metallothermic reduction reactor would be greater than a batch reactor, requiring fewer reactors.

Neutralization of HF to CaF_2 was not explicitly analyzed in the engineering analysis report for the conversion to metal options (LLNL 1997). However, the process could be implemented and would produce approximately one-third as much CaF_2 as would be produced under the conversion to oxide with neutralization options.

F.2.4 Conversion Technologies and Chemical Forms Considered But Not Analyzed in Detail

The conversion technologies analyzed in the engineering analysis report (LLNL 1997) and the PEIS are those with a sufficient technical basis to carry out preconceptual designs. A number of other promising conversion technologies were considered, but, with minor exceptions, these are in the early stages of conceptualization or development. These options are also discussed in the engineering analysis report (LLNL 1997).

For conversion to an oxide form, technologies considered but not analyzed in detail include a molten metal catalyzed process; the Cameco process (patent pending), which uses a different chemical process than steam hydrolysis/pyrolysis; a conversion process that produces a by-product of aluminum trifluoride (AlF_3); and a defluorination process that results in the production of hydrofluorocarbons. For conversion to metal, a plasma dissociation process was considered but not analyzed in detail.

F.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the conversion options, including impacts from construction and facility operations. For each area of impact, a description of the assessment methodology (including models) is provided in Appendix C.

The environmental impacts from the conversion options were evaluated based on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to all conversion facility operations:

- All facility designs were based on a single conversion plant sized to process the entire inventory of DOE-generated depleted UF_6 cylinders over a 20-year period (approximately 2,300 cylinders per year).
- The conversion plant was assumed to operate 24 hours per day, 7 days per week, 52 weeks per year, with 20% down-time.
- A "stand-alone" cylinder treatment facility (for empty cylinders) is collocated with the conversion plant.

The location of a conversion facility at one of the three current storage sites, if required at all, would not be decided until some time in the future. Instead, for each conversion option, the environmental impacts were calculated separately for a single hypothetical facility located at each of the three current depleted UF_6 storage sites. The three current storage sites were used to provide a reasonable range of environmental conditions. A more detailed assessment of site considerations would be addressed, as appropriate, as part of the second phase (tier) of the programmatic NEPA approach.

For each conversion option, the potential environmental impacts are presented as a range within each area of impact. This range is intended to provide a reasonable estimate of the magnitude of impacts, taking into account the uncertainty relative to the specific technologies and sites that would ultimately be selected for conversion. The range of impacts results from two factors: (1) fundamental differences among the technologies within each conversion option and (2) differences in the site conditions.

F.3.1 Human Health — Normal Operations

F.3.1.1 Radiological Impacts

Radiological impacts to involved workers during normal operations at conversion facilities would result primarily from external radiation from the handling of depleted uranium materials. Impacts to noninvolved workers and members of the public would result primarily from trace amounts of uranium compounds released to the environment. Detailed discussions of the methodologies used in radiological impact analysis are provided in Appendix C and in Cheng et al. (1997).

F.3.1.1.1 Conversion to U_3O_8

Conversion to U_3O_8 would result in average radiation exposure of about 300 mrem/yr to involved workers and less than 0.01 mrem/yr to noninvolved workers and members of the public. Radiation doses and cancer risks associated with normal operations of the U_3O_8 conversion facilities are listed in Tables F.4 and F.5, respectively. The two conversion technologies evaluated are described in Section F.2.1. Due to the similarity of the conversion processes, the airborne emission rates of uranium compounds and the material handling activities are expected to vary only slightly from each other, resulting in similar radiological impacts.

Involved Workers. Radiation exposures for the involved workers are estimated according to the descriptions of material handling activities provided in the engineering analysis report (LLNL 1997). Due to the preliminary nature of each facility design, the estimated radiation doses are subject to a large degree of uncertainty. The results presented in this appendix should be used only for purposes of comparison among different technologies. Radiation exposure of involved workers would be monitored by a dosimetry program and maintained below regulatory limits.

The collective dose for involved workers is estimated to be about 41 person-rem/yr for 135 workers for the U_3O_8 conversion processes. This would result in about 0.02 excess latent cancer fatalities (LCFs) per year (or about 2 LCFs over a 100-year period) among the involved workers. If evenly distributed among involved workers, the average individual dose would be approximately 300 mrem/yr, well below the regulatory limit of 5,000 mrem/yr for workers (10 *Code of Federal Regulations* [CFR] Part 835). This corresponds to an average cancer risk of about 1×10^{-4} per year (1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. Estimated doses and health risks are much lower for noninvolved workers than for involved workers. Inhalation of U_3O_8 particulates accounts for more than 99.9% of the radiological exposures for noninvolved workers. The radiation dose (risk of an LCF) to a maximally exposed noninvolved worker would range from 1.6×10^{-3} mrem/yr (6×10^{-10} per year) to 5.8×10^{-3} mrem/yr (2×10^{-9} per year), which is a very small fraction (less than 1 in 1,000) of the maximally allowable dose limit (10 mrem/yr) from airborne emissions (40 CFR Part 61). The population of noninvolved workers would vary from site to site. For representative noninvolved worker population sizes ranging from 2,000 to 3,500, the resulting collective dose would range from 0.0021 to 0.0045 person-rem/yr.

General Public. The locations of the maximally exposed individual (MEI) for the general public are either at or near the site boundary. Although other exposure pathways are also considered, inhalation exposure accounts for more than 95% of the total dose. The radiation dose for the MEI would be negligible, ranging from 0.0049 to 0.0088 mrem/yr, compared with the dose limit of 10 mrem/yr from airborne emissions. The potential radiation dose resulting from drinking

TABLE F.4 Radiological Doses from Conversion/Treatment Options under Normal Operations[a]

Option	Dose to Receptor					
	Involved Workers[b]		Noninvolved Workers[c]		General Public	
	Average Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[d] (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
Conversion to U_3O_8	300	41	1.6×10^{-3} – 5.8×10^{-3}	2.1×10^{-3} – 4.5×10^{-3}	4.9×10^{-3} – 8.8×10^{-3}	3.9×10^{-2} – 1.4×10^{-1}
Conversion to UO_2	180 – 340	49 – 54	3.2×10^{-3} – 2.2×10^{-2}	4.2×10^{-3} – 1.7×10^{-2}	9.7×10^{-3} – 3.3×10^{-2}	7.8×10^{-2} – 5.1×10^{-1}
Conversion to metal	230 – 240	33 – 67	6.8×10^{-4} – 1.7×10^{-2}	9.0×10^{-4} – 1.3×10^{-2}	2.1×10^{-3} – 2.6×10^{-2}	1.7×10^{-2} – 4.0×10^{-1}
Cylinder treatment	160	16	4.9×10^{-6} – 1.8×10^{-5}	6.5×10^{-6} – 1.4×10^{-5}	1.5×10^{-5} – 2.7×10^{-5}	1.2×10^{-4} – 4.1×10^{-4}

[a] Impacts are reported as ranges, which result from variations in the three representative facility locations and the different conversion technologies within each option.

[b] Involved workers are those workers directly involved with the handling of radioactive materials. Calculation results are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[c] Noninvolved workers include individuals who work at the facility but are not directly involved in handling materials and individuals who work on-site but not within the facility. The population size of noninvolved workers ranges from 2,000 to 3,500 for all options.

[d] The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point at the location that would result in the largest dose, which includes doses from inhalation, external radiation, and incidental soil ingestion.

[e] The MEI for the general public was assumed to be located off-site at the point that would result in the largest dose from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

[f] Collective dose was estimated for the populations (ranging from 500,000 to 880,000 persons) within a radius of 50 miles (80 km) around the three representative sites. The exposure pathways considered are inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil.

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TABLE F.5 Latent Cancer Risks from Conversion/Treatment Options under Normal Operations[a]

Option	Latent Cancer Risk to Receptor					
	Involved Workers[b]		Noninvolved Workers[c]		General Public	
	Average Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[d] (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
Conversion to U_3O_8	1×10^{-4}	2×10^{-2}	6×10^{-10} – 2×10^{-9}	9×10^{-7} – 2×10^{-6}	2×10^{-9} – 4×10^{-9}	2×10^{-5} – 7×10^{-5}
Conversion to UO_2	7×10^{-5} – 1×10^{-4}	2×10^{-2}	1×10^{-9} – 9×10^{-9}	2×10^{-6} – 7×10^{-6}	5×10^{-9} – 2×10^{-8}	4×10^{-5} – 3×10^{-4}
Conversion to metal	9×10^{-5} – 1×10^{-4}	1×10^{-2} – 3×10^{-2}	3×10^{-10} – 7×10^{-9}	4×10^{-7} – 5×10^{-6}	1×10^{-9} – 1×10^{-8}	9×10^{-6} – 2×10^{-4}
Cylinder treatment	6×10^{-5}	6×10^{-3}	2×10^{-12} – 7×10^{-12}	3×10^{-9} – 5×10^{-9}	8×10^{-12} – 1×10^{-11}	6×10^{-8} – 2×10^{-7}

[a] Impacts are reported as ranges, which result from variations in the three representative facility locations and the different conversion technologies within each option.

[b] Involved workers are those workers directly involved with the handling of radioactive materials. Calculation results are presented as average individual risk and collective risk for the worker population.

[c] Noninvolved workers include individuals who work at the facility but are not directly involved in handling materials and individuals who work on-site but not within the facility. The population size of noninvolved workers ranges from 2,000 to 3,500 for all options.

[d] The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point at the location that would result in the largest risk, which includes risks from inhalation, external radiation, and incidental soil ingestion.

[e] The MEI for the general public was assumed to be located off-site at the point that would result in the largest risk from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

[f] Collective risk was estimated for the populations (ranging from 500,000 to 880,000 persons) within a radius of 50 miles (80 km) around the three representative sites. The exposure pathways considered are inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil.

contaminated surface water would be two orders of magnitude less than that from exposure to airborne emissions.

For a location with an off-site population ranging from 500,000 to 880,000 persons within a 50-mile (80-km) distance from the site boundary, the collective dose would range from 0.039 to 0.14 person-rem/yr, which corresponds to about 2×10^{-5} to 7×10^{-5} LCF per year (less than 1 chance in 10,000 of 1 LCF per year in the population).

F.3.1.1.2 Conversion to UO_2

Conversion to UO_2 would result in average radiation exposure of less than 340 mrem/yr to involved workers and less than 0.04 mrem/yr to noninvolved workers and members of the public, similar to those for conversion to U_3O_8. The radiation doses and cancer risks associated with normal operations of the UO_2 conversion facilities are listed in Tables F.4 and F.5, respectively.

Involved Workers. The estimated collective dose for involved workers ranges from 49 to 54 person-rem/yr, slightly greater than conversion to U_3O_8. This would result in approximately 0.02 excess cancer fatality per year (2 LCFs over a 100-year period). If evenly distributed among involved workers (about 160 to 270 workers), the average individual dose would range from about 180 to 340 mrem/yr, well below the annual worker dose limit of 5,000 mrem/yr. This corresponds to an average cancer risk of 7×10^{-5} to 1×10^{-4} per year (less than 1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. The doses to noninvolved workers are similar to but slightly higher than those for conversion to U_3O_8. The dose to the MEI would range from 0.0032 to 0.022 mrem/yr, which is negligible compared with the dose limit of 10 mrem/yr for airborne emissions. For representative population sizes ranging from 2,000 to 3,500, the collective dose would range from 0.0042 to 0.017 person-rem/yr. The estimated number of potential LCFs would be less than 0.00001 per year.

General Public. The estimated radiation dose to the MEI for the general public would be slightly higher than that from conversion to U_3O_8, ranging from 0.0097 to 0.033 mrem/yr. These values are well below the radiation dose limit of 10 mrem/yr set for airborne emissions. The radiation dose from drinking contaminated surface water would be very small compared with the dose from airborne emissions. The collective dose for a population of 500,000 to 880,000 persons would range from 0.078 to 0.51 person-rem/yr. This would correspond to 4×10^{-5} to 3×10^{-4} LCF per year among the population (less than 1 chance in 3,000 of 1 LCF per year).

F.3.1.1.3 Conversion to Metal

Conversion to uranium metal would result in average exposure of less than 240 mrem/yr to involved workers and less than 0.03 mrem/yr to noninvolved workers and members of the public. The radiological impacts and cancer risks from operations of the metal conversion facilities are shown in Tables F.4 and F.5, respectively.

Involved Workers. The collective dose to involved workers would range from 33 to 67 person-rem/yr, similar to conversion to U_3O_8 and conversion to UO_2. The corresponding number of LCFs would range from 0.01 to 0.03 per year (1 to 3 LCFs over a 100-year period) among a worker population of approximately 140 to 270. If evenly distributed among workers, the average annual worker dose would be about 240 mrem/yr, which is well below the regulatory limit of 5,000 mrem/yr. The corresponding cancer risk is 0.0001 per year (less than 1 chance in 10,000 of developing 1 LCF per year).

Noninvolved Workers. The radiation dose to noninvolved workers would be similar to those for conversion to U_3O_8 and conversion to UO_2 and would be negligible compared with the regulatory dose limit of 10 mrem/yr. The collective dose would range from 0.0009 to 0.013 person-rem/yr for 2,000 to 3,500 workers.

General Public. The radiation dose for the MEI of the general public would range from 0.0021 to 0.026 mrem/yr, which corresponds to a cancer risk of 1×10^{-9} to 1×10^{-8} per year (less than 1 chance in 100 million of developing 1 LCF per year). The radiation dose from drinking contaminated surface water would be very small compared with the dose from airborne emissions. The collective dose for the population of 500,000 to 880,000 people living within 50 miles (80 km) of the site would range from 0.017 to 0.4 person-rem/yr. This corresponds to about 9×10^{-6} to 2×10^{-4} LCF per year within the exposed population.

F.3.1.1.4 Cylinder Treatment Facility

The empty UF_6 cylinders from the conversion facilities would be decontaminated at a cylinder treatment facility before reuse or final disposal. Average radiological exposure incurred by involved workers would be less than 200 mrem/yr, and maximum exposures incurred by noninvolved workers and the off-site public would be less than 3×10^{-5} mrem/yr. The estimated radiological impacts and cancer risks from cylinder treatment operations are presented in Tables F.4 and F.5, respectively.

Involved Workers. The average annual dose received by involved workers would be approximately 160 mrem/yr, which was calculated by evenly distributing the estimated collective dose of 16 person-rem/yr to a worker population of approximately 100. The average dose is a small fraction of the dose limit of 5,000 mrem/yr and corresponds to a cancer risk of 6×10^{-5} per year (1 chance in 16,000 of developing 1 LCF per year). The collective number of LCFs among the involved workers would be 6×10^{-3} per year.

Noninvolved Workers. Only a small amount of U_3O_8 (0.01 lb/yr) would be released to the atmosphere from the cylinder treatment facility. Radiological exposure to the noninvolved worker MEI would be negligible (less than 1.8×10^{-5} mrem/yr). The collective dose would range from 6.5×10^{-6} to 1.4×10^{-5} person-rem/yr for a population of 2,000 to 3,500.

General Public. The radiation exposure of the general public MEI from normal operations at the treatment facility would be negligible (less than 2.7×10^{-5} mrem/yr). The collective dose to the off-site population of 500,000 to 880,000 people would be less than 4.1×10^{-4} person-rem/yr.

F.3.1.2 Chemical Impacts

Potential chemical impacts to human health from normal operations at the conversion facilities would result primarily from exposure to trace amounts of insoluble uranium compounds (i.e., UO_2, U_3O_8, and UF_4) and HF released from process exhaust stacks. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses used for uranium compounds and HF, and calculational methods used in the chemical impact analysis are provided in Appendix C and Cheng et al. (1997).

Conversion to U_3O_8, UO_2, or metal would result in very low-level exposures to hazardous chemicals. No adverse health effects would be expected during normal operations. Hazardous chemical human health impacts resulting from normal operations of the conversion facilities are summarized in Table F.6. The hazard indices for all conversion processes are more than 5,000 times lower than the hazard index of 1, which is the level at which adverse health effects might be expected to occur in some exposed individuals. The range of chemical exposures to the noninvolved workers and general public results primarily from the assumed locations of the representative conversion facilities.

One of the UO_2 conversion options, the gelation process, would also generate emissions of the chemical trichloroethylene from the process stack. The estimated increased lifetime carcinogenic risk of cancer incidence for noninvolved workers and members of the general public from exposure to trichloroethylene would be less than 1×10^{-8}, a very small increased risk that would not be considered an adverse impact.

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TABLE F.6 Chemical Impacts to Human Health for Conversion/Treatment Options under Normal Operations[a]

Option	Impacts to Receptor			
	Noninvolved Workers[b]		General Public	
	Hazard Index for MEI[c,d]	Population Risk[e] (persons at risk/yr)	Hazard Index for MEI[c,f]	Population Risk[e] (persons at risk/yr)
Conversion to U_3O_8	3.9×10^{-7} – 1.5×10^{-6}	–	3.4×10^{-5} – 1.2×10^{-4}	–
Conversion to UO_2	7.5×10^{-7} – 3.1×10^{-6}	–	6.2×10^{-5} – 1.9×10^{-4}	–
Conversion to metal	4.8×10^{-7} – 3.0×10^{-6}	–	4.1×10^{-5} – 1.5×10^{-4}	–
Cylinder treatment	4.2×10^{-10} – 1.5×10^{-9}	–	3.5×10^{-8} – 7.1×10^{-8}	–

[a] Impacts are reported as ranges, which result from variations in the three representative facility locations and the different conversion technologies within each option.

[b] Noninvolved workers include individuals who work at the facility but are not directly involved in handling hazardous materials and individuals who work on-site but not within the facility.

[c] The hazard index is an indicator for potential adverse health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation. Hazard indices were calculated for combined exposures to uranium compounds and HF.

[d] The MEI for the noninvolved workers was assumed to be located on-site 100 m or more from the release point at the location that would result in the largest exposure from airborne emissions, including inhalation and incidental ingestion of contaminated soil.

[e] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[f] The MEI for the general public was assumed to be located off-site at the location that would result in the largest exposures through inhalation and ingestion of soil and drinking water.

The empty UF_6 cylinders from the conversion facilities would be decontaminated at a cylinder treatment facility prior to final disposal. Estimates of the hazardous chemical impacts to human health resulting from cylinder treatment operations are also summarized in Table F.6. The hazard indices from the cylinder treatment facility would be hundreds of times lower than those predicted for the conversion options, for which no adverse human health impacts were predicted.

F.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum from high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table F.7. The following sections present the results for radiological and chemical health impacts of the highest-consequence accident in each frequency category. Results for all accidents listed in Table F.7 are presented in Policastro et al. (1997). A detailed description of the methodology and assumptions used in the calculations is also provided in Appendix C and Policastro et al. (1997).

F.3.2.1 Radiological Impacts

Table F.8 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table F.9. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions, three representative sites, and two or three technologies were considered for each conversion option (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence of between 1 in 10,000 and 1 in 1 million per year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming that an accident occurred) would be 9.2 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table F.9] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the conversion facility accidents.

F.3.2.2 Chemical Impacts

The accidents considered in this section are listed in Table F.7. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables F.10 and F.11. The results are presented as (1) number of people with potential for adverse effects and (2) number of

TABLE F.7 Accidents Considered for the Conversion Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to U_3O_8					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in the shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
HF system leak during upgrading of HF to anhydrous HF	An HF absorber column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	216	15	Stack
HF system leak during HF neutralization	An HF distillation column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	10	15	Stack
Loss of cooling water during upgrading of HF to anhydrous HF	Cooling water is lost to the HF distillation column condenser, and HF vapor is removed by a limestone bed before reaching the environment.	HF	22	2	Stack
Loss of cooling water during HF neutralization	Cooling water is lost to the absorption column coolers, and HF vapor is released to the atmosphere.	HF	19	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA[b]	NA	NA
U_3O_8 drum spill	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the floor inside the storage facility.	U_3O_8	0.00014	30	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HFs, releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released through the building stack.	HF	45	15	Stack

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to U_3O_8 (Cont.)					
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in.-deep water pool.	HF	150	60 (continuous)	Ground
Earthquake	The U_3O_8 storage building is damaged during a design-basis earthquake, and 10% of the stored drums are breached.	U_3O_8	41	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the conversion reactor ignites and causes the reactor to rupture.	U_3O_8 HF	0.27 7	30	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single U_3O_8 drum in the U_3O_8 storage building.	U_3O_8	69	0.5	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	118,000	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to UO_2					
Likely Accidents (frequency: 1 or more times in 100 years)					
Ammonia stripper overpressure	Cooling water is lost to the ammonia stripping column, and ammonia vapor is released to the atmosphere.	Ammonia	15	1	Ground
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
HF system leak during upgrading of HF to anhydrous HF	An HF absorber line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	216	15	Stack
HF system leak during HF neutralization	An HF distillation column line leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	10	15	Stack
Loss of cooling water during upgrading of HF to anhydrous HF	Cooling water is lost to the HF distillation column condenser, and HF vapor is removed by a limestone bed before reaching the environment.	HF	22	2	Stack
Loss of cooling water during HF neutralization	Cooling water is lost to the absorption column coolers, and HF vapor is released to the atmosphere.	HF	19	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Trichloroethylene (TCE) spill	A TCE storage tank spills onto the floor during operations, and the pool of TCE evaporates and is released to the environment.	TCE	120	120	Stack
Trichloroethylene vapor leak	The exhaust line from the gel sphere dryers leaks 5% of its flowing contents due to potential pipe leakage.	TCE	20	60	Stack
UO_2 drum spill	A single UO_2 drum is damaged by a forklift and spills its contents onto the floor inside the storage facility.	UO_2	0.000056	30	Stack

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to UO_2 (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HF, releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released to the indoor air of the process building.	HF	45	15	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in.-deep water pool.	HF	147	60 (continuous)	Ground
Earthquake	The UO_2 storage building is damaged during a design-basis earthquake, and 10% of the stored drums are breached.	UO_2	9.8	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the ceramic UO_2 conversion reactor ignites and causes the reactor to rupture.	UO_2 HF	0.25 7	30	Stack
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the gelation conversion reactor ignites and causes the reactor to rupture.	UO_2	0.017	30	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single ceramic UO_2 drum in the UO_2 storage building.	UO_2	3.7	0.5	Ground
Tornado	A windblown missile from a design-basis tornado pierces a single UO_2 drum produced by gelation in the UO_2 storage building.	UO_2	5.6	0.5	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to UO_2 (Cont.)					
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	117,920	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Conversion to Metal					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
HF system leak	An off-gas line from the conversion reactor to the condenser leaks 5% of its flowing contents due to potential vessel, pump, or pipe leakage.	HF	3.6	15	Stack
Loss of cooling water	Cooling water is lost to the reactor HF coolers, and HF vapor is released to the atmosphere.	HF	17	2	Stack
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
UF_4 drum spill	A single UF_4 drum is damaged by a forklift and spills its contents onto the floor of the process building.	UF_4	0.00015	30	Stack

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to Metal (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Ammonia release	An ammonia fill line is momentarily disconnected, and ammonia is released at grade.	Ammonia	255	1	Ground
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
HF pipeline rupture	An earthquake ruptures an underground pipeline transporting HF and releasing it to the ground.	HF	500	10	Soil
HF storage tank overflow	An HF storage tank overflows during filling, spilling onto the floor; the pool of HF evaporates and is released to the indoor air of the process building.	HF	45	15	Stack
Nitric acid (HNO_3) release	Due to equipment failure, hot HNO_3 flows through a relief valve.	HNO_3	6	2	Stack
Uranium metal fire	The wooden boxes containing the uranium metal product burn, affecting a total of 34 uranium derbies.	U_3O_8	0.058	30	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in.-deep water pool.	HF	147	60 (continuous)	Ground
Earthquake	The uranium product storage building is damaged during a design-basis earthquake, and some of the boxes containing uranium metal are breached.	U_3O_8	0.058	30	Ground
Hydrogen explosion	Due to equipment malfunction, hydrogen that accumulated in the conversion reactor ignites and causes the reactor to rupture.	UF_4 HF	0.05 2	30	Stack
Reactor rupture	A reactor containing molten uranium metal is damaged or breached, releasing hot molten uranium metal as airborne particles.	U_3O_8	0.0026	15	Stack
Tornado	A design-basis tornado does not result in significant releases because uranium is in metal form.	No release	NA	NA	NA
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground

TABLE F.7 (Cont.)

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Conversion to Metal (Cont.)					
Incredible Accidents (frequency: less than 1 in 1 million years)					
Anhydrous HF tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled anhydrous HF storage tank.	HF	7,920	120	Ground
Ammonia tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled ammonia storage tank.	Ammonia	118,000	20	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Cylinder Treatment Facility					
Likely Accidents (frequency: 1 or more times in 100 years)					
Loss of off-site electrical power	Off-site electrical power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
U_3O_8 drum spill	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the ground outside the storage facility.	U_3O_8	0.138	30	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Loss of scrubber water	Water is lost to both HF scrubbers, and HF is released with the off gas.	HF	26	30	Stack
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Depleted UF_6 cylinder rupture	A truck crashes into the depleted UF_6 heel storage pad, damaging two cylinders; the fuel from the truck ignites and releases all of the depleted UF_6.	UO_2F_2 HF	38.5 10	30	Ground
Earthquake	The solids product building is damaged during a design-basis earthquake, and 50% of the stored drums are breached.	U_3O_8	1.9	30	Ground
HF aqueous tank rupture	The evaporator tank fails, releasing its entire contents of HF to the floor; the pool of aqueous HF evaporates and is released to the indoor air of the process building.	HF	3.4	60	Stack
Tornado	A windblown missile from a design-basis tornado pierces a single U_3O_8 drum in the solids product building.	U_3O_8	69	0.5	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

[b] NA = not applicable.

TABLE F.8 Estimated Radiological Doses per Accident Occurrence for the Conversion Options

Option/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Conversion to U_3O_8									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	7.1	2.3×10^{-3}	3.0×10^{-1}	3.3×10^{-3}	8.1×10^{-2}	7.8×10^{-5}	7.4×10^{-3}
Earthquake	EU	9.2	8.4×10^{2}	2.7×10^{-1}	2.0×10^{1}	3.9×10^{-1}	9.6	9.2×10^{-3}	8.0×10^{-1}
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	2.5	4.9×10^{-3}	2.7×10^{-1}	8.7×10^{-4}	2.2×10^{-1}	6.2×10^{-4}	2.5×10^{-2}
Conversion to UO_2									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	7.1	2.3×10^{-3}	3.0×10^{-1}	3.3×10^{-3}	8.1×10^{-2}	7.8×10^{-5}	7.4×10^{-3}
Earthquake	EU	2.3	2.1×10^{2}	6.8×10^{-2}	5.1	9.6×10^{-2}	2.4	2.3×10^{-3}	2.0×10^{-1}
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	2.5	4.9×10^{-3}	2.7×10^{-1}	8.7×10^{-4}	2.2×10^{-1}	6.2×10^{-4}	2.5×10^{-2}
Conversion to metal									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	7.1	2.3×10^{-3}	3.0×10^{-1}	3.3×10^{-3}	8.1×10^{-2}	7.8×10^{-5}	7.4×10^{-3}
Uranium metal fire	U	2.4×10^{-6}	1.2×10^{-3}	2.6×10^{-6}	2.0×10^{-2}	4.9×10^{-7}	2.4×10^{-11}	2.0×10^{-6}	1.1×10^{-3}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	7.5	1.5×10^{-2}	5.6×10^{1}	3.7×10^{-3}	5.2×10^{-1}	1.9×10^{-3}	5.2×10^{-1}
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	2.5	4.9×10^{-3}	2.7×10^{-1}	8.7×10^{-4}	2.2×10^{-1}	6.2×10^{-4}	2.5×10^{-2}
Cylinder treatment									
U_3O_8 drum spill	L	3.1×10^{-2}	2.8	9.2×10^{-4}	6.9×10^{-2}	1.3×10^{-3}	3.2×10^{-2}	3.1×10^{-5}	2.7×10^{-3}
Tornado[d]	EU	4.3×10^{-1}	3.8×10^{1}	1.3×10^{-2}	2.5	4.3×10^{-1}	1.1×10^{1}	1.0×10^{-2}	4.5×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

[d] Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

TABLE F.9 Estimated Radiological Health Risks per Accident Occurrence for the Conversion Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Conversion to U_3O_8									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	3×10^{-3}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-5}	4×10^{-8}	4×10^{-6}
Earthquake	EU	4×10^{-3}	3×10^{-1}	1×10^{-4}	1×10^{-2}	2×10^{-4}	4×10^{-3}	5×10^{-6}	4×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	1×10^{-3}	2×10^{-6}	1×10^{-4}	3×10^{-7}	9×10^{-5}	3×10^{-7}	1×10^{-5}
Conversion to UO_2									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	3×10^{-3}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-5}	4×10^{-8}	4×10^{-6}
Earthquake	EU	9×10^{-4}	8×10^{-2}	3×10^{-5}	3×10^{-3}	4×10^{-5}	1×10^{-3}	1×10^{-6}	1×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	1×10^{-3}	2×10^{-6}	1×10^{-4}	3×10^{-7}	9×10^{-5}	3×10^{-7}	1×10^{-5}
Conversion to metal									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	3×10^{-3}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-5}	4×10^{-8}	4×10^{-6}
Uranium metal fire	U	1×10^{-9}	5×10^{-7}	1×10^{-9}	1×10^{-5}	2×10^{-10}	1×10^{-14}	1×10^{-9}	6×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	3×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	1×10^{-3}	2×10^{-6}	1×10^{-4}	3×10^{-7}	9×10^{-5}	3×10^{-7}	1×10^{-5}
Cylinder treatment									
U_3O_8 drum spill	L	1×10^{-5}	1×10^{-3}	5×10^{-7}	3×10^{-5}	5×10^{-7}	1×10^{-5}	2×10^{-8}	1×10^{-6}
Tornado[e]	EU	2×10^{-4}	2×10^{-2}	7×10^{-6}	1×10^{-3}	2×10^{-4}	4×10^{-3}	5×10^{-6}	2×10^{-4}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCFs) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risks to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

TABLE F.10 Number of Persons with Potential for Adverse Effects from Accidents under the Conversion Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Conversion to U_3O_8									
Corroded cylinder spill, dry conditions	L	Yes	240	No	0	Yes	2	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	520	Yes	10	Yes[f]	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes[f]	0	Yes	3
HF tank rupture	I	Yes	1,100	Yes	41,000	Yes	770	Yes	18
Conversion to UO_2									
Corroded cylinder spill, dry conditions	L	Yes	240	No	0	Yes	2	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	520	Yes	10	Yes[f]	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes[f]	0	Yes	3
HF tank rupture	I	Yes	1,100	Yes	41,000	Yes	770	Yes	18
Conversion to metal									
Corroded cylinder spill, dry conditions	L	Yes	240	No	0	Yes	2	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	520	Yes	10	Yes[f]	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes[f]	0	Yes	3
HF tank rupture	I	Yes	1,100	Yes	41,000	Yes	770	Yes	18
Cylinder treatment									
U_3O_8 drum spill[g]	L	No	0	No	0	No	0	No	0
Loss of scrubber water[g]	U	No	0	No	0	No[i]	0	No	0
Tornado[h]	EU	Yes	1	No	0	NA[i]	NA	NA	NA

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect differences in assumed meteorological conditions at the time of the accident. In general, the maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas the minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the representative sites were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

[h] Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

[i] NA = not applicable.

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TABLE F.11 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Conversion Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Conversion to U_3O_8									
Corroded cylinder spill, dry conditions	L	Yes	5	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	370	Yes[f]	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	440	Yes[f]	0	Yes	4	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Conversion to UO_2									
Ammonia stripper overpressure	L	Yes	40	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	370	Yes[f]	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	440	Yes[f]	0	Yes	4	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Conversion to metal									
Corroded cylinder spill, dry conditions	L	Yes	5	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	370	Yes[f]	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	440	Yes[f]	0	Yes	4	No	0
Ammonia tank rupture	I	Yes	420	Yes	1,700	Yes	180	Yes	8
Cylinder treatment									
U_3O_8 drum spill[g]	L	No	0	No	0	No	0	No	0
Loss of scrubber water[g]	U	No[f]	0	No	0	No[f]	0	No	0
Tornado[h]	EU	Yes[f]	0	No	0	NA[i]	NA	NA	NA

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect different meteorological conditions at the time of the accident. In general, the maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas the minimum risks would occur under D stability with 4 m/s wind speed. An exception is worker impacts for the ammonia tank rupture, for which maximum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse affects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the representative sites were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

[h] Meteorological conditions analyzed for the tornado were D stability with 20 m/s wind speed.

[i] NA = not applicable.

people with potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of workers and off-site population) (Policastro et al. 1997). The numbers of noninvolved workers and members of the off-site public represent the impacts if the associated accident was assumed to occur. The accidents listed in Tables F.10 and F.11 are not identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The impacts may be summarized as follows:

- If the accidents identified in Tables F.10 and F.11 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 41,000 (maximum corresponding to HF tank rupture), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1,700 (maximum corresponding to ammonia tank rupture).

- If the accidents identified in Tables F.10 and F.11 were to occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 1,100 (maximum corresponding to HF tank rupture), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 440 (maximum corresponding to corroded cylinder spill, wet conditions — water pool).

- The largest impacts would be caused by HF tank rupture; corroded cylinder spill, wet conditions – rain; ammonia tank rupture; and vehicle-induced fire involving three full 48G cylinders. Accidents involving stack emissions would have very small impacts compared with accidents involving releases at ground level due to the large dilution (and lower source terms due to filtration and deposition) involved with the stack emissions.

- The bounding accidents for the conversion options (conversion to U_3O_8, UO_2, and metal) would have nearly identical impacts.

- For the most severe accidents in each frequency category, the noninvolved worker MEI and the public MEI would have the potential for both adverse effects and irreversible adverse effects. The likely accidents for each conversion option (frequency of more than one chance in 100 per year) would result in no potential adverse or irreversible adverse effects for the general public. The generally reduced impacts to the public MEI compared with the noninvolved worker MEI are related to dispersion of the chemical release with downwind distance (except for UF_6 cylinder fire with plume rise).

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009 through 2028). The results indicate that the

maximum risk values would be less than 1 for all accidents except the following:

- *Potential Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely): Workers
  Corroded cylinder spill, wet conditions – rain (U, unlikely): Workers

- *Potential Irreversible Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely): Workers
  Ammonia stripper overpressure (L, likely): Workers
  Corroded cylinder spill, wet conditions – rain (U, unlikely): Workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for noninvolved workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated irreversible adverse effects was calculated. For the worker and general public accidents involving UF_6 releases shown in Table F.10, exposure to HF and uranium compounds could be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Thus, for the corroded cylinder spill accidents having a range of 0 to 440 irreversible adverse effects for noninvolved workers, approximately 0 to 4 worker deaths would be expected; no deaths would be expected for members of the general public from such accidents. For the ammonia tank rupture accident caused by an earthquake, exposure to ammonia would result in death for about 2% of the persons experiencing irreversible adverse effects. This would correspond to about 4 to 8 deaths among noninvolved workers and 0 to 34 deaths for the general public. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from assuming worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

F.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all conversion facility workers was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Annual fatality and injury rates for construction and manufacturing, respectively, were used for the construction and operational phases of the conversion facility lifetime.

No on-the-job fatalities are predicted for any of the options analyzed, but a range of about 300 to 500 injuries is predicted during the conversion facility lifetimes. Overall, the largest impacts are predicted for conversion to UO_2 through gelation and for conversion to metal through batch reduction because these options require larger numbers of employees. All other conversion options would result in similar impacts; fewer impacts are predicted for the cylinder treatment facility (i.e., approximately 170 injuries).

Because the conversion technologies analyzed for conversion of U_3O_8 would employ almost the same number of workers, there are essentially no differences between them. There would be a probability of about 0.35 of an on-the-job fatality (sum of 0.18 for the construction phase and 0.17 for the operations phase) for the U_3O_8 conversion options (Table F.12). The predicted injury incidence would be about 285 injuries over the lifetime of the facility.

The predicted probability of worker fatalities for conversion to UO_2 ranges from 0.4 to 0.59 (Table F.12). The predicted injury incidence ranges from about 320 to 492 injuries over the lifetime of the UO_2 conversion facility. The upper ends of the ranges result from the larger number of workers required for operation of the gelation facility.

The predicted probability of worker fatalities for conversion to metal ranges from about 0.4 to 0.55 (Table F.12). The predicted injury incidence ranges from about 300 to 490 injuries over the lifetime of the metal conversion facility. The upper ends of the ranges result from the larger number of workers required for operation of the batch reduction facility.

For the cylinder treatment facility option, the probability of an on-the-job fatality is about 0.19 (sum of 0.08 for the construction phase and 0.11 for the operations phase) (Table F.12). The estimated injury incidence would be about 170 over the lifetime of the facility.

F.3.3 Air Quality

Additional details regarding the analysis of air quality impacts for the conversion option are presented in Tschanz (1997).

F.3.3.1 Construction

The annual emissions of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM_{10}) expected during conversion plant construction are listed in Table F.13. The estimated 1-hour maximum pollutant concentrations at the facility boundary during construction are shown in Table F.14. Additional estimates were made for the conversion technology that had the highest estimated 1-hour maximum pollutant concentrations (i.e., gelation); these estimated concentrations are given in Table F.15). Although all of these pollutant concentrations would be much higher than those for plant operations, they remain below

TABLE F.12 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Conversion Options[a]

	Impacts to Conversion Facility Workers[b]			
	Incidence of Fatalities		Incidence of Injuries	
Option	Construction	Operations	Construction	Operations
Conversion to U_3O_8	0.18	0.16–0.17	66	215–219
Conversion to UO_2	0.22–0.30	0.18–0.29	79–108	243–384
Conversion to metal	0.22–0.25	0.17–0.30	79–92	222–395
Cylinder treatment	0.08	0.11	30	140

[a] Impacts are reported as ranges, which result from variations in the employment requirements for the different conversion technologies for each option.

[b] Potential hazards were estimated for all conversion facility workers.

Source: Injury and fatality rates used in calculations taken from National Safety Council (1995).

TABLE F.13 Emissions to the Atmosphere from Construction of a Depleted UF_6 Conversion Plant during the Peak Year

	Emissions to Atmosphere (tons/yr)				
Option	SO_2	NO_2	HC	CO	PM_{10}
Conversion to U_3O_8	2	28	8	190	40–50
Conversion to UO_2	2–3	30–46	8–13	200–320	50–60
Conversion to metal	2–3	30–40	8–12	200–270	50–60

Source: LLNL (1997).

ambient air quality standards. One possible exception is PM_{10}, for which concentrations were estimated to be 90% of the 24-hour standard of 150 $\mu g/m^3$. Some fugitive dust control measures would be necessary to mitigate this potentially high concentration. Construction of the conversion plant in a region of already high, even if compliant, ambient pollutant concentrations might require consideration of changes and/or controls for the emission of the other pollutants as well.

Estimated emissions from the cylinder treatment facility for all aspects of construction and operations are of the same order of magnitude (generally about 0.4 to 0.7 times as large) as those associated with the baseline cylinder transfer facility (see Appendix E), and the cylinder treatment facility area would be about half as large as the baseline cylinder transfer facility area. Except for the

TABLE F.14 Maximum 1-Hour Average Pollutant Concentrations at the Nearest Point on the Facility Boundary from Construction of a Conversion Facility[a]

Option	Pollutant ($\mu g/m^3$)				
	SO_2	NO_2	HC	CO	PM_{10}
Conversion to U_3O_8	26	360	100	2,400	520
Conversion to UO_2	25–37	380–570	100–160	2,400–3,900	620–740
Conversion to metal	25–36	360–480	100–140	2,500–3,200	610–720

[a] The ranges shown for some pollutants include results from the various technologies used for the conversion option and the differences in representative sites used for analysis.

TABLE F.15 Maximum Air Quality Impacts from Conversion Facility Construction[a]

Pollutant	Estimated Pollutant Emissions[b]							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration[c] ($\mu g/m^3$)	Fraction of Standard[d]	Concentration[c] ($\mu g/m^3$)	Fraction of Standard[d]	Concentration[c] ($\mu g/m^3$)	Fraction of Standard[d]	Concentration[c] ($\mu g/m^3$)	Fraction of Standard[d]
CO	3,810	0.1	3,100	0.30	–	–	–	–
NO_x	–	–	–	–	–	–	16	0.17
SO_2	–	–	–	–	5.8	0.02	0.9	0.01
PM_{10}	–	–	–	–	136	0.90	21	0.42

[a] Estimated pollutant emissions are given for the conversion to UO_2 gelation option, which would have the highest emissions.

[b] Values are listed only for pollutant/averaging time period combinations that have applicable air quality standards.

[c] Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

[d] Ratio of the concentration to the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

1-hour average results, the analytical results shown in Table F.16 for the cylinder treatment facility are about 0.2 to 0.4 times as large as those shown in Appendix E, Tables E.9-E.11, for the cylinder transfer facility. The 1-hour average impacts of construction of a cylinder treatment facility would be essentially the same as those for cylinder transfer facility construction.

F.3.3.2 Operations

Hourly emission rates during operations were determined from annual emission rates given in the engineering analysis report (LLNL 1997); these rates are shown in Table F.17. The methods used to analyze the impacts of pollutant emissions are described in Appendix C. All air pollutant concentrations during operations would be well below applicable ambient air quality standards for all conversion options. The maximum ground-level atmospheric concentrations at the representative facility boundaries from the boiler stack's emissions are listed in Tables F.18 through F.20. At the upper ends of the ranges, the nearest any of the criteria pollutant concentrations would come to a corresponding air quality standard is the annual nitrogen oxides (NO_x) concentration, which would be between 0.0007 and 0.002 of the annual NO_x standard.

Maximum air quality impacts from the process stacks are also listed in Tables F.18 through F.20. State HF standards in Tennessee and Kentucky have been used for comparative purposes. The estimated 24-hour maximum HF concentrations at representative facility boundaries for the conversion to U_3O_8 with anhydrous HF are about 2% of the respective state standards. The batch conversion to uranium metal is the only case for which NO_2 would be emitted from the process stack, and the NO_2 emission rate from the process stack in that case would be about eight times larger than from the boiler stack. Nevertheless, the estimated maximum annual NO_2 concentrations at the representative facility boundaries are less than 1% of the respective state standards.

TABLE F.16 Air Quality Impacts from Construction of the Cylinder Treatment Facility

	Estimated Pollutant Emissions							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range[a] ($\mu g/m^3$)	Fraction of Standard[b]	Range[a] ($\mu g/m^3$)	Fraction of Standard[b]	Range[a] ($\mu g/m^3$)	Fraction of Standard[b]	Range[a] ($\mu g/m^3$)	Fraction of Standard[b]
CO	1,800 – 3,500	0.088	310 – 450	0.045	120 – 180	–	7.2 – 13	–
NO_x	280 – 520	–	47 – 69	–	19 – 27	–	1.1 – 2.0	0.02
PM_{10}	390 – 720	–	65 – 95	–	26 – 37	0.25	1.5 – 2.6	0.052

[a] Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

[b] Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded. Pollutant/averaging time period combinations for which no air quality standard exists are noted with a dash (–).

TABLE F.17 Emissions to the Atmosphere from Operation of a Depleted UF_6 Conversion Plant

	Emissions to Atmosphere (lb/yr)						
Option/Source	SO_2	NO_2	HC	CO	PM_{10}	HF	Uranium Compounds
Conversion to U_3O_8							
Boiler stack	60–80	8,300–10,000	180–200	4,100–5,000	310–400	–	–
Process stack	–	–	–	–	–	300–900	3.3 U_3O_8
Generator stack	60	400	400	2,300	80	–	–
Conversion to UO_2							
Boiler stack	23–820	3,800–110,000	170–2,300	800–55,000	290–4,100	–	–
Process stack	–	–	–	–	–	300–900	2.5–12 UO_2
Generator stack	54–80	400–720	400–690	2,300–3,700	20–140	–	–
Conversion to metal							
Boiler stack	60–100	8,200–14,000	170–290	4,000–6,700	300–500	–	–
Process stack	–	117,000	–	–	–	300	1.2–9.6 U_3O_8; 3.8 UF_4
Generator stack	54–60	460–600	410–490	2,700–3,600	90–120	–	–

Source: LLNL (1997).

Each emergency generator would operate for 300 hours or less during 1 year. When it was operating, however, an emergency generator would produce higher concentrations of criteria pollutants at the facility boundaries than would the boiler. The estimated pollutant concentrations from the generator are listed in Tables F.18 through F.20. Compared with the air quality standards, the estimated concentrations are no more than 5% of allowed values.

The boiler stack parameters are identical for the cylinder treatment facility and the baseline cylinder transfer facility (see Appendix E). Given the similarities in the input data, the results of the air quality analyses for the two facilities should be expected to be comparable. Although not presented explicitly here, the same can be said of the impacts for operations. In summary, all of the criteria pollutant impacts of the cylinder treatment facility would not differ substantially from those of the cylinder transfer facility; all of the impacts not explicitly noted here are considered to be negligible. The only pollutant of concern emitted by the cylinder treatment facility process stack would be HF, and it, too, would be comparable for the two facilities. The cylinder treatment facility process stack would produce maximum annual average HF concentrations of 1.6×10^{-6} µg/m^3. This concentration is several orders of magnitude smaller than any applicable HF air quality standard.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue that would be affected by emissions data for the entire area around a proposed conversion site. The pollutants most related to ozone formation that would result from the

TABLE F.18 Air Quality Impacts from Operations for Conversion to U_3O_8

Option/ Stack/ Pollutant	Estimated Pollutant Emissions[a]							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]
Conversion to U_3O_8 with Anhydrous HF								
Boiler stack								
CO	0.92 – 1.01	3×10^{-5}	0.37 – 0.63	6×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.054 – 0.090	0.0009
Generator stack								
CO	320 – 440	0.011	64 – 270	0.027	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.025 – 0.069	0.02	0.0040 – 0.0073	2×10^{-5}
U_3O_8	–	–	–	–	–	–	1.4×10^{-5} – 2.6×10^{-5}	NS[d]
Conversion to U_3O_8 with HF Neutralization								
Boiler stack								
CO	0.81 – 0.89	2×10^{-5}	0.31 – 0.57	6×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.046 – 0.077	0.0008
Generator stack								
CO	320 – 440	0.011	64 – 270	0.027	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.0091 – 0.022	0.006	0.0012 – 0.0023	6×10^{-6}
U_3O_8	–	–	–	–	–	–	0.000013 – 0.000026	NS

[a] Values are listed only for pollutant/averaging time period combinations with air quality standards.

[b] Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

[c] Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

[d] NS = No annual average air quality standard is available for U_3O_8.

TABLE F.19 Air Quality Impacts from Operations for Conversion to UO_2

Option/ Stack/ Pollutant	Estimated Pollutant Emissions[a]							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]
Conversion to UO_2 with Anhydrous HF								
Boiler stack								
CO	0.77 – 0.82	2×10^{-5}	0.31 – 0.51	5×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.045 – 0.079	0.0008
Generator stack								
CO	550 – 690	0.017	120 – 440	0.044	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.020 – 0.052	0.015	0.0030 – 0.0064	2×10^{-5}
U_3O_8	–	–	–	–	–	–	4×10^{-5} – 8.5×10^{-5}	NS[d]
Conversion to UO_2 with HF Neutralization								
Boiler stack								
CO	0.71 – 0.77	2×10^{-5}	0.28 – 0.47	5×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.041 – 0.070	0.0007
Generator stack								
CO	550 – 690	0.017	120 – 440	0.044	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.0067 – 0.017	0.005	0.00099 – 0.0021	5×10^{-6}
U_3O_8	–	–	–	–	–	–	4.0×10^{-5} – 8.4×10^{-5}	NS[d]
Conversion to UO_2 with Gelation Process								
Boiler stack								
CO	1.7 – 1.8	5×10^{-5}	0.71 – 1.3	1×10^{-4}	–	–	–	–
NO_x	–	–	–	–	–	–	0.058 – 0.17	0.002
Generator stack								
CO	NA[e]	NA	NA	NA	NA	NA	NA	NA
NO_x	NA	NA	NA	NA	NA	NA	NA	NA
Process stack								
HF	–	–	–	–	0.016 – 0.029	0.01	0.0022 – 0.0040	1×10^{-5}
U_3O_8	–	–	–	–	–	–	1.0×10^{-5} – 1.7×10^{-5}	NS[d]

[a] Values are listed only for pollutant/averaging time period combinations with air quality standards.

[b] Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

[c] Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

[d] NS = No annual average air quality standard is available for U_3O_8.

[e] NA = Data not available.

TABLE F.20 Air Quality Impacts from Operations for Conversion to Uranium Metal

Option/ Stack/ Pollutant	Estimated Pollutant Emissions[a]							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]	Range[b] ($\mu g/m^3$)	Fraction of Standard[c]
Batch Process								
Boiler stack								
CO	0.88 – 0.90	2×10^{-5}	0.35 – 0.56	6×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.049 – 0.101	0.0010
Generator stack								
CO	580 – 720	0.018	120 – 460	0.046	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.0061 – 0.0125	0.004	0.00083 – 0.0019	5×10^{-6}
UF_4	–	–	–	–	–	–	1.0×10^{-5} – 2.4×10^{-5}	NS[d]
U_3O_8	–	–	–	–	–	–	2.6×10^{-5} – 6.1×10^{-5}	NS
NO_2	–	–	–	–	–	–	0.32 – 0.74	0.007
Continuous Process								
Boiler stack								
CO	0.71 – 0.77	2×10^{-5}	0.28 – 0.47	5×10^{-5}	–	–	–	–
NO_x	–	–	–	–	–	–	0.042 – 0.072	0.0007
Generator stack								
CO	550 – 690	0.017	120 – 440	0.044	–	–	Not calculated	
NO_x	–	–	–	–	–	–	Not calculated	
Process stack								
HF	–	–	–	–	0.0068 – 0.0172	0.005	0.0010 – 0.0021	5×10^{-6}
UF_4	–	–	–	–	–	–	1.3×10^{-5} – 2.7×10^{-5}	NS
U_3O_8	–	–	–	–	–	–	4.1×10^{-5} – 8.6×10^{-5}	NS

[a] Values are listed only for pollutant/averaging time period combinations with air quality standards.

[b] Concentrations are the second highest values estimated for one entire year. Short-term standards are not to be exceeded more than once per year.

[c] Ratio of the upper end of the concentration range to the respective air quality standard. A ratio of less than 1 indicates that the standard is not exceeded.

[d] NS = No annual average air quality standard is available for this pollutant.

conversion of depleted UF_6 are HC and NO_x. In later Phase II studies, when specific technologies and sites would be selected, the potential effects on ozone of these pollutants at a proposed site could be put in perspective by comparing them with the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region.

F.3.4 Water and Soil

This section discusses impacts of the conversion options on surface water, groundwater, and soils. The impacts are evaluated over a range of conditions present at the representative sites and are also relevant for a similarly sized generic site located in the vicinity of a river that could be used to supply water for construction and normal operations and to receive liquid waste discharges. The major conversion option parameters are summarized in Table F.21.

F.3.4.1 Surface Water

The methodology used to determine potential impacts to surface water for each conversion technology is described in Appendix C and Tomasko (1997).

F.3.4.1.1 Conversion to U_3O_8

Construction. Construction of a U_3O_8 conversion facility would produce increased runoff to nearby surface waters because of replacing soil and vegetation with either buildings or paved areas, approximately 13 acres (5.3 ha) (LLNL 1997). The amount of increased runoff would be negligible compared with the assumed existing area for runoff (0.3 to 0.8% of the representative site areas). None of the construction activities would measurably affect floodplains.

Table F.21 shows the quantity of water that would be used during construction of the U_3O_8 conversion facility (about 8 million gal/yr). This water would be withdrawn from nearby rivers or pumped from underlying aquifers. If the rate of water consumption were constant, the average rate of withdrawal would be about 15 gpm. This rate of withdrawal would be negligible compared to average flows in the adjacent rivers (less than 0.0001%). If the water were obtained from aquifers, there would be no impacts to the surface waters. Construction impacts would, therefore, range from none to negligible.

For construction, the net volume of water disposed of would be about 4 million gal/yr (7.6 gpm) (Table F.21). The primary contaminants of concern would be construction chemicals, organics, and some suspended solids. The wastewater would be discharged to nearby surface waters under a National Pollutant Discharge Elimination System (NPDES) permit, or to an appropriate

TABLE F.21 Summary of Conversion Option Parameters Affecting Water Quality and Soil[a]

Option	Disturbed Land Area (acres)	Operations Area (acres)	Construction Water (million gal/yr)	Operations Water (million gal/yr)
Conversion to U_3O_8	20	13	Raw = 8 Waste = 4	Raw = 34 – 47 Waste = 15 – 23 Sanitary = 1.2
Conversion to UO_2	22 – 31	14 – 20	Raw = 4 – 12 Waste = 5 – 6	Raw = 41 – 285 Waste = 9.7 – 135 Sanitary = 0.7 – 2.3
Conversion to metal	23 – 26	15 – 16	Raw = 10 – 12 Waste = 5 – 6	Raw = 55 Waste = 25 – 26 Sanitary = 1.4 – 2.3

Option	Accident Scenario	Radioactive Release to Surface Water[a] (Ci/yr)	Radioactive Effluent Concentration[b] (pCi/L)	Dilution Factor[c]	Surface Water Concentration (pCi/L)
Conversion to U_3O_8	HF pipeline break	0.001	12 – 17	47,000 – 4,200,000	4.1×10^{-6} – 2.6×10^{-4}
Conversion to UO_2	HF pipeline break	0.002 – 0.003	6 – 21	42,000 – 500,000	1.2×10^{-5} – 5.0×10^{-4}
Conversion to metal	HF pipeline break	0.001 – 0.002	10 – 21	42,000 – 2,600,000	4.0×10^{-6} – 4.9×10^{-4}

[a] Data from engineering analysis report (LLNL 1997).

[b] Concentration derived from estimated annual radioactive release and annual wastewater discharge.

[c] Dilution factor based on average flow conditions in receiving rivers.

wastewater sewer. By following good engineering practices (e.g., stockpiling materials away from surface water drainages, covering construction piles with tarps to prevent erosion by precipitation, and cleaning up small chemical spills as soon as they occur), concentrations in the wastewater would be small (well below any drinking water criteria).

Once in the surface water, mixing and dilution of the pollutants would occur. This dilution would be greater than 270,000:1 for average flow conditions in nearby rivers. This amount of dilution would reduce any contamination present to concentrations well below regulatory standards. Because the concentration of contamination in the water would be very low, impacts to sediment in the streams would also be negligible.

Operations. For normal operations, no impacts would occur to surface runoff, and there would be no measurable impacts on floodplains (effluent discharges to surface waters less than 0.001% of the average flows). As indicated in Table F.21, normal operation of the U_3O_8 conversion facility would require at most 47 million gal/yr (approximately 89 gpm) of raw water. If this water were obtained from nearby rivers, impacts would be negligible, less than 0.004% of the average flows. If the raw water were obtained from wells, there would be no impacts to surface waters.

A maximum of 23 million gal/yr of wastewater would be generated during operations, including cooling tower blowdown, process water, and industrial waste water. Another 1.2 million gal/yr of sanitary wastewater would be produced (Table F.21). For constant rates of discharge, about 44 gpm of wastewater and 2.3 gpm of sanitary water would be released to the environment at approved NPDES locations.

The primary contaminants of concern for the wastewater would be uranium and chemicals used to inhibit rust, reduce friction, and enhance heat exchange (e.g., copolymers, phosphates, phosphonates, calcium, magnesium, nitrates, sodium, and potassium). As discussed in the engineering analysis report (LLNL 1997), approximately 0.001 Ci/yr of uranium with an activity of 4×10^{-7} Ci/g would be released in the discharge water. For a waste volume of 23 million gal/yr (Table F.21), the uranium concentration in the effluent would be about 30 µg/L. After dilution in nearby surface water, the concentration would be much less than the proposed U.S. Environmental Protection Agency (EPA) drinking water standard for uranium of 20 µg/L, used here for comparison. Concentrations of the other chemicals released would also be expected to be very low and within the guidelines of an NPDES permit.

Accident Scenarios. Most of the accidents analyzed would involve outdoor releases on impermeable concrete pads in the cylinder yards; such releases could be cleaned up with little loss of the contaminated material to the soil. The only postulated accident that would release contaminated water to the environment is an HF pipeline break produced by an earthquake (Table F.21). Anhydrous HF would be pumped from the process building to the HF storage building through an underground pipeline that would carry liquid HF at a rate of 10 gpm (0.63 L/s) through 200 ft (61 m) of 1-in. (2.5-cm) pipe. For this accident scenario, 100% of the HF would drain into the ground at a point 3 ft (0.91 m) below grade during a 10-minute period. Approximately 500 lb (227 kg) of liquid HF (60 gal [227 L]) would be released. After 48 hours, the contaminated soil was assumed to be removed. Because of the rapid response to the accident, the HF would have little time to travel into the soil. For a silty sand, the travel distance would be about 2 ft (6.1 m) (Tomasko 1997). Removal of the contaminated soil and soil water would prevent any contamination problems to the groundwater and would prevent any cross contamination with surface waters. Therefore, there would be no net impact from this accident. Because this accident scenario would not affect surface runoff or existing floodplains, impacts to these parameters would also be nonexistent.

F.3.4.1.2 Conversion to UO_2

The environmental parameters associated with the UO_2 conversion alternatives are similar to those for U_3O_8 conversion (Table F.21), except for raw water use, which would be about five times larger for normal operations. If water were withdrawn from a nearby river, impacts would be negligible and would be less than 0.03% of the average flows. If it were withdrawn from wells, there would be no surface water impacts. Because of this option's similarities to the U_3O_8 conversion option, impacts to surface water produced by UO_2 conversion would be essentially the same as those for U_3O_8 conversion (i.e., none to negligible).

As was the case for the conversion to U_3O_8 option, discharge waters would receive from 0.002 to 0.003 Ci/yr. For the water discharges listed in Table F.21, the equivalent concentrations would range from 6 to 76 pCi/L (30 to 400 µg/L). After dilution in nearby surface waters, concentrations would be much less than the EPA proposed drinking water standard for uranium, used here for comparison.

F.3.4.1.3 Conversion to Metal

The environmental parameters associated with conversion to metal are very similar to those for U_3O_8 conversion (Table F.21); however, raw water usage for construction and normal operation would be about 50% higher. If the construction water was obtained from a nearby river, the rate of withdrawal would be negligible compared to average flows (less than 0.001%). For normal operations, the increased rate of withdrawal would produce an impact less than 0.005% of the average flows. If the construction water and water for normal operations were obtained from wells, there would be no impacts on surface water.

As was the case for the conversion to U_3O_8 and UO_2 options, discharge waters would receive either 0.001 or 0.002 Ci/yr. For the water discharges listed in Table F.21, the equivalent concentrations would range from 25 to 53 µg/L. After dilution in nearby surface waters, the concentrations would be much less than the EPA proposed drinking water standard for uranium, used here for comparison.

F.3.4.1.4 Cylinder Treatment

Construction and operation of the cylinder treatment facility would use less land and water and produce less wastewater than the construction and operation of conversion facilities, as shown in Table F.22. Thus, potential impacts would be smaller. There are no postulated accidents that would directly release contaminants to surface water (LLNL 1997).

TABLE F.22 Summary of Environmental Parameters for the Cylinder Treatment Facility

Parameter	Unit	Construction	Operations	Accidents
Land area	acres	8.7	–	None
Disturbed land	acres	4.5	–	None
Water	million gal/yr	3.6	3.4	None
Wastewater[a]	million gal/yr	1.3	2.3	None

[a] Includes sanitary wastewater, cooling tower blowdown, industrial water, and process water.

F.3.4.2 Groundwater

The methodology for assessing impacts to groundwater for each conversion technology is described in detail in Appendix C and Tomasko (1997).

F.3.4.2.1 Conversion to U_3O_8

Potential impacts to groundwater could occur during construction, normal operations, and postulated accident scenarios. These impacts include the following: changes in effective recharge to underlying aquifers; changes in the depth to groundwater; changes in the direction of groundwater flow; and changes in groundwater quality.

If construction water were supplied from underlying aquifers, approximately 15 gpm would be withdrawn. This withdrawal represents a maximum 0.1% increase in extraction over that at representative facilities and would produce a negligible impact on the groundwater system. If the construction water were obtained from surface water, there would be no groundwater impacts. Groundwater quality could also be impacted by construction activities. For example, exposed chemicals could be mobilized by precipitation and infiltrate the surficial aquifers. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rainfall, promptly cleaning up any chemical spills, and providing retention basins to catch and hold any contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

Normal operations of the conversion facility would require about 65 gpm of raw water (Table F.21). If pumped from wells in the surficial aquifers, the impact would be negligible (0.5% increase in extraction). If withdrawn from nearby surface water, there would be no impact on groundwater. Because discharges to groundwater are not planned for normal operations, there would

be no direct impacts to groundwater quality. Potential impacts could be derived from interaction with surface water; however, because impacts to surface water are negligible, impacts to groundwater via a surface water pathway would be even less.

As discussed in Section F.3.4.1.1, only one accident scenario, the HF pipeline break, would potentially release contaminants to the groundwater (Table F.21). Because of rapid mitigation and the small volume of HF in the release, this scenario would have a negligible impact on groundwater quality and would not affect recharge, depth to groundwater, or direction of flow.

F.3.4.2.2 Conversion to UO_2

The environmental parameters associated with the UO_2 conversion alternatives are very similar to those for U_3O_8 conversion (Table F.21), except for raw water use during normal operations (about five times larger). If water were obtained from underlying aquifers, pumping would represent an increase of about 5% of the current groundwater use. These impacts would be negligible.

F.3.4.2.3 Conversion to Metal

The environmental parameters associated with the metal conversion alternatives are very similar to those for U_3O_8 conversion (Table F.21), except for a 50% increase in raw water use during construction and normal operations. If the water for construction and normal operations was obtained from underlying aquifers, pumping would increase by 0.15% above current usage during construction, and by 0.8% of the current use for normal operations. These impacts would be negligible. If the water needed for construction and operations was obtained from surface water, there would be no impacts to groundwater.

During construction, groundwater concentrations would be kept below EPA guidelines (EPA 1996) by following good engineering practices. During normal operations, there would be no impacts to groundwater quality because direct discharges to groundwater are not planned.

F.3.4.2.4 Cylinder Treatment Facility

For the cylinder treatment facility, there would be no direct impacts to groundwater during normal operations because groundwater would not be used to supply the water required (Table F.22) and there would be no discharges of wastewater to the ground. Impacts to groundwater during construction of the cylinder treatment facility include changes in effective recharge, changes in the depth to the water table, changes in the direction of groundwater flow, and changes in quality.

Construction of the cylinder treatment facility would decrease the permeability of about 4.5 acres (1.8 ha) of land because of paving and building. This loss of permeable land would reduce recharge, increase the depth to the water table, and change the direction of groundwater flow; however, because the area affected would be small (about 0.1 to 0.3% of the land area available), these impacts would be negligible and limited to small, local regions in the immediate vicinity of the paved lots and building footprints.

During construction, groundwater quality would also be impacted. For example, stockpiled chemicals could be mobilized by precipitation and infiltrate the surficial aquifers. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rain, promptly cleaning up any chemical spills, and providing retention basins to catch and hold any contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

F.3.4.3 Soil

The methodology for estimating potential impacts to soil is described in detail in Appendix C and Tomasko (1997).

F.3.4.3.1 Conversion to U_3O_8

Potential impacts to soil could occur during construction, normal operations, and postulated accident scenarios. These impacts include changes in topography, permeability, quality, and erosion potential. The impacts are evaluated over a range of conditions present at the representative sites and are also applicable for a similarly sized generic site located in the vicinity of a major river.

Paving and construction would alter about 13 acres (5.3 ha) and potentially disturb up to 20 acres (8.1 ha) (LLNL 1997). Soil beneath the buildings and paved areas may be altered permanently. Although the alteration of these lands might be permanent, the net impact would be negligible in comparison to the representative land areas involved (ranging from 0.3 to 0.8% of the land area available). A larger range of values is associated with the potential land area disturbed (ranging from 0.5 to 1.2% of the land area available). These impacts could include increased permeability, modification of the local topography, changes in the soil chemistry, and increases in the potential for soil erosion. These impacts would, however, be insignificant on a sitewide scale. In addition, impacts to these areas would be mitigated with time (e.g., disturbed soil would be regraded to natural contours and seeded with natural vegetation, thereby returning the soils to their original condition).

By following good engineering practices (e.g., disturbing as little soil as possible, contouring and reseeding disturbed lands, scheduling construction activities to minimize land disturbance, controlling runoff, using tarps to prevent chemical/precipitation interactions, and cleaning up any spills as soon as they occurred), negligible impacts to soils should occur.

Because normal operations would not affect soil, there would be no soil impacts. The only accident identified that could potentially impact the soil is an HF pipeline rupture (Table F.21), discussed in Section F.3.4.1.1. Because of rapid mitigation (any contaminated soil would be cleaned up within 48 hours of the rupture) and the small release volume (60 gal of HF), impacts to the soil would be negligible.

F.3.4.3.2 Conversion to UO_2

The environmental parameters associated with the UO_2 conversion alternatives are very similar to those for U_3O_8 conversion (Table F.21). Because of these similarities, impacts to soil for UO_2 conversion would be negligible.

F.3.4.3.3 Conversion to Metal

The environmental parameters associated with the metal conversion alternatives are very similar to those for U_3O_8 conversion (Table F.21). Because of these similarities, impacts to soils would be essentially the same as those previously presented, i.e., none to negligible.

F.3.4.3.4 Cylinder Treatment Facility

For the cylinder treatment facility, the only impacts would occur during construction. There would be no discharges to the ground under normal operations, and there are no accidents identified in LLNL (1997) that would lead to direct contamination of the soil. Impacts from construction would include changes in topography, permeability, quality, and erosion potential. By following good engineering and construction practices (e.g., covering chemicals with tarps, cleaning up chemical spills as soon as they occur, and providing retention basins to catch and hold any contaminated surface runoff), impacts to soil quality would be negligible.

F.3.5 Socioeconomics

The impact of each conversion option on socioeconomic activity was estimated for a region of influence (ROI) at the three representative sites. The assessment methodology is discussed in Appendix C and Allison and Folga (1997).

Each of the conversion options is likely to have a small impact on socioeconomic conditions in the ROIs surrounding the three representative sites described in Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8. This is largely because a major proportion of the expenditures associated with procurement for the construction and operation of each technology option flows

outside the ROI to other locations in the United States, reducing the concentration of local economic effects of each conversion option.

Slight changes in employment and income would occur in each ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required to construct and operate each conversion option, and other local investment associated with construction and operation. In addition to creating new (direct) jobs at each site, each conversion option would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at each site. Jobs and income created directly by each conversion option, together with indirect activity in the ROI, would contribute slightly to reduction in unemployment in the ROI surrounding each site. Minimal impacts are expected on local population growth, and consequently on local housing markets and local fiscal conditions.

The effects of constructing and operating each conversion technology on regional economic activity (measured in terms of employment and personal income) and on population, housing, and local public revenues and expenditures are described in Sections F.3.5.1 through F.3.5.4. Impacts are presented as ranges to include impacts that would occur with each conversion option and for the cylinder treatment facility at each of the representative sites. Impacts for the three sites are presented for the peak year of construction (assumed to be 2006) and the first year of operations (assumed to be 2009). The potential impacts for each conversion option and for the cylinder treatment facility are presented in Table F.23.

F.3.5.1 Conversion to U_3O_8

During the peak year of construction of a U_3O_8 conversion facility, between 240 and 250 direct jobs would be created at the site and 170 to 330 additional jobs would be created indirectly in the site ROI (Table F.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 410 to 580 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from $14 million to $17 million during the peak year. During the first year of operations of the U_3O_8 conversion facility, 440 to 510 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROIs, with total income ranging from $14 million to $15 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 to 0.05 percentage points from 1999 through 2028.

Construction of the U_3O_8 conversion facility would be expected to generate direct in-migration of 330 to 340 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROIs, bringing the total number of in-migrants to between 410 and 470 in the peak year (Table F.23). Operation of the U_3O_8 conversion facility would be expected to generate direct and indirect job in-migration of 220 to 340 in the first year of

TABLE F.23 Potential Socioeconomic Impacts of the Conversion Options

	Conversion to U_3O_8		Conversion to UO_2	
	Construction[a]	Operations[b]	Construction[a]	Operations[b]
Economic activity in the ROI				
Direct jobs	240 – 250	200 – 210	330 – 630	230 – 360
Indirect jobs	170 – 330	240 – 300	230 – 730	310 – 920
Total jobs	410 – 580	440 – 510	560 – 1,400	500 – 1,300
Income ($ million)				
Direct income	11	10	15 – 28	11 – 18
Total income	14 – 17	14 – 15	19 – 42	16 – 28
Population in-migration into the ROI	410 – 470	220 – 340	570 – 1,200	210 – 1,100
Housing demand				
Number of units in the ROI	150 – 170	80 – 130	210 – 440	80 – 390
Public finances				
Change in ROI fiscal balance (%)	0.1 – 0.3	<0.1 – 0.2	0.1 – 0.7	<0.1 – 0.6

	Conversion to Uranium Metal		Cylinder Treatment Facility	
	Construction[a]	Operations[b]	Construction[a]	Operations[b]
Economic activity in the ROI				
Direct jobs	380 – 440	210 – 370	100	130
Indirect jobs	230 – 470	310 – 520	40 – 80	130 – 180
Total jobs	610 – 910	520 – 890	150 – 180	260 – 310
Income ($ million)				
Direct income	12 – 16	10 – 18	5	10
Total income	15 – 25	15 – 27	5 – 6	13 – 14
Population in-migration into the ROI	650 – 790	240 – 630	160 – 180	240 – 300
Housing demand				
Number of units in the ROI	240 – 290	90 – 230	60 – 70	90 – 110
Public finances				
Change in ROI fiscal balance (%)	0.1 – 0.5	<0.1 – 0.4	<0.0 – 0.1	<0.0 – 0.2

[a] Impacts are for the peak year of construction, 2007. Socioeconomic impacts were assessed for 1999 through 2008.

[b] Impacts are the annual averages for operations for the period 2009 through 2028.

operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.01 to 0.04 percentage points from 1998 through 2028.

A U_3O_8 conversion facility would generate a demand for 150 to 170 additional rental housing units during the peak year of construction (Table F.23), representing an impact of 2.7-11% on the projected number of vacant rental housing units in the representative site ROIs. A demand for 80 to 130 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.7 to 2.7% on the number of vacant owner-occupied housing units in the ROIs.

During the peak year of construction, 410 to 470 people would be expected to in-migrate into the ROI at the site, leading to increases of between 0.1 and 0.3% over forecasted baseline revenues and expenditures in the representative site ROI (Table F.23). In the first year of operations, 220 to 340 in-migrants would be expected, leading to increases of less than 0.1 to 0.2% in local revenues and expenditures.

F.3.5.2 Conversion to UO_2

During the peak year of construction of a UO_2 conversion facility, 330 to 630 direct jobs would be created at the site and 230 to 730 additional jobs indirectly in the site ROI (Table F.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 560 to 1,400 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from $19 million to $42 million during the peak year. During the first year of operations of the UO_2 conversion facility, 540 to 1,200 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from $16 million to $28 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 to 0.1 percentage points from 1999 through 2028.

Construction of the UO_2 conversion facility would be expected to generate direct in-migration of 460 to 860 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROIs, bringing the total number of in-migrants to between 570 and 1,200 in the peak year (Table F.23). Operation of the UO_2 conversion facility would be expected to generate direct and indirect job in-migration of 210 to 1,100 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.01 to 0.06 percentage points from 1999 through 2028.

The UO_2 conversion facility would generate a demand for 210 to 440 additional rental housing units during the peak year of construction, representing an impact of 3.8 to 28% on the

projected number of vacant rental housing units in the representative site ROIs (Table F.23). A demand for 80 to 390 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.7 to 8.2% on the number of vacant owner-occupied housing units in the ROIs.

During the peak year of construction, 570 to 1,200 people would be expected to in-migrate into the ROI at the site, leading to increases of 0.1 to 0.7% over forecasted baseline revenues and expenditures in the representative site ROIs (Table F.23). In the first year of operations, 210 to 1,100 in-migrants would be expected, leading to increases of less than 0.1 to 0.6% in local revenues and expenditures.

F.3.5.3 Conversion to Metal

During the peak year of construction of a metal conversion facility, 380 to 440 direct jobs would be created at the site and 230 to 470 additional jobs indirectly in the site ROI (Table F.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 610 to 910 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from $15 million to $25 million during the peak year. During the first year of operations of the metal conversion facility, 520 to 890 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from $15 million to $27 million. Construction and operation of the conversion facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 to 0.09 percentage points from 1999 through 2028.

Construction of the metal conversion facility would be expected to generate direct in-migration of 520 to 600 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to between 650 and 790 in the peak year (Table F.23). Operation of the metal conversion facility would be expected to generate direct and indirect job in-migration of 240 to 630 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 to 0.08 percentage points from 1999 through 2028.

The metal conversion facility would generate a demand for 240 to 290 additional rental housing units during the peak year of construction, representing an impact of 4.3 to 18.5% on the projected number of vacant rental housing units in the representative site ROIs (Table F.23). A demand for 90 to 230 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8 to 4.9% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 650 to 790 people would be expected to in-migrate into the ROI surrounding the site, leading to increases of 0.1 to 0.5% over forecasted baseline revenues and expenditures in the representative site ROIs (Table F.23). In the first year of operations, 240 to 630 in-migrants would be expected, leading to increases of less than 0.1 to 0.4% in local revenues and expenditures.

F.3.5.4 Cylinder Treatment Facility

During the peak year of construction of a cylinder treatment facility, approximately 100 direct jobs would be created at the site and 40 to 80 additional jobs indirectly in the site ROI (Table F.23) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 150 to 180 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with total income ranging from $5 million to $6 million during the peak year. During the first year of operations of the cylinder treatment facility, 260 to 310 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with total income ranging from $13 million to $14 million. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 to 0.03 percentage points from 1999 through 2028.

Construction of the cylinder treatment facility would be expected to generate direct in-migration of 140 people in the peak year of construction at the site. Additional indirect job in-migration would also be expected in the site ROI, bringing the total number of in-migrants to between 160 and 180 in the peak year (Table F.23). Operation of the cylinder treatment facility would be expected to generate direct and indirect job in-migration of 240 to 300 in the first year of operations. Construction and operation of the facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of less than 0.01 to 0.02 percentage points from 1999 through 2028.

The cylinder treatment facility would generate a demand for 60 to 70 additional rental housing units during the peak year of construction, representing an impact of 1.1 to 4.4% on the projected number of vacant rental housing units in the representative site ROIs (Table F.23). A demand for 90 to 110 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8 to 2.3% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 160 to 180 people would be expected to in-migrate into the ROI surrounding the site, leading to increases of 0.0 to 0.1% over forecasted baseline revenues and expenditures in the representative site ROIs (Table F.23). In the first year of operations, 240 to 300 in-migrants would be expected, leading to increases of less than 0.1 to 0.2% in local revenues and expenditures.

F.3.6 Ecology

Moderate impacts to ecological resources could result from construction of a conversion facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a conversion facility would be negligible. Potential impacts to vegetation, wildlife, wetlands, and threatened and endangered species were assessed. The methodology used in the ecological impact analysis is discussed in Appendix C.

F.3.6.1 Conversion to U_3O_8

Site preparation for the construction of a facility to convert UF_6 to U_3O_8 would require the disturbance of approximately 20 acres (8 ha), including the permanent replacement of approximately 13 acres (5.3 ha) with structures and paved areas. Existing vegetation would be destroyed during land clearing activities. Determination of the vegetation communities that would be eliminated by site preparation would depend on the future location of the facility. Communities occurring on undeveloped land at the three representative sites are relatively common and well represented in the vicinity of the sites. Impacts to high-quality native plant communities may occur if facility construction requires disturbance to vegetation communities outside of the currently fenced areas (see Section F.3.9 for a discussion of land use). Construction of the conversion facility would not be expected to threaten the local population of any species. The loss of up to 20 acres (8 ha) of undeveloped land would constitute a moderate adverse impact. Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table F.24.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities, and thus competition for food and nesting sites, would increase in these areas, potentially reducing the survivability or reproductive capacity of displaced individuals. Many wildlife species would be expected to quickly recolonize replanted areas near the conversion facility following completion of construction. The permanent loss of up to 13 acres (5.3 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the sites. Therefore, construction of a conversion facility for U_3O_8 production would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section F.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be impacted by filling or draining during construction. Impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the conversion facility were located immediately adjacent to

TABLE F.24 Impacts to Ecological Resources from Construction of a Conversion Facility and Cylinder Treatment Facility

Option/Resource	Type of Impact	Degree of Impact
Conversion to U_3O_8		
Vegetation	Loss of 20 acres	Moderate adverse impact
Wildlife	Loss of 13 to 20 acres	Minor to moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact
Conversion to UO_2		
Vegetation	Loss of 22 to 31 acres	Moderate adverse impact
Wildlife	Loss of 14 to 31 acres	Moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact
Conversion to metal		
Vegetation	Loss of 23 to 26 acres	Moderate adverse impact
Wildlife	Loss of 15 to 26 acres	Moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact
Cylinder treatment facility		
Vegetation	Loss of 9 acres	Moderate adverse impact
Wildlife	Loss of 5 to 9 acres	Moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact

wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Water Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any state or federally listed threatened or endangered species at any of the representative sites. Prior to construction of a conversion facility, a site-specific survey for federal- and state-listed threatened, endangered, or candidate species or

species of special concern would be conducted. Impacts to these species could thus be avoided or, where impacts were unavoidable, appropriate mitigation could be developed.

During operations, ecological resources in the vicinity of the conversion facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section F.3.3.2). The highest annual average air concentration of U_3O_8 at a representative site boundary would be less than 2.6×10^{-5} $\mu g/m^3$. This would result in a radiation exposure to the general public (nearly 100% due to inhalation) of less than 0.009 mrem/yr (Section F.3.1.1), well below the DOE guidelines of 100 mrem/yr (0.00027 rad/d). Wildlife species are less sensitive to radiation than humans (proposed DOE guidelines would require an absorbed dose limit to terrestrial animals of 0.1 rad/d). Therefore, impacts to wildlife due to radiation effects would be expected to be negligible. Toxic effects of chronic inhalation of U_3O_8 are minor at a concentration of 17 mg/m^3 for tested animal species. This is many orders of magnitude greater than expected emissions. Therefore, toxic effects to wildlife due to U_3O_8 inhalation would also be expected to be negligible. See Appendix C for further discussion.

The maximum annual average air concentration of hydrogen fluoride at a site boundary, due to operation of a conversion facility, would be less than 0.0073 $\mu g/m^3$ (Section F.3.3.2). Chronic exposure to HF gas produces only mild effects in tested animal species at concentrations as high as 7 mg/m^3, considerably higher than expected emissions. Therefore, toxic effects to wildlife from HF emissions would be expected to be negligible.

A portion of the U_3O_8 released from the process stack of a conversion facility would become deposited on the soils surrounding the site. Uptake of uranium-containing compounds can cause adverse effects to vegetation. Deposition of U_3O_8 on soils, resulting from atmospheric emissions, would result in soil uranium concentrations considerably below the lowest concentration known to produce toxic effects in plants. Therefore, toxic effects on vegetation due to U_3O_8 uptake would be expected to be negligible.

Effluent discharges to surface waters would result in a uranium concentration of about 12 pCi/L (0.03 mg/L) as uranyl nitrate (Section F.3.4.1). Resulting dose rates to maximally exposed organisms would be considerably lower than the dose limit of 1 rad/d for aquatic organisms, which is required by DOE Order 5400.5. Uranyl nitrate concentrations in the effluent also would be considerably lower than 0.15 mg/L, the lowest concentration known to cause toxic effects in aquatic biota. Mixing of the effluent with surface water downstream of the outfall would result in a dilution factor of more than 50,000. Therefore, impacts to aquatic biota would be considered to be negligible.

For the U_3O_8 conversion process, water withdrawal from surface waters or groundwater, as well as wastewater discharge, could potentially alter water levels which could in turn affect aquatic ecosystems including wetlands (including wetlands located along the periphery of these surface water bodies). However, water level changes due to process water withdrawal and wastewater discharge would be negligible (Section F.3.4.1). Therefore, impacts to wetlands would be expected to be negligible.

A potential release of contaminants due to the occurrence of an earthquake was analyzed. The subsequent rupture of an HF pipeline would potentially release anhydrous HF into the surrounding soil, surface water, or groundwater. Due to the brief duration of the release, the small volume involved, and rapid mitigation, the expected impacts to surface water, groundwater, and soil would be negligible (Section F.3.4). Therefore, impacts to ecological resources from such an accident would also be expected to be negligible. Facility accidents, as discussed in Section F.3.2, could result in adverse impacts to ecological resources. The affected species and the degree of impact would depend on a number of factors such as location of the accident, season, and meteorological conditions.

F.3.6.2 Conversion to UO_2

The construction of a facility to convert depleted UF_6 to UO_2 would generally result in the types of impacts associated with conversion to U_3O_8. Site preparation for the construction of a facility to convert depleted UF_6 to UO_2 would require the disturbance of approximately 22 to 31 acres (8.9 to 12.5 ha), including the permanent replacement of approximately 14 to 19 acres (5.5 to 7.8 ha) with structures and paved areas. The loss of 22 to 31 acres (8.9 to 12.5 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. The permanent loss of up to 19 acres (7.8 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the representative sites. However, habitat use in the vicinity of the facility might be greatly reduced for many species due to the construction of a perimeter fence. Consequently, the construction of a conversion facility for UO_2 production is considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction would be expected to be negligible (Section F.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Impacts to wetlands and protected species due to facility construction would be similar to impacts associated with conversion to U_3O_8.

During operations, exposures to contaminants from conversion to UO_2 would generally be slightly larger than for conversion to U_3O_8, but all exposures would be well below levels that might produce adverse effects. All impacts would therefore be negligible. Impacts to ecological resources from accident scenarios would be as discussed for conversion to U_3O_8 (Section F.3.6.1).

F.3.6.3 Conversion to Metal

Construction of a facility to convert depleted UF_6 to uranium metal would generally result in the types of impacts associated with conversion to U_3O_8. Site preparation would require the disturbance of approximately 23 to 26 acres (9.4 to 11 ha), including the permanent replacement of about 15 to 16 acres (6.2 to 6.5 ha) with structures and paved areas. The loss of 23 to 26 acres (9.4

to 11 ha) of undeveloped land would constitute a moderate adverse impact to vegetation and wildlife. Impacts due to facility construction are shown in Table F.24.

During operation of the metal conversion facility, exposure to contaminants would be considerably below levels known to cause toxic effects in biota. The resulting impacts would therefore be negligible. Impacts to ecological resources from accidents would be as discussed for conversion to U_3O_8 (Section F.3.6.1).

Construction of a cylinder treatment facility would generally result in the types of impacts associated with construction of a conversion facility; however, the area affected would be smaller (Table F.24). Site preparation for constructing a cylinder treatment facility would require the disturbance of approximately 9 acres (4 ha). About 5 acres (2 ha) would be permanently replaced with structures, paved areas, and landscaping. The loss of 9 acres (4 ha) of undeveloped land would constitute a moderate adverse impact to vegetation and wildlife. Exposure to contaminants resulting from operation of a cylinder treatment facility would be considerably below levels known to result in toxic effects to biota. The resulting impacts would therefore be negligible.

F.3.7 Waste Management

Impacts on waste management from wastes generated during construction and normal operations at the depleted UF_6 conversion facilities would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or on a regional/national scale. The types of wastes that are expected to be generated by the depleted UF_6 conversion include low-level radioactive waste (LLW), low-level mixed waste (LLMW), hazardous waste, nonhazardous solid waste, and nonhazardous wastewater. Currently, there are numerous DOE and commercial facilities that treat and/or dispose of LLW, hazardous waste, nonhazardous solid waste, and wastewaters. The treatment/disposal of LLMW is limited by regulatory and technological restrictions.

F.3.7.1 Conversion to U_3O_8

Construction of a facility to convert UF_6 into U_3O_8 would generate both hazardous and nonhazardous wastes. Approximately 115 m^3 of hazardous waste, 700 m^3 of nonhazardous solid waste, and 15,000 m^3 of wastewater would be generated during construction (see Table F.25). This compares with existing contributions for hazardous waste ranging from approximately 80 m^3/yr to 1,000 m^3/yr, solid waste loads for the representative sites of 2,100 to 28,000 m^3/yr, and wastewater loads of 500,000 to 880,000 m^3 annually for the representative sites (see Appendix C, Table C.3). No radioactive waste would be generated during the construction phase of the facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into U_3O_8 would generate radioactive, hazardous, and nonhazardous wastes (Table F.25). The conversion facility would generate 140 to 600 m^3/yr of

TABLE F.25 Wastes Generated from Construction and Operations Activities for Depleted UF_6 Conversion[a]

Activity/ Waste Category	Volume Ranges for the Options		
	Conversion to U_3O_8	Conversion to UO_2	Conversion to Metal
Construction[a] (m^3)			
Low-level waste	–	–	–
Low-level mixed waste	–	–	–
Hazardous waste	115	140 – 200	140 – 180
Nonhazardous waste			
Solids	700	1,300	860 – 1,130
Wastewater	3,800	7,600	5,700 – 7,580
Sanitary wastewater	11,400	17,000	13,200 – 15,200
Operations (m^3/yr)			
Low-level waste			
Combustible waste	76.5	88.0 – 136	76.5 – 420
Noncombustible	62 – 68.2	82.0 – 140	112 – 470
Grouted	0 – 466	0 – 466	0 – 997
Total	140 – 600	170 – 740	190 – 1,890
Low-level mixed waste	1.1	1.1 – 8.8	1.1
Hazardous waste	7.32	7.32 – 17	7.32 – 9.5
Nonhazardous waste			
Solids	380 – 11,000[b]	520 – 30,600[b]	6,580 – 6,840[c]
Wastewater	58,000 – 87,100	74,900 – 510,000	94,000 – 96,500
Sanitary wastewater	4,540 – 4,920	5,680 – 8,700	5,300 – 8,700

[a] Total waste generated during construction period of 4 years.

[b] Includes 240 to 10,630 m^3 of CaF_2.

[c] Includes 67 m^3 of CaF_2 and 5,850 to 6,110 m^3 of MgF_2.

LLW, which, at the upper end, represents approximately 7 to 27% of the representative site LLW loads (see Appendix C, Table C.3). The U_3O_8 conversion facility waste input would represent less than 1% of DOE LLW generation. The U_3O_8 conversion facility would generate approximately 1.1 m^3/yr of LLMW, which is less than 1% of the LLMW generation at the representative sites (ranging from 100 to 5,000 m^3/yr LLMW) (see Appendix C, Table C.3). The U_3O_8 conversion facility would generate approximately 7 m^3/yr of hazardous waste, which would result in an increase of about 1 to 10% of the hazardous waste loads at the representative sites; and about 60,000 to

90,000 m^3/yr of wastewater, representing between 9 and 17% of the current loads for wastewater at the representative sites.

The CaF_2 potentially produced in the U_3O_8 conversion process was assumed to have a uranium content of less than 1 ppm (LLNL 1997). It is currently unknown whether this CaF_2 could be sold (e.g., as feedstock for commercial production of anhydrous HF) or whether the low uranium content would require disposal as either a nonhazardous solid waste or as LLW. The nonhazardous solid waste generation estimates for conversion to U_3O_8 and UO_2, as shown in Table F.25, are based on the assumption that CaF_2 would be disposed of as nonhazardous solid waste, generating approximately 380 to 11,000 m^3/yr of nonhazardous solid waste (from 18 to 500% of the current nonhazardous solid waste loads at the representative sites, depending on the conversion technology chosen). If CaF_2 were considered to be LLW, it would represent an additional 3 to 480% of the current LLW loads at the representative sites. The upper end of the range of nonhazardous and LLW volume increases (which correspond to the HF neutralization process) would constitute a potentially large impact to either nonhazardous or LLW management activities at an actual site. Disposal as LLW might require the CaF_2 to be grouted, generating up to 21,300 m^3/yr of grouted waste. The maximum volume of LLW generated would still represent less than 10.4% of the projected DOE complexwide LLW disposal volume, constituting a moderate impact with respect to complexwide LLW management. It is also unknown whether CaF_2 LLW would be considered DOE waste if the conversion were conducted by a private commercial enterprise. If CaF_2 could be sold, the nonhazardous solid waste or LLW management impacts would be reduced to a low level for U_3O_8 conversion technologies.

The impacts from normal operation of the U_3O_8 conversion facility would range from negligible to large, depending upon the choice of technology and the ultimate generation volumes and disposition of CaF_2 for the facility. Overall, the waste input resulting from normal operations at the U_3O_8 conversion facility would be expected to have a moderate impact on waste management. If CaF_2 were disposed of as nonhazardous solid waste, the increased input could be managed by expanding the capacity of the nonhazardous solid waste disposal facilities at the actual site.

F.3.7.2 Conversion to UO_2

Construction of a facility to convert UF_6 into UO_2 would generate approximately the same quantity of hazardous wastes as conversion to U_3O_8. Construction would generate approximately 1,300 m^3 of solid nonhazardous wastes and up to 24,000 m^3 of wastewater (see Table F.25). These waste loads are well below the representative site waste inputs for comparable wastes. No radioactive waste would be generated during the construction phase of the facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into UO_2 would generate radioactive, hazardous, and nonhazardous wastes (Table F.25). The conversion facility would generate about 9 to 33% of the representative site LLW loads (see Appendix C, Table C.3). The UO_2 conversion facility would

generate up to 465 m^3/yr of a solid, grouted LLW that would require off-site disposal. The conversion facility LLW input would represent less than 1% of the projected annual DOE LLW treatment volume. The UO_2 conversion facility would generate from 1 to 9% of the LLMW generation for the representative sites (see Appendix C, Table C.3). The UO_2 conversion facility would generate 7 to 17 m^3/yr of hazardous waste, which would result in a minor increase to the hazardous waste load from routine operations at the representative site. The UO_2 conversion facility would add 520 to 30,600 m^3/yr of nonhazardous solid waste and about 80,000 to 500,000 m^3/yr of wastewater (see Table F.25).

As in the U_3O_8 conversion option, it is currently unknown whether CaF_2 generated in the conversion to UO_2 option could be sold or whether the low uranium content (less than 1 ppm) would require disposal as either a nonhazardous solid waste or as LLW. The nonhazardous solid waste generation estimates for conversion to UO_2 shown in Table F.25 are based on the assumption that CaF_2 would be disposed of as nonhazardous solid waste, generating about 240 to 11,000 m^3/yr of nonhazardous solid waste (up to 500% of the current nonhazardous solid waste loads at the representative sites, depending on the conversion technology chosen). If CaF_2 were considered to be LLW, it would represent up to 480% of the current LLW loads at the representative sites. The upper end of the range of nonhazardous and LLW volume increases (which correspond to the HF neutralization process) would constitute a potentially large impact to either nonhazardous or LLW management activities at an actual site. Disposal as a LLW might require the CaF_2 to be grouted, generating up to 21,300 m^3/yr of grouted waste. However, the maximum volume of LLW generated would still represent less than 10.4% of the projected DOE complexwide LLW disposal volume, constituting a moderate impact with respect to complexwide LLW management, if the CAF_2 were considered DOE waste. If CaF_2 could be sold, the nonhazardous solid waste or LLW management impacts would be reduced to a low level for UO_2 conversion technologies.

The large range in the expected volume of nonhazardous solid waste and wastewater is also a result of differences in UO_2 conversion technologies. The gelation technology would result in the highest nonhazardous waste generation volumes. The range of 520 to 30,600 m^3/yr for nonhazardous solid wastes represents an approximate range of 2 to 1,500% (15 times) the annual nonhazardous solid waste production at the representative sites. The estimated range for wastewater generation represents a range of about 13 to 115% of the annual wastewater generation at the representative sites.

The impacts from normal operation of the UO_2 conversion facility would range from negligible to large, depending upon the choice of technology for this facility. Overall, the waste input resulting from normal operations at the UO_2 conversion facility would be expected to have a moderate impact on waste management. The increased solid waste input could be managed by expanding the capacity of the solid nonhazardous waste disposal facilities at the sites. The increased wastewater input would be handled by existing site wastewater capabilities of the representative sites.

F.3.7.3 Conversion to Metal

Construction of the facility to convert UF_6 into uranium metal would generate approximately the same quantity of hazardous and nonhazardous wastes as conversion to U_3O_8 or UO_2 (Table F.25). No radioactive waste would be generated during the construction phase of the facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

Operations at the facility to convert UF_6 into uranium metal would generate radioactive, hazardous, and nonhazardous wastes (Table F.25). The conversion facility would generate about 23 to 85% of the representative site LLW loads (see Appendix C, Table C.3). A metal conversion facility LLW input would represent less than 3% of the projected annual DOE LLW treatment volume. The metal conversion facility would generate less than 1% of the LLMW generation at the representative sites (see Appendix C, Table C.3) and less than 12% of the hazardous waste load from routine operations at the three representative sites. The metal conversion facility would add from 25 to 325% of the existing representative site solid waste load and from 12 to 20% of the load for wastewater. The increased solid waste input could be managed by expanding the disposal capacity of the solid nonhazardous waste disposal facilities at the actual site.

It is possible that the MgF_2 waste generated in the conversion to metal option would be sufficiently contaminated with uranium to require disposal as LLW rather than as solid nonhazardous waste. The uranium level in the MgF_2 is estimated to be about 90 ppm (LLNL 1997). Such disposal might require the MgF_2 waste to be grouted, generating about 6,150 to 12,300 m^3/yr of grouted waste for LLW disposal. This volume range represents about 72 to 560% of the current LLW generation for the representative three sites (see Appendix C, Table C.3). However, it would represent less than 6% of the projected DOE complexwide LLW disposal volume, constituting a low impact with respect to complexwide LLW management, if the MgF_2 were considered a DOE waste.

Neutralization of HF to CaF_2 was not explicitly analyzed in the engineering analysis report for the conversion to metal options (LLNL 1997). However, the process could be implemented and would produce approximately one-third as much CaF_2 as would be produced under the conversion to oxide with neutralization options (i.e., approximately 3,500 m^3/yr of CaF_2). If this CaF_2 waste were disposed of as LLW, it would constitute less than 3% of the DOE complexwide LLW disposal volume, representing a low impact with respect to complexwide LLW management.

Overall, the waste input resulting from normal operations at the uranium metal conversion facility would have a moderate impact on waste management.

F.3.7.4 Cylinder Treatment Facility

All of the conversion options would require the removal of depleted UF_6 from the storage cylinders, resulting in a large number of empty cylinders. These empty UF_6 cylinders from the conversion facility would be decontaminated at the cylinder treatment facility and then prepared for

disposal as scrap metal. It was assumed for this assessment that the cylinder treatment facility would be washing the empty cylinders with water to remove the "heels" of depleted UF_6. The resulting aqueous wash solution would be evaporated and converted to solid U_3O_8 and HF. The U_3O_8 would be packaged and sent for disposal. The HF would be neutralized to CaF_2 and separately packaged for either disposal or sale.

Construction of the cylinder treatment facility would generate both hazardous and nonhazardous wastes. These waste quantities — hazardous, 18 m^3; solid nonhazardous, 300 m^3; and sanitary and other nonhazardous liquids, 28,000 m^3 — all represent only minimal waste management impacts at any of the three potential sites. No radioactive waste would be generated during construction of this facility.

The amounts of waste generated annually during operation of the cylinder treatment facility are given in Table F.26. Included are crushed old cylinders and wastes obtained (U_3O_8 and CaF_2) from disposal of the "heels." All of these wastes, except the crushed old cylinders, represent only negligible impacts to the waste management system. Over 20 years of operations, the crushed old cylinders (2,322 cylinders/yr) would generate about 125,000 m^3 (6,190 m^3/yr × 20 years) of waste volume for disposal. It was assumed that the treated cylinders with a very low residual radiation level

TABLE F.26 Annual Waste Generation during Operation of the Cylinder Treatment Facility

Waste Category	Volume (m^3/yr)
Low-level waste	
Combustible solids	31
Contaminated metal and other noncombustible solids	11
U_3O_8	6.3
Low-level mixed waste	0.2
Hazardous waste	2
Nonhazardous waste	
Solids	100
Wastewater	6,400
CaF_2	14
Sanitary waste	2,300
Crushed cylinders	6,190

would become part of the DOE scrap metal inventory. If a disposal decision were made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume.

F.3.7.5 Summary

The impacts from the uranium metal conversion facility would be greater than the waste management impacts resulting from operations of U_3O_8 conversion, unless CaF_2 required disposal as a waste. In the latter case, the impacts to waste management facilities for U_3O_8 conversion would probably exceed those for uranium metal conversion. The largest waste volumes would result from conversion to UO_2.

F.3.8 Resource Requirements

Utilities and materials required for constructing the conversion facility for UF_6 to U_3O_8, UO_2, or uranium metal are listed in Table F.27. The equipment for conversion processes would be purchased from equipment vendors. The total quantities of commonly used materials of construction (e.g, carbon steel, stainless steel) for equipment would be minor compared to the quantities required for facility construction, as listed in Table F.27. The primary specialty materials required for fabricating process equipment include Monel and Inconel (LLNL 1997). Utilities and materials required for operating the three conversion facilities are shown in Table F.28.

F.3.9 Land Use

F.3.9.1 Conversion to U_3O_8

Impacts to land use from the construction and operation of a U_3O_8 conversion facility would be negligible. Such impacts would be limited to the clearing of required land, minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic. Under this conversion option, a conversion facility would require approximately 20 acres (8 ha) for construction and about 13 acres (5 ha) for operation (see Table F.29). The construction phase requires more land because space is needed for material excavation storage, equipment staging, and construction material laydown areas.

The amount of land required for this conversion option would not be great enough to require major land modification. However, it should be noted that siting a conversion facility at a location that is already dedicated to similar use could result in fewer land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

TABLE F.27 Resource Requirements for Constructing a Conversion Facility

Utilities/Materials	Unit	Total Consumption: Conversion to U_3O_8	Total Consumption: Conversion to UO_2	Total Consumption: Conversion to Metal
Utilities				
Electricity[a]	MWh	30,000	35,000	35,000 – 45,000
Solids				
Concrete	yd^3	15,000 – 18,000	21,000 – 44,300	20,000 – 23,000
Steel (carbon or mild)	ton	6,000 – 7,000	8,000 – 8,800	9,000 – 10,000
Liquids				
Diesel fuel	million gal	0.75	0.45 – 0.80	0.80 – 1.0
Gasoline	million gal	0.75	0.40 – 0.80	0.80 – 1.0
Gases				
Industrial gases (propane)	gal	4,000	4,400	4,400 – 5,500
Specialty materials				
Monel	ton	15 – 30	25 – 88	20 – 100
Inconel	ton	10	10 – 88	0 – 4
Titanium	ton	NA[b]	0 – 33	0 – 10

[a] The peak electricity demand during any hour would be as follows: conversion to U_3O_8, about 1.5 MW; conversion to UO_2, about 1.5 MW; conversion to metal, from 1.5 to 2.5 MW.

[b] NA = not applicable.

Source: LLNL (1997).

Impacts to land use outside the boundaries of a conversion facility would include negligible and temporary traffic impacts associated with project construction peaks. Also, because of the handling of UF_6 at the facility, NUREG-1140 (McGuire 1985) suggests that a 1-mile protective action distance be established around such a facility, which would cover an area of about 960 acres. The protective action distance is the recommended distance for which emergency planning would be appropriate to mitigate off-site exposure to accidental releases.

F.3.9.2 Conversion to UO_2

Impacts to land use from the UO_2 conversion option would be only slightly greater than those associated with other conversion options. The areal requirements for this option range from

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TABLE F.28 Resource Requirements for Operating a Conversion Facility

Utilities/Materials	Unit	Average Annual Requirement		
		Conversion to U_3O_8	Conversion to UO_2	Conversion to Metal
Utilities				
Electricity[a]	GWh	11.0	24 – 29	25 – 44
Liquid fuel	gal	6,000	3,040 – 7,000	6,500 – 9,500
Natural gas	million scf[b]	102 – 118	38 – 116	100 – 167
Solids				
Calcium hydroxide (hydrated lime)	million lb	0.388 – 1.27	0.388 – 1.27	0.247
Calcium oxide (quicklime)	million lb	0 – 29	0 – 29	NA[c]
Cement	lb	0 – 862,000	0 – 862,000	0 – 940,000
Detergent	lb	500	600	600 – 700
Iron	million lb	NA	NA	0 – 1.3
Magnesium	million lb	NA	NA	8.4 – 8.6
Sodium chloride	lb	NA	NA	0 – 514,000
Pelletizing lubricant	lb	NA	236,000	NA
Liquids				
Ammonia	million lb	0 – 0.662	2.9	2.4
Hydrochloric acid	lb	11,100 – 18,200	8,900 – 13,600	5,300 – 9,500
Nitric acid	lb	NA	NA	0 – 230,000
Sodium hydroxide	lb	8,800 – 14,400	7,000 – 10,700	4,200 – 7,500

[a] Peak electricity demand during any hour would be as follows: conversion to U_3O_8, about 1.5 MW; conversion to UO_2, from 3.2 to 4.0 MW; conversion to metal, from 3.3 to 6.0 MW.

[b] scf = standard cubic feet measured at 14.7 psia and 60°F.

[c] NA = not applicable.

Source: LLNL (1997).

22 to 31 acres (9 to 13 ha) for construction and from 14 to 20 acres (5.5 to 8 ha) for operations (Table F.29). Siting a conversion facility at a location that is already dedicated to similar use could result in fewer land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

Impacts to local traffic patterns outside potential UO_2 conversion plant sites could be greater than those expected under the conversion to U_3O_8 option due to the potential for increased traffic volume associated with greater construction workforce demands. However, such impacts would be temporary and would be expected to diminish during the operations phase. The protective

TABLE F.29 Land Requirements for the Conversion Options

Option	Land Requirement (acres)[a] Construction	Operation
Conversion to U_3O_8	20	13
Conversion UO_2	22 – 31	14 – 20
Conversion to metal	23 – 26	15 – 16

[a] NUREG-1140 (McGuire 1985) suggests that each conversion facility establish a protective action distance for emergency planning, which would incorporate an area of about 960 acres around each facility.

Source: LLNL (1997).

action distance described in Section F.3.9.1 would be applicable to an area of about 960 acres around the facility.

F.3.9.3 Conversion to Metal

Land-use impacts from the conversion to uranium metal option would be minimal. Land requirements (Table F.29) would be similar to those discussed for the conversion to UO_2 option, and impacts related to construction traffic outside the conversion plant sites would be negligible. The protective action distance would be applicable to an area of about 960 acres around the facility.

F.3.9.4 Cylinder Treatment Facility

Impacts to land use from the construction and operation of a cylinder treatment facility would be negligible and of a lesser magnitude than those generated under any of the conversion options. Although the cylinder treatment facility could be a stand-alone facility, it is likely to be integrated into a depleted UF_6 conversion facility. If the cylinder treatment facility were incorporated into a conversion facility, it would require less than 1 acre (0.4 ha) of land, regardless of the conversion option. Such a small areal requirement would account for much less than 1% of the land available for development at the representative sites. If construction of a cylinder treatment facility and conversion facility occurred simultaneously, the peak construction labor force of 230 for the

cylinder treatment facility could slightly increase the magnitude (expected to be negligible) of off-site traffic impacts associated with the conversion facility construction.

As a stand-alone facility, the cylinder treatment facility would require 8.7 acres (3.5 ha) of land for construction and 4.5 acres (2 ha) for operations. The areal requirement would probably not be large enough to result in land-use impacts, particularly if the facility were sited at a location already dedicated to a similar industrial-type use.

F.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the conversion options considered in this PEIS were implemented include impacts to cultural resources and environmental justice, as well as impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of the conversion facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites (e.g., impacts on cultural resources, threatened and endangered species, wetlands, and environmental justice). These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS.

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APPENDIX G:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR LONG-TERM STORAGE AS UF_6 AND URANIUM OXIDE

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NOTATION (APPENDIX G)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

ALARA	as low as reasonably achievable
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 μm or less
ROI	region of influence

Chemicals

CaF_2	calcium fluoride
CO	carbon monoxide
HC	hydrocarbons
HF	hydrogen fluoride
NO_x	nitrogen oxides
SO_x	sulfur oxides
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

cm	centimeter(s)	µg	microgram(s)
cm^3	cubic centimeter(s)	m	meter(s)
ft	foot (feet)	m^3	cubic meter(s)
ft^2	square foot (feet)	min	minute(s)
g	gram(s)	mrem	millirem(s)
gal	gallon(s)	MWh	megawatt hour(s)
gpm	gallon(s) per minute	MWyr	megawatt year(s)
ha	hectare(s)	rem	roentgen equivalent man
in.	inch(es)	s	second(s)
kg	kilogram(s)	scm	standard cubic meter(s)
km	kilometer(s)	yd^3	cubic yard(s)
L	liter(s)	yr	year(s)
lb	pound(s)		

APPENDIX G:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR LONG-TERM STORAGE AS UF_6 AND URANIUM OXIDE

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the long-term storage options for DOE-generated UF_6 cylinders and uranium oxide considered in the PEIS. The discussion provides background information for these options, as well as a summary of the estimated environmental impacts associated with each option.

Storage is defined as holding material for a temporary period, after which the material is either converted to another chemical form, used, disposed of, or stored elsewhere. Storage options would preserve access to the depleted uranium for use at a later date by storing it in a retrievable form in a facility designed for indefinite, low-maintenance operation.

Storage Options

Depleted uranium could be stored until use at a later date. Storage options are defined by the chemical form of the uranium and the type of storage facility. The following storage options are considered in the PEIS:

Storage as UF_6. Storage of UF_6 could take place in cylinders similar to those currently used. Storage facilities considered include yards, buildings, and an underground mine.

Storage as U_3O_8. Depleted uranium could be stored in drums as U_3O_8 following conversion. Storage facilities considered for U_3O_8 include buildings, belowground vaults, and an underground mine.

Storage as UO_2. Similar to options for U_3O_8, depleted uranium could be stored in drums as UO_2 in buildings, belowground vaults, and an underground mine.

The storage options in the PEIS are defined by the chemical form of the depleted uranium stored and the type of storage facility. Depleted uranium could be stored as UF_6, or, following chemical conversion, as triuranium octaoxide (U_3O_8) or uranium dioxide (UO_2). Storage as UF_6 would take place in cylinders similar to those currently used, whereas U_3O_8 or UO_2 would be stored in drums. Several different types of storage facilities are considered for each chemical form (summarized in Table G.1). For storage of UF_6 cylinders, the storage options considered include outdoor yards, aboveground buildings, and an underground mine. For storage of U_3O_8 and UO_2 in drums, the storage options include aboveground buildings, belowground vaults, and an underground mine. Each type of storage facility is described in Section G.3.

TABLE G.1 Summary of Depleted Uranium Chemical Forms and Storage Options Considered

	Storage Option Considered			
Chemical Form	Yards	Buildings	Vaults	Mines
UF_6	Yes	Yes	No	Yes
U_3O_8	No	Yes	Yes	Yes
UO_2	No	Yes	Yes	Yes

The choice of the chemical form of the depleted uranium for storage would depend in part on the desired end use or disposition of the material. For instance, storage in the form of UF_6 would provide maximum flexibility for future uses; however, UF_6 is not as chemically stable as other chemical forms because it becomes a gas at relatively low temperatures and is soluble in water. Storage in the form of UO_2 or U_3O_8 is attractive in view of their long-term stability, and may be the form of the material preferred for use as shielding or for disposal.

All storage facilities would be stand-alone, single-purpose facilities consisting of a central receiving building/warehouse surrounded by storage areas, all within a security fence. The storage facility would be capable of receiving containers of depleted uranium by truck or railcar, inspecting the containers, repackaging the material if necessary, and placing the containers into storage. Depending on the option, containers would be stored in a series of yards, buildings, vaults, or underground mine tunnels (called drifts). Once placed in storage, the containers of depleted uranium would require only routine monitoring and maintenance activities. The containers would be routinely inspected for damage or corrosion, the air would be monitored for indications of releases that would signify the presence of damaged containers, and any damaged containers would be repaired or replaced. The storage facilities would be designed to protect the stored material from the environment and prevent potential releases of material to the environment.

In general, potential environmental impacts would occur during (1) construction of a storage facility, (2) routine storage facility operations, and (3) potential storage accidents. The potential impacts during construction are generally limited to the duration of the construction period and result from typical land-clearing and construction activities. Potential impacts during operations would result primarily from the handling and inspection of containers. Impacts could also occur from potential accidents that release hazardous materials to the environment.

In general, the environmental impacts from the storage options were evaluated on the basis of information described in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997). For each storage option except storage as UF_6 in yards, the engineering analysis report provides preconceptual facility design data, including descriptions of facility layouts,

resource requirements, estimates of effluents, wastes, and emissions, and estimates of potential accident scenarios. The design of facilities required for UF_6 storage in yards was partially based on current yard storage practices (Parks 1997), as well as the designs for building and mine storage of UF_6 presented in the engineering analysis report (LLNL 1997). The assessment considers storage of depleted uranium through the year 2039. Storage facilities were assumed to receive containers of DOE-generated depleted uranium over a 20-year period beginning in 2009 and store the material for a period of 11 years after receipt of the last container.

G.1 SUMMARY OF STORAGE OPTION IMPACTS

Potential environmental impacts for the storage options are summarized in Table G.2. The potential environmental impacts from the storage options are not site-specific because the location of a storage facility will not be decided until sometime in the future (see Chapter 3). Instead, for assessment purposes, the environmental impacts were determined for a storage facility at representative sites. A more detailed assessment of specific storage technologies and site conditions will be conducted as appropriate as part of the second tier of the *National Environmental Policy Act* (NEPA) process.

The following general conclusions can be drawn from the summary table:

- The environmental impacts from storage tend to be small for all chemical forms and types of storage facilities.
- For storage as UF_6, yard storage has slightly greater environmental impacts than storage in buildings or a mine.
- For storage as U_3O_8, the environmental impacts tend to be similar among buildings, vaults, and a mine.
- For storage as UO_2, the environmental impacts tend to be similar among buildings, vaults, and a mine.
- The differences in impacts among chemical forms are partially related to differences in material bulk densities, with denser material, such as UO_2, requiring less storage space. UF_6 storage impacts also consider the greater reactivity of this form and the small potential for release of HF gas. However, differences in environmental impacts among the forms tend to be small.

TABLE G.2 Summary of Long-Term Storage Option Impacts

A. UF_6

Impacts from Storage as UF_6 in Yards	Impacts from Storage as UF_6 in Buildings	Impacts from Storage as UF_6 in a Mine
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 680 person-rem Total number of LCFs: 0.3 LCF	**Involved Workers:** Total collective dose: 240 person-rem Total number of LCFs: 0.1 LCF	**Involved Workers:** Total collective dose: 240 person-rem Total number of LCFs: 0.1 LCF
Noninvolved Workers: Negligible impacts	**Noninvolved Workers:** Negligible impacts	**Noninvolved Workers:** Negligible impacts
General Public: Negligible impacts	**General Public:** Negligible impacts	**General Public:** Negligible impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 7.5 person-rem Number of LCFs: 3×10^{-3}	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 7.5 person-rem Number of LCFs: 3×10^{-3}	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 7.5 person-rem Number of LCFs: 3×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 56 person-rem Number of LCFs in population within 50 miles: 3×10^{-2} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 56 person-rem Number of LCFs in population within 50 miles: 3×10^{-2} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 56 person-rem Number of LCFs in population within 50 miles: 3×10^{-2} LCF

TABLE G.2 (Cont.)

Impacts from Storage as UF_6 in Yards	Impacts from Storage as UF_6 in Buildings	Impacts from Storage as UF_6 in a Mine
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 520 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 520 persons	Number of persons potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 520 persons
Number of persons with potential for irreversible adverse effects: 440 persons	Number of persons with potential for irreversible adverse effects: 440 persons	Number of persons with potential for irreversible adverse effects: 440 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 2,500 persons	Number of persons with potential for adverse effects: 2,500 persons	Number of persons with potential for adverse effects: 2,500 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
	Human Health — Accidents: Physical Hazards	
Construction and Operations: **All Workers:** Less than 1 (0.1) fatality, approximately 92 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.25) fatality, approximately 150 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.36) fatality, approximately 187 injuries
	Air Quality	
Construction: 24-hour PM_{10} concentration potentially as large as 20% of standard; concentrations of other criteria pollutants all below 2% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 3% of standard; concentrations of other criteria pollutants 1% or less of respective standards	**Construction:** All pollutant concentrations less than those for storage in buildings
Operations: Concentrations of all criteria pollutants below 0.03% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 0.5% of standard; all other criteria pollutant concentrations 0.2% or less of respective standards	**Operations:** All pollutant concentrations less than those for storage in buildings

TABLE G.2 (Cont.)

Impacts from Storage as UF_6 in Yards	Impacts from Storage as UF_6 in Buildings	Impacts from Storage as UF_6 in a Mine
	Water	
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
	Soil	
Construction: Moderate, but temporary, impacts	**Construction:** Moderate, but temporary, impacts	**Construction:** Moderate, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
	Socioeconomics	
Construction: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Potentially moderate impacts on employment and income
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Operations:** Potentially moderate impacts on employment and income
	Ecology	
Loss of 77-144 acres; potentially moderate to large impacts to vegetation and wildlife	Loss of 62-131 acres; potentially moderate to large impacts to vegetation and wildlife	Loss of 32-96 acres; potentially moderate to large impacts to vegetation and wildlife
	Waste Management	
Construction: Negligible to moderate, but temporary, impacts (solid waste)	**Construction:** Negligible to moderate, but temporary, impacts (solid waste)	**Construction:** Negligible to moderate, but temporary, impacts (solid waste)
Operations: Negligible impacts (all waste forms)	**Operations:** Negligible impacts (all waste forms)	**Operations:** Negligible impacts (all waste forms)
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
	Land Use	
Use of approximately 144 acres; potential moderate impacts	Use of approximately 131 acres; potential moderate impacts	Use of approximately 96 acres; potential moderate impacts, including impacts from disposal of excavated material

TABLE G.2 (Cont.)

B. U_3O_8

Impacts from Storage as U_3O_8 in Buildings	Impacts from Storage as U_3O_8 in Vaults	Impacts from Storage as U_3O_8 in a Mine
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 940 person-rem Total number of LCFs: 0.4 LCF	**Involved Workers:** Total collective dose: 940 person-rem Total number of LCFs: 0.4 LCF	**Involved Workers:** Total collective dose: 950 person-rem Total number of LCFs: 0.4 LCF
Noninvolved Workers: Negligible impacts	**Noninvolved Workers:** Negligible impacts	**Noninvolved Workers:** Negligible impacts
General Public: Negligible impacts	**General Public:** Negligible impacts	**General Public:** Negligible impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 7.4 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 670 person-rem Number of LCFs: 0.3	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 7.4 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 670 person-rem Number of LCFs: 0.3	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 7.4 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 670 person-rem Number of LCFs: 0.3
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 16 person-rem Number of LCFs in population within 50 miles: 8×10^{-3} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 16 person-rem Number of LCFs in population within 50 miles: 8×10^{-3} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 16 person-rem Number of LCFs in population within 50 miles: 8×10^{-3} LCF

TABLE G.2 (Cont.)

Impacts from Storage as U_3O_8 in Buildings	Impacts from Storage as U_3O_8 in Vaults	Impacts from Storage as U_3O_8 in a Mine
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
	Human Health — Accidents: Physical Hazards	
Construction and Operations: All Workers: Less than 1 (0.29) fatality, approximately 165 injuries	**Construction and Operations: All Workers:** Less than 1 (0.26) fatality, approximately 151 injuries	**Construction and Operations: All Workers:** Less than 1 (0.43) fatality, approximately 222 injuries
	Air Quality	
Construction: Annual NO_x concentration potentially as large as 2.2% of standard; all other criteria pollutant concentrations less than 0.7% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 13% of standard; all other criteria pollutant concentrations less than 3% of respective standards	**Construction:** All pollutant concentrations less than those for storage in buildings
Operations: Annual NO_x concentration potentially as large as 0.6% of standard; all other criteria pollutant concentrations less than 0.2% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 1% of standard; all other criteria pollutant concentrations less than 0.3% of respective standards	**Operations:** All pollutant concentrations less than those for storage in buildings

TABLE G.2 (Cont.)

Impacts from Storage as U_3O_8 in Buildings	Impacts from Storage as U_3O_8 in Vaults	Impacts from Storage as U_3O_8 in a Mine
	Water	
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
	Soil	
Construction: Moderate, but temporary, impacts	**Construction:** Moderate, but temporary, impacts	**Construction:** Moderate, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
	Socioeconomics	
Construction: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Potentially moderate impacts on employment and income
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Operations:** Potentially moderate impacts on employment and income
	Ecology	
Loss of 72-148 acres; potentially moderate to large impacts to vegetation and wildlife	Loss of 86-212 acres; potentially moderate to large impacts to vegetation and wildlife	Loss of 54-124 acres; potentially moderate to large impacts to vegetation and wildlife
	Waste Management	
Construction: Minimal to moderate, but temporary, impacts (solid waste)	**Construction:** Minimal to moderate, but temporary, impacts (solid waste)	**Construction:** Minimal to moderate, but temporary, impacts (solid waste)
Operations: Negligible impacts (all waste forms)	**Operations:** Negligible impacts (all waste forms)	**Operations:** Negligible impacts (all waste forms)
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
	Land Use	
Use of approximately 148 acres; potential moderate impacts	Use of approximately 213 acres; potential large impacts, including impacts from disposal of excavated material	Use of approximately 120 acres; potential moderate impacts, including impacts from disposal of excavated material

TABLE G.2 (Cont.)

C. UO_2

Impacts from Storage as UO_2 in Buildings	Impacts from Storage as UO_2 in Vaults	Impacts from Storage as UO_2 in a Mine
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 540 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 540 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 540 person-rem Total number of LCFs: 0.2 LCF
Noninvolved Workers: Negligible impacts	**Noninvolved Workers:** Negligible impacts	**Noninvolved Workers:** Negligible impacts
General Public: Negligible impacts	**General Public:** Negligible impacts	**General Public:** Negligible impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 7.7 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 700 person-rem Number of LCFs: 0.3	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 7.7 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 700 person-rem Number of LCFs: 0.3	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 7.7 rem Risk of LCF to MEI: 3×10^{-3} Collective dose: 700 person-rem Number of LCFs: 0.3
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.23 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 17 person-rem Number of LCFs in population within 50 miles: 9×10^{-3} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.23 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 17 person-rem Number of LCFs in population within 50 miles: 9×10^{-3} LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.23 rem Risk of LCF to MEI: 1×10^{-4} Collective dose to population within 50 miles: 17 person-rem Number of LCFs in population within 50 miles: 9×10^{-3} LCF

TABLE G.2 (Cont.)

Impacts from Storage as UO_2 in Buildings	Impacts from Storage as UO_2 in Vaults	Impacts from Storage as UO_2 in a Mine
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
	Human Health — Accidents: Physical Hazards	
Construction and Operations: **All Workers:** Less than 1 (0.16) fatality, approximately 111 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.14) fatality, approximately 104 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.24) fatality, approximately 143 injuries
	Air Quality	
Construction: Annual NO_x concentration potentially as large as 2% of standard; all other criteria pollutant concentrations 0.5% or less of respective standards	**Construction:** Annual NO_x concentration potentially as large as 11% of standard; all other criteria pollutant concentrations 3% or less of respective standards	**Construction:** All pollutant concentrations less than those for storage in buildings
Operations: Annual NO_x concentration potentially as large as 0.4% of standard; all other criteria pollutant concentrations 0.1% or less of respective standards	**Operations:** Annual NO_x concentration potentially as large as 0.8% of standard; all other criteria pollutant concentrations 0.2% or less of respective standards	**Operations:** All pollutant concentration less than those for storage in buildings
	Water	
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater

TABLE G.2 (Cont.)

Impacts from Storage as UO_2 in Buildings	Impacts from Storage as UO_2 in Vaults	Impacts from Storage as UO_2 in a Mine
	Soil	
Construction: Moderate, but temporary, impacts **Operations:** No impacts	**Construction:** Moderate, but temporary, impacts **Operations:** No impacts	**Construction:** Moderate, but temporary, impacts **Operations:** No impacts
	Socioeconomics	
Construction: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances **Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances **Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction:** Potentially moderate impacts on employment and income **Operations:** Potentially moderate impacts on employment and income
	Ecology	
Potentially moderate impacts to vegetation and wildlife	Potentially large impacts to vegetation and wildlife	Potentially moderate impacts to vegetation and wildlife
	Waste Management	
Construction: Minimal to moderate, but temporary, impacts (solid waste) **Operations:** Negligible impacts (all waste forms)	**Construction:** Minimal to moderate, but temporary, impacts (solid waste) **Operations:** Negligible impacts (all waste forms)	**Construction:** Minimal to moderate, but temporary, impacts (solid waste) **Operations:** Negligible impacts (all waste forms)
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
	Land Use	
Use of approximately 79 acres; potential moderate impacts	Use of approximately 114 acres; potential moderate impacts	Use of approximately 74 acres; potential moderate impacts, including impacts from disposal of excavated material

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

G.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the different storage options considered in the assessment of storage impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). That report includes detailed information, such as descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

The chemical form of the depleted uranium (i.e., whether it is UF_6, U_3O_8, or UO_2) determines the type of storage container, the total number of containers required, and the storage configuration (the way containers would be stacked). For storage of UF_6, U_3O_8, and UO_2, the following assumptions would apply to all storage facilities:

- The analysis of storage impacts for UF_6 was based on the assumption that UF_6 would be stored in cylinders meeting all applicable storage requirements, either the current cylinders or new cylinders. Cylinder preparation for transportation to a long-term storage site would require thorough inspection of the cylinders to determine that they meet transportation requirements; cylinders not meeting these requirements would be placed in overcontainers for shipment or would have their contents transferred to new cylinders. Cylinder preparation activities were assumed to be carried out so that the cylinders could be delivered to the long-term storage site and placed into storage without further preparation. However, a certain number of cylinders were assumed to be damaged during transport and handling, and the contents of these cylinders were assumed to be transferred to new cylinders at the long-term storage site.

- Depleted UF_6 cylinders would be stacked two high, as is the current practice for outside storage of these cylinders, in rows 1.2 m (4 ft) apart.

- U_3O_8 would be stored in powdered form in 55-gal (210-L) drums, consistent with current practice. Based on a bulk density of about 3 g/cm^3, the weight of a filled drum would be about 700 kg (1,600 lb). Approximately 714,000 55-gal drums would be required. The drums would be stored in rows of four-drum pallets, two pallets high. The width of each row would be about 1.2 m (4 ft), with 1 m (3 ft) between rows to allow for drum inspections.

- UO_2 would be stored in a sintered form in 30-gal (110-L) drums. Based on a bulk density of sintered UO_2 of about 9 g/cm^3, a filled 30-gal drum weighs about 1,100 kg (2,400 lb). Approximately 420,000 30-gal drums would be required. As with U_3O_8, the drums would be stored in rows of four-drum pallets, two pallets high. The width of each row would be about 1 m (3 ft), with 1 m (3 ft) between rows, to allow for drum inspections.

- For UF_6 cylinders and U_3O_8 and UO_2 drums, the contents of containers damaged during handling and storage would be transferred to new containers (0.7% of the drums containers received annually were assumed to require replacement [LLNL 1997]).

In these configurations, the total area required for storage would range from 96 to 144 acres (39 to 58 ha) for UF_6, from 124 to 212 acres (50 to 86 ha) for U_3O_8, and from 74 to 114 acres (30 to 46 ha) for UO_2. The storage areas differ primarily because the bulk densities differ between the chemical forms. Although the total storage area required differs among chemical forms, the basic designs of the storage facilities — buildings, vaults, and mines — would be similar for each. For instance, buildings of similar type would be used for the storage of UF_6, U_3O_8, and UO_2; however, 17 buildings would be required for storage of UF_6 cylinders, 20 buildings for storage of U_3O_8 drums, and only 9 buildings for storage of UO_2 drums. Because UF_6 is currently stored in cylinder yards at the three storage sites, long-term storage of UF_6 in cylinder yards at a single, centralized location was also examined.

The following sections provide a summary description of each of the storage options. Note that in addition to the primary storage units, each facility also would have an administration building, a receiving warehouse, a repackaging building (attached to the receiving warehouse), and a workshop. Storage facilities for UF_6 would require a cylinder washing facility to recover the heels from damaged cylinders after the removal of the UF_6.

G.2.1 Storage in Yards

Only depleted UF_6 would be stored in outdoor yards. Yard construction would be similar to current practice; the yards would consist of an 8-in. (20-cm) stabilized base under a 12-in. (30-cm) nonreinforced concrete pad. Twenty pads with dimensions of approximately 160 m × 80 m would be required. Additional facilities required for yard storage include a receiving warehouse and repackaging building, a cylinder washing building, and an administration building. Maintenance activities assessed for long-term yard storage are similar to those associated with the continued storage strategy (Parks 1997), and include routine inspections, ultrasonic inspections, valve monitoring and maintenance, and regular painting of the cylinders. The contents of any of the cylinders damaged during handling or storage would be subsequently transferred to new cylinders; the old cylinders would be washed and sent for further disposition.

G.2.2 Storage in Buildings

Storage in buildings is considered for UF_6, U_3O_8, and UO_2. Aboveground buildings would be built on-grade and consist of a concrete slab covered by a steel, preengineered, single-span structure. This type of building is commonly called a "Butler" building. Each building would be approximately 840 ft (260 m) long and 160 ft (50 m) wide, with a height of approximately 20 ft

(6 m). The number of buildings required for storage of UF_6, U_3O_8, and UO_2 would be 17, 20, and 9, respectively. Construction would follow generally accepted practices. Additional facilities are provided which combine receiving/inspection operations with administration, shipping/unloading capabilities, and permanent monitoring capabilities (to ensure the integrity of the stored containers).

G.2.3 Storage in Vaults

Storage in vaults is considered for U_3O_8 and UO_2. Belowground vaults are subsurface reinforced concrete structures, 131 ft (40 m) wide × 266 ft (81 m) long, with a height of approximately 20 ft (6 m). The concrete walls are 1 ft (0.3 m) thick, with a floor slab thickness of 2 ft (0.6 m). The majority of the structure is located underground, with only the roof area above grade. A steel roof supported by trusses is used which can be removed to allow access to the vault by a mobile crane outside the structure. A total of 79 vaults would be required for storage of U_3O_8, and 35 for storage of UO_2.

G.2.4 Storage in a Mine

Storage in a mine is considered for UF_6 (dry mine only), U_3O_8, and UO_2. A belowground mine facility consists of surface buildings where the depleted uranium is inspected and prepared for storage, access shafts from the surface to the belowground drifts, and mined storage drifts. Storage drifts are lateral extensions of belowground tunnels in which depleted uranium can be stored. The dimensions of the drifts are 35 ft (11 m) wide × 330 ft (100 m) long and 18 ft (5 m) high. Each drift would contain two rows of UF_6 cylinders stored side-by-side, five rows of 30-gal UO_2 drums on pallets, or four rows of 55-gal U_3O_8 drums on pallets. The number of drifts required for storage of UF_6, U_3O_8, and UO_2 would be 180, 215, and 105, respectively.

G.2.5 Storage Technologies and Chemical Forms Considered But Not Analyzed

Storage of UF_6 in the potentially moist environment of a belowground vault or a mine was not considered due to potential accelerated corrosion of the steel cylinders. In addition, storage as depleted uranium metal was not considered because uranium metal is not as stable as U_3O_8 or UO_2, it is subject to surface oxidation.

G.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the storage options, including impacts from construction and facility operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C.

The environmental impacts from the storage options were evaluated based primarily on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to storage facility operations:

- The assessment considers storage of depleted uranium through the year 2039.
- Two phases of facility operations are considered. Phase I beginning in 2009 corresponds to the first 20 years, when the facilities would receive UF_6 cylinders or UO_2 or U_3O_8 drums from off-site and place them into storage. Phase II corresponds to the next 11 years, when passive storage of cylinders or drums would take place.
- Construction of support buildings and initial storage facilities would begin about 2007, and additional storage facilities would be built as needed throughout Phase I.
- All storage containers would be routinely inspected, and any damaged containers would be replaced.
- UF_6 cylinder content transfers and empty cylinder washing activities would be the only sources of emissions associated with normal (nonaccident) operations. All U_3O_8 and UO_2 drum content transfers would be enclosed mechanical operations that would not involve material releases.

As described in Chapter 3, the potential environmental impacts from the storage options were not determined on a site-specific basis because the location of a storage facility would not be decided until sometime in the future. Instead, for yards, buildings, and vaults, the environmental impacts were calculated using the site conditions at the three current depleted UF_6 storage sites. These three representative sites were used to provide a reasonable range of environmental conditions. For assessment of mine storage, a representative dry location was assumed (storage in a wet mine environment was not considered reasonable due to potential corrosion of containers). A more detailed assessment of site considerations would be addressed, as appropriate, as part of the second phase (tier) of the programmatic NEPA approach.

G.3.1 Human Health — Normal Operations

G.3.1.1 Radiological Impacts

Radiation doses and the associated cancer risks were estimated for exposed individuals and collective populations. Radiation doses to the involved workers would result mainly from external radiation during handling of containers of uranium and during routine inspection activities. Radiation

doses to noninvolved workers and the general public would result from release of uranium compounds to the environment. According to the engineering analysis report (LLNL 1997), airborne emissions of depleted uranium would be negligible during normal operations of the storage facilities. Results from water quality analyses (Section G.3.4) also showed that potential impacts to surface water would be negligible. Therefore, radiological impacts to noninvolved workers and the off-site general public would be negligible for all storage options.

Discussion of the methodologies used in radiological impact analysis is provided in Appendix C and Cheng et al. (1997). The estimated results for involved workers are presented in Table G.3 and G.4 for all storage options. The results indicate that average radiation exposure to involved workers would be less than 1,200 mrem/yr.

G.3.1.1.1 Storage as UF_6

Radiation exposures for involved workers from storage as UF_6 would result mainly from cylinder handling, painting (for storage in yards), repackaging, and surveillance activities. Collective radiological impacts from storage in yards would be more than twice that from storage in buildings and mines. Compared with buildings and mines, storage in yards would require more cylinder inspection and cylinder maintenance (painting) activities to control corrosion in an outdoor environment. Radiological impacts would be similar for storage in buildings and storage in a mine. The collective dose would range from about 7.6 to 22 person-rem/yr (considering Phase I and Phase II) for a worker population of 19 to 26 individuals. The corresponding number of latent cancer fatalities (LCFs) among the involved workers would range from 0.003 to 0.009 per year (1 to 3 LCFs over a 300-year period).

The average annual individual doses were obtained by dividing the collective dose by the number of workers. To provide a conservative estimate of doses, the calculations did not consider the implementation of as low as reasonably achievable (ALARA) practices to minimize exposures. Because the exact number of workers required to conduct all types of activities is uncertain at this preliminary stage, the estimated average individual doses also involve a large degree of uncertainty. The estimated average individual dose ranges from 290 to 920 mrem/yr for the storage options, with a corresponding individual risk of a latent cancer fatality of 0.0001 to 0.0004 per year (a chance of about 1 to 4 in 10,000 per year). The average individual dose would be well below the regulatory limit of 5,000 mrem/yr (10 *Code of Federal Regulations* [CFR] Part 835) and would be smaller than the DOE administrative control limit of 2,000 mrem/yr (DOE 1992).

G.3.1.1.2 Storage as U_3O_8

For storage as U_3O_8, the worker activities would be expected to be similar among the three storage options — buildings, vaults, and mines. Therefore, radiological impacts to involved workers would be similar among these options. For all three options, the estimated collective dose is about

TABLE G.3 Radiological Doses from Long-Term Storage Options under Normal Operations

Option	Dose to Receptor: Involved Worker[a] Average Dose (mrem/yr)	Involved Worker[a] Collective Dose (person-rem/yr)	Noninvolved Worker[b] MEI Dose (mrem/yr)	Noninvolved Worker[b] Collective Dose (person-rem/yr)	General Public[c] MEI Dose (mrem/yr)	General Public[c] Collective Dose (person-rem/yr)
Storage as UF_6						
Yards	920	22	~0	~0	~0	~0
Buildings	290	7.6	~0	~0	~0	~0
Mine	420	7.6	~0	~0	~0	~0
Storage as U_3O_8						
Buildings	880	30	~0	~0	~0	~0
Vaults	910	30	~0	~0	~0	~0
Mine	1,200	30	~0	~0	~0	~0
Storage as UO_2						
Buildings	810	17	~0	~0	~0	~0
Vaults	670	17	~0	~0	~0	~0
Mine	920	17	~0	~0	~0	~0

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[b] Noninvolved workers are individuals who do not participate in material handling activities and individuals who work on-site but not within the facility. Because negligible airborne emission of radioactive materials would be expected from the storage facility (LLNL 1997), radiation doses to noninvolved workers would be negligible.

[c] The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the storage site. Radiation doses to the off-site public would be negligible because airborne emission of radioactive materials (LLNL 1997) and impacts to surface water quality would be negligible (Section G.3.4).

TABLE G.4 Latent Cancer Risks from Long-Term Storage Options under Normal Operations

Option	Latent Cancer Risk to Receptor					
	Involved Worker[a]		Noninvolved Workers[b]		General Public[c]	
	Average Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk (risk/yr)	Collective Risk (fatalities/yr)
Storage as UF_6						
Yards	4×10^{-4}	9×10^{-3}	~ 0	~ 0	~ 0	~ 0
Buildings	1×10^{-4}	3×10^{-3}	~ 0	~ 0	~ 0	~ 0
Mine	2×10^{-4}	3×10^{-3}	~ 0	~ 0	~ 0	~ 0
Storage as U_3O_8						
Buildings	4×10^{-4}	1×10^{-2}	~ 0	~ 0	~ 0	~ 0
Vaults	4×10^{-4}	1×10^{-2}	~ 0	~ 0	~ 0	~ 0
Mine	5×10^{-4}	1×10^{-2}	~ 0	~ 0	~ 0	~ 0
Storage as UO_2						
Buildings	3×10^{-4}	7×10^{-3}	~ 0	~ 0	~ 0	~ 0
Vaults	3×10^{-4}	7×10^{-3}	~ 0	~ 0	~ 0	~ 0
Mine	4×10^{-4}	7×10^{-3}	~ 0	~ 0	~ 0	~ 0

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population.

[b] Noninvolved workers are individuals who do not participate in material handling activities and individuals who work on-site but not within the facility. Because negligible airborne emission of radioactive materials would be expected from the storage facility (LLNL 1997), cancer risks to noninvolved workers would be negligible.

[c] The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the storage site. Cancer risks to the off-site public would be negligible because airborne emission of radioactive materials (LLNL 1997) and impacts to surface water quality would be negligible (Section G.3.4).

960

30 person-rem/yr for 25 to 34 workers. The corresponding number of LCFs among workers would be about 0.01 per year (about 1 LCF over a 100-year period).

The estimated average individual dose ranges from about 880 to 1,200 mrem/yr for the U_3O_8 storage options, with a corresponding individual risk of a latent cancer fatality of 0.0004 to 0.0005 per year (a chance of about 1 in 2,000). The average dose would be well below the regulatory dose limit of 5,000 mrem/yr.

Storage as U_3O_8 would result in greater collective exposures for involved workers than storage as UF_6 or UO_2 because a larger number of containers would be needed for U_3O_8 than for UF_6 and UO_2. Consequently, the number of operations for transferring containers, retrieving damaged containers, and surveying the stored inventory would be the greatest for U_3O_8 among the three chemical forms for depleted uranium.

G.3.1.1.3 Storage as UO_2

The storage practices for UO_2 drums would be similar to those for U_3O_8 drums; however, the total number of UO_2 drums would be less than the number of U_3O_8 drums. As a result, the estimated collective exposures to involved workers from drum handling and inspection activities would be less for UO_2 than for U_3O_8. On the other hand, the number of UO_2 drums would be greater than the number of UF_6 cylinders. Therefore, collective exposures for storage in buildings and in a mine would be greater for UO_2 than for UF_6.

Radiological impacts to workers would be similar among the UO_2 storage options. The collective dose to involved workers would be about 17 person-rem/yr for 19 to 26 workers. The corresponding number of latent cancer fatalities among workers would be about 0.007 per year (about 1 LCF over a 140-year period).

The estimated average individual dose ranges from 800 to 920 mrem/yr, with a corresponding individual risk of an LCF of about 0.0003 to 0.0004 per year (a chance of about 1 in 2,500). The average dose would be well below the regulatory dose limit.

G.3.1.2 Chemical Impacts

Chemical impacts to the maximally exposed individual (MEI) were assessed for noninvolved workers and the public. However, according to the engineering analysis report (LLNL 1997), no airborne emissions of uranium would be expected for long-term storage facilities and only small quantities of hydrogen fluoride (HF) would be emitted under the UF_6 storage option. Therefore, the only potential chemical exposures for noninvolved workers and the public that were considered are those that would result from airborne emissions of HF emitted from the cylinder transfer and washing operations. In addition, potential chemical exposures resulting from the storage

facilities wastewater emissions were considered for the off-site general public; however, results from water quality analyses (Section G.3.4.1) showed that potential impacts to surface water bodies would be negligible. Information on the methodologies used for the chemical impact analysis is provided in Appendix C and Cheng et al. (1997).

The results of the analysis of hazardous chemical human health impacts from long-term storage options are summarized in Table G.5. No impacts on human health from chemical exposures would be expected during normal operations of storage facilities.

For the long-term storage option, the engineering analysis report (LLNL 1997) assumed that a low percentage of cylinders and drums would require repackaging annually due to handling or

TABLE G.5 Chemical Impacts to Human Health for Long-Term Storage Options under Normal Operations[a]

		Impacts to Receptor			
		Noninvolved Workers[a]		General Public[b]	
Option	Type	Hazard Index for MEI[c]	Collective Risk[d] (ind. at risk/yr)	Hazard Index for MEI[c]	Collective Risk[d] (ind. at risk/yr)
Storage as UF_6	Yards	~ 0	–	~ 0	–
	Buildings	~ 0	–	~ 0	–
	Mines	~ 0	–	~ 0	–
Storage as U_3O_8	Buildings	~ 0	–	~ 0	–
	Vaults	~ 0	–	~ 0	–
	Mines	~ 0	–	~ 0	–
Storage as UO_2	Buildings	~ 0	–	~ 0	–
	Vaults	~ 0	–	~ 0	–
	Mines	~ 0	–	~ 0	–

[a] Noninvolved workers include individuals who work at the facility but are not involved in hands-on activities and individuals who work on-site but not within the facility. Because no airborne emission of uranium and/or very low levels of HF are expected from the storage facility, there would essentially be no noncarcinogenic health impacts to the noninvolved workers.

[b] The off-site general public is defined as residents who live with a radius of 50 miles (80 km) around the storage site. There would essentially be no noncarcinogenic health impacts to the general public because no airborne emission of uranium and/or very low levels of HF are expected from the storage facility, there would essentially be no noncarcinogenic health impacts to the noninvolved workers.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

corrosion damage. These repackaging operations would result in the only potential releases and exposures to uranium and fluoride compounds for the storage options. For drum repackaging, electrically powered transfer equipment would pour the contents of the damaged drums into new drums, minimizing involved worker contact with the drum contents. The transfer equipment would operate in such a way as to keep the operation enclosed and eliminate dust generation for the U_3O_8 and UO_2 storage forms.

For storage as UF_6, repackaging would require heating the cylinder in an autoclave and transferring the contents to a new cylinder. A small "heel" of UF_6 (approximately 22 lb [10 kg]) would remain in the emptied cylinder; this material would be removed in the cylinder washing building, converted to uranyl fluoride (UO_2F_2) and calcium fluoride (CaF_2), and disposed of. Small amounts of HF would be released from the cylinder washing building stack from the conversion of the UF_6 heels to UO_2F_2. The maximum annual emission of HF for the Phase I and Phase II operational periods of long-term UF_6 storage would be about 0.10 kg/yr (in yards). In comparison, the maximum estimated annual emission of HF for any of the depleted UF_6 conversion options would be 408 kg/yr. Therefore, the maximum estimated annual emission of HF from any of the UF_6 storage facilities would be more than 4,000 times lower than the maximum annual emission of HF from conversion facilities. Because the results of the conversion analyses (Appendix F) did not indicate any human health impacts and the atmospheric release and transport of HF would occur under similar conditions, the small quantities of HF present in the storage facility emissions would also not result in human health impacts.

For storage as UF_6, it should also be noted that emissions due to breaches were not assumed because all cylinders would be inspected once every 4 years and would be repackaged immediately if any handling or corrosion damage was identified. Additionally, yard storage assumes that rigorous maintenance would take place, such as ultrasonic test inspections, valve monitoring, and regular painting.

Airborne emissions of depleted uranium are not expected during normal operations of the storage facilities, according to data provided in the engineering analysis report (LLNL 1997). Therefore, no matter which chemical form of depleted uranium is selected, chemical impacts to noninvolved workers and the off-site general public would be negligible.

G.3.2 Human Health — Accident Conditions

For long-term storage as U_3O_8 and UO_2, a range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents was presented in the engineering analysis report (LLNL 1997). Accidents analyzed for long-term storage in yards were consistent with those analyzed for continued cylinder storage (Appendix D), as given in the safety analysis reports (LMES 1997a-c). These accidents are listed in Table G.6. The following sections present the results for radiological and chemical health impacts of the highest consequence

TABLE G.6 Accidents Considered for the Long-Term Storage Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Storage as UF_6					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Storage as U_3O_8					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the repackaging building	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the ground inside the repackaging building.	U_3O_8	0.00028	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The repackaging building is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	U_3O_8	33	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the repackaging building structure and its confinement systems.	U_3O_8	33	0.5	Ground

TABLE G.6 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Storage as U_3O_8 (Cont.)					
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire or explosion inside the repackaging building	A fire or explosion within the repackaging facility affects the contents of a single pallet of drums.	U_3O_8	0.0011	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Storage as UO_2					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the repackaging building	A single UO_2 drum is damaged by a forklift and spills its contents onto the ground inside the repackaging building.	UO_2	0.00011	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The repackaging building is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	UO_2	33	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the repackaging building structure and its confinement systems.	UO_2	33	0.5	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire or explosion inside the repackaging building	A fire or explosion within the repackaging facility affects the contents of a single pallet of drums.	UO_2	0.00045	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

accident in each frequency category. Results for all accidents listed in Table G.6 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C and Policastro et al. (1997).

G.3.2.1 Radiological Impacts

The radiological doses to various receptors for the accidents that would result in the highest dose from each frequency category are listed in Table G.7. The LCF risks for these accidents are given in Table G.8. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions and three representative sites were considered for each long-term storage option (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 7.7 rem. This dose is less than the 25 rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table G.8] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all accidents.

G.3.2.2 Chemical Impacts

The accidents considered in this section are listed in Table G.6. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables G.9 and G.10. The results are presented as (1) number of people with potential for adverse effects and (2) number of people with potential for irreversible adverse effects. The tables present the results for the accident within the frequency category that would affect the largest number of people (total of noninvolved workers and off-site population) (Policastro et al. 1997). The numbers of noninvolved workers and

TABLE G.7 Estimated Radiological Doses per Accident Occurrence for the Long-Term Storage Options

Option/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Storage as UF_6									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	7.1	2.3×10^{-3}	3.0×10^{-1}	3.3×10^{-3}	8.1×10^{-2}	7.8×10^{-5}	7.4×10^{-3}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	7.5	1.5×10^{-2}	5.6×10^{1}	3.7×10^{-3}	5.2×10^{-1}	1.9×10^{-3}	5.2×10^{-1}
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	2.5	4.9×10^{-3}	2.7×10^{-1}	8.7×10^{-4}	2.2×10^{-1}	6.2×10^{-4}	2.5×10^{-2}
Storage as U_3O_8									
Mishandling/drop of drum inside the repackaging building	L	9.4×10^{-9}	3.0×10^{-6}	9.7×10^{-9}	1.8×10^{-6}	2.8×10^{-12}	8.1×10^{-25}	4.8×10^{-10}	5.2×10^{-8}
Earthquake	U	7.4	6.7×10^{2}	2.2×10^{-1}	1.6×10^{1}	3.1×10^{-1}	7.8	7.4×10^{-3}	6.4×10^{-1}
Fire or explosion inside the repackaging building	EU	3.6×10^{-8}	1.2×10^{-5}	3.7×10^{-8}	6.7×10^{-6}	1.1×10^{-11}	3.1×10^{-24}	1.8×10^{-9}	2.0×10^{-7}
Storage as UO_2									
Mishandle/drop of drum inside the repackaging building	L	3.7×10^{-9}	1.2×10^{-6}	3.8×10^{-9}	7.0×10^{-7}	1.1×10^{-12}	3.2×10^{-25}	1.9×10^{-10}	2.1×10^{-8}
Earthquake	U	7.7	7.0×10^{2}	2.3×10^{-1}	1.7×10^{1}	3.2×10^{-1}	8.1	7.7×10^{-3}	6.7×10^{-1}
Fire or explosion inside the repackaging building	EU	1.5×10^{-8}	4.8×10^{-6}	1.5×10^{-8}	2.8×10^{-6}	4.4×10^{-12}	1.3×10^{-24}	7.5×10^{-10}	8.3×10^{-8}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

TABLE G.8 Estimated Radiological Health Risks per Accident Occurrence for the Long-Term Storage Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Storage as UF_6									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	3×10^{-3}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-5}	4×10^{-8}	4×10^{-6}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	3×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	2×10^{-4}	1×10^{-6}	3×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	1×10^{-3}	2×10^{-6}	1×10^{-4}	3×10^{-7}	9×10^{-5}	3×10^{-7}	1×10^{-5}
Storage as U_3O_8									
Mishandle/drop of drum inside the repackaging building	L	4×10^{-12}	1×10^{-9}	5×10^{-12}	9×10^{-10}	1×10^{-15}	3×10^{-28}	2×10^{-13}	3×10^{-11}
Earthquake	EU	3×10^{-3}	3×10^{-1}	1×10^{-4}	8×10^{-3}	1×10^{-4}	3×10^{-3}	4×10^{-6}	3×10^{-4}
Fire or explosion inside the repackaging building	I	1×10^{-11}	5×10^{-9}	2×10^{-11}	3×10^{-9}	4×10^{-15}	1×10^{-27}	9×10^{-13}	1×10^{-10}
Storage as UO_2									
Mishandle/drop of drum inside the repackaging building	L	1×10^{-12}	5×10^{-10}	2×10^{-12}	3×10^{-10}	4×10^{-16}	1×10^{-28}	9×10^{-14}	1×10^{-11}
Earthquake	EU	3×10^{-3}	3×10^{-1}	1×10^{-4}	9×10^{-3}	1×10^{-4}	3×10^{-3}	4×10^{-6}	3×10^{-4}
Fire or explosion inside the repackaging building	I	6×10^{-12}	2×10^{-9}	8×10^{-12}	1×10^{-9}	2×10^{-15}	5×10^{-28}	4×10^{-13}	4×10^{-11}

a Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCFs) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

b The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

c Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

d Maximum and minimum risks reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

TABLE G.9 Number of Persons with Potential for Adverse Effects from Accidents under the Long-Term Storage Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Storage as UF_6									
Yard									
Corroded cylinder spill, dry conditions	L	Yes	240	No	0	Yes	2	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	520	Yes	10	Yes[f]	52	No	0
Vehicle-induced fire, three full 48G cylinders	EU	Yes	310	Yes	2,500	Yes[f]	0	Yes	3
Small plane crash, 48G cylinders	I	Yes	290	Yes	53	Yes[f]	0	No	0
Buildings/Mine									
Corroded cylinder spill, dry conditions	L	Yes	240	No	0	Yes	2	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	520	Yes	10	Yes[f]	52	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	310	Yes	2,500	Yes[f]	0	Yes	3
Small plane crash, 2 full 48G cylinders	I	Yes	290	Yes	53	Yes[f]	0	No	0
Storage as U_3O_8									
Mishandle/drop of drum/ cylinder inside[g]	L	No	0	No	0	No	0	No	0
Earthquake	U	Yes	1	No	0	No	0	No	0
Fire or explosion involving reagent inside[g]	EU	No	0	No	0	No	0	No	0
Storage as UO_2									
Mishandle/drop of drum/ cylinder inside[g]	L	No	0	No	0	No	0	No	0
Earthquake	U	Yes	1	No	0	No	0	No	0
Fire or explosion involving reagent inside[g]	EU	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 31 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the representative sites were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

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TABLE G.10 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Long-Term Storage Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Storage as UF_6									
Yard									
Corroded cylinder spill, dry conditions	L	Yes	5	No_f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	370	Yes_f	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	440	Yes_f	0	Yes	4	No	0
Small plane crash, 2 full 48G cylinders	I	Yes	2	No	0	No	0	No	0
Buildings/Mine									
Corroded cylinder spill, dry conditions	L	Yes	5	No_f	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	370	Yes_f	0	Yes	3	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	440	Yes_f	0	Yes	4	No	0
Small plane crash, 2 full 48G cylinders	I	Yes	2	No	0	No	0	No	0
Storage as U_3O_8									
Mishandle/drop of drum/cylinder inside[g]	L	No_f	0	No	0	No	0	No	0
Earthquake	U	Yes_f	0	No	0	No	0	No	0
Fire or explosion involving reagent inside[g]	EU	No	0	No	0	No	0	No	0
Storage as UO_2									
Mishandle/drop of drum/cylinder inside[g]	L	No_f	0	No	0	No	0	No	0
Earthquake	U	Yes_f	0	No	0	No	0	No	0
Fire or explosion involving reagent inside[g]	EU	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the representative sites were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

members of the off-site public represent the impacts if the associated accident was assumed to occur. The accidents listed in Tables G.9 and G.10 are not identical because an accident with the largest impacts for the adverse effects endpoint might not lead to the largest impacts for the irreversible adverse effects endpoint. The results of the chemical impacts analysis may be summarized as follows:

- If the accidents identified in Tables G.9 and G.10 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 2,500 (maximum corresponding to vehicle-induced fire accident involving three full 48G cylinders), and the number of off-site persons with potential for irreversible adverse effects was estimated to be 0.

- If the accidents identified in Tables G.9 and G.10 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 520 (maximum corresponding to the corroded cylinder spill accident with rain conditions), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 440 (maximum corresponding to corroded cylinder spill accident with pooling).

- The noninvolved worker population would receive the majority of the severe impacts and the off-site population much less, except for the vehicle-induced fire accident involving three full 48G cylinders. In such case, the plume would rise and hit the ground at distances downwind. The overall risk (frequency times consequence), however, is very low due to the low frequency of occurrence.

- The impacts resulting from the vehicle-induced fire involving three full 48G UF_6 cylinders would be large for members of the general public in terms of potential adverse effects because of the considerable source terms associated with such an accident.

- The overall impact for accidents associated with long-term storage as UF_6 in buildings/mines would be about the same as that associated with storage in a yard. Storage as U_3O_8 would have almost the same impacts as storage as UO_2, with both options having very small impacts compared with the potential impacts for storage as UF_6.

- Stack releases would have much lower impacts than ground-level releases.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years in operations (31 years, 2009 through 2039). The results indicated that

the maximum risk values would be less than 1 for all accidents except the following:

- *Potential Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely): Workers
  Corroded cylinder spill, wet conditions – rain (U, unlikely): Workers

- *Potential Irreversible Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely): Workers
  Corroded cylinder spill, wet conditions – rain (U, unlikely): Workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for noninvolved workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table G.10 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures would likely be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for noninvolved workers experiencing a range of 0 to 440 irreversible adverse effects, 0 to about 4 deaths would be expected. No deaths would be expected among the general public. These are the maximum potential consequences of the accidents, the upper ends of the ranges assume worst-case weather conditions and that the wind would be blowing in the direction where the highest numbers of people would be exposed.

G.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all long-term storage facility workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the duration of the construction and operational phases of the facility.

No on-the-job fatalities are predicted for any of the storage options analyzed (range of 0.10 for UF_6 yard storage to 0.43 for U_3O_8 mine storage, for the total construction, Phase I operations, and Phase II operations). The range of predicted injuries is about 92 to 222 for the entire facility lifetimes. Physical hazard risks of fatality and injury are presented in Table G.11 by construction, Phase I, and Phase II components. The largest component of physical hazard risks generally results

TABLE G.11 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Long-Term Storage Options

	Impacts to All Long-Term Storage Facility Workers[a]					
	Incidence of Fatalities[b]			Incidence of Injuries[b]		
Option	Construction	Phase I Operations	Phase II Operations	Construction	Phase I Operations	Phase II Operations
Storage as UF_6	0.04 – 0.30	0.04	0.02	16 – 110	48 – 53	24 – 29
Storage as U_3O_8	0.20 – 0.36	0.04 – 0.05	0.02	83 – 132	55 – 64	25 – 27
Storage as UO_2	0.09 – 0.18	0.04	0.02	33 – 66	50 – 53	22 – 24

[a] Impacts are reported as ranges, which result from variations in the employment requirements for the different long-term storage chemical forms and facility types. All construction and operational workers at the storage facilities are included in physical hazard risk calculations.

[b] Fatality and injury incidence rates used in the calculations were taken from National Safety Council (1995).

from construction; except for UF_6 yard storage, construction physical hazard risks are 3 to 4 times greater than risks from Phase I and II operations combined. The maximum impacts are predicted for storage as U_3O_8 in mines; the differences in predicted impacts result from the increased work effort required to construct mines and to inspect the greater number of U_3O_8 containers during the operational phases. However, the overall differences in ranges of physical hazard risks between chemical forms and storage types are fairly small.

For storage as UF_6, the probability of an on-the-job fatality ranges from 0.10 for storage in yards to 0.36 for storage in mines — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 92 to 187 injuries over the lifetime of the facility.

For storage as U_3O_8, the probability of an on-the-job fatality ranges from 0.29 for storage in vaults to 0.43 for storage in mines — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 151 to 222 injuries over the lifetime of the facility.

For storage as UO_2, the probability of an on-the-job fatality ranges from 0.16 for storage in buildings to 0.24 for storage in mines — including construction, Phase I, and Phase II of storage. The predicted injury incidence ranges from about 104 to 143 injuries over the lifetime of the facility.

G.3.3 Air Quality

The methodology used to analyze impacts of the long-term storage options is described in Appendix C and Tschanz (1997). The storage site was assumed to be centered within a larger facility, and pollutant concentrations — carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides

(NO_x), sulfur oxides (SO_x), and PM_{10} (particulate matter with a mean diameter of 10 μm or less) — were estimated for the boundaries of that facility. Screening modeling of construction emissions was used to estimate hourly pollutant concentrations under very conservative meteorological conditions at the boundary point that would be the shortest distance from the center of the facility. The maximum 1-hour concentrations for the representative facilities examined are shown in Table G.12. These impacts would occur when construction was under way at the corner of the storage site nearest the chosen boundary point. Concentrations from construction at the center of the storage site would be 1.5 to 2 times smaller than the ones listed in the table. Among the listed results, the PM_{10} values might require close consideration in actual construction of any sites similar to the assumed preconceptual ones. Based on the size of the estimated 1-hour concentrations, it is possible that, under particularly unfavorable conditions, concentrations could exceed the 24-hour PM_{10} standard of 150 $\mu g/m^3$.

Air quality impacts associated with storage in a mine were not analyzed in detail because the potential emissions associated with mine storage would be smaller than those for the other storage options considered. For example, during construction of facilities for long-term storage of U_3O_8, CO emissions for mine construction would be about 30% of those for aboveground buildings and only about 10% of those for belowground vaults. Similar ratios would apply for comparisons of emissions during operations associated with placing the uranium compounds in the storage facilities.

The maximum impacts of CO and NO_x at the facility boundaries during operations to place depleted uranium in storage are shown in Table G.13 for the averaging periods for which standards

TABLE G.12 Maximum 1-Hour Pollutant Concentrations at Long-Term Storage Facility Boundaries as a Result of Construction Emissions under Worst-Case Meteorological Conditions

	Maximum 1-Hour Concentration ($\mu g/m^3$)				
	Aboveground Building Storage			Belowground Vault Storage	
Pollutant	UF_6	U_3O_8	UO_2	U_3O_8	UO_2
CO	77	94	54	280	140
HC	34	38	21	110	55
NO_x	390	450	250	1,300	670
SO_x	26	30	17	85	44
PM_{10}[a]	370	420	240	460	250

[a] Fugitive dust emissions from land disturbance have been included with PM_{10} emissions from construction equipment to estimate total PM_{10} concentrations.

TABLE G.13 Maximum Pollutant Concentrations at Facility Boundaries from Operations Emissions during Long-Term Storage

	CO				NO_x	
	1-Hour Average		8-Hour Average		Annual Average	
Option	Pollutant Concentration ($\mu g/m^3$)	Percent of Standard at Maximum	Pollutant Concentration ($\mu g/m^3$)	Percent of Standard at Maximum	Pollutant Concentration ($\mu g/m^3$)	Percent of Standard at Maximum
Aboveground Buildings						
Storage as UF_6	6.2 – 7.9	0.02	1.6 – 1.9	0.02	0.18 – 0.48	0.5
Storage as U_3O_8	6.8 – 7.5	0.02	1.8 – 2.3	0.02	0.24 – 0.57	0.6
Storage as UO_2	5.4 – 6.9	0.02	1.1 – 1.7	0.02	0.13 – 0.39	0.4
Belowground Vaults						
Storage as U_3O_8	9.3 – 12.9	0.03	2.6 – 3.2	0.03	0.40 – 0.95	1.0
Storage as UO_2	10.0 – 10.7	0.03	2.1 – 3.1	0.03	0.27 – 0.82	0.8

exist. In all cases, the concentrations due to the storage operations are 1% or less of the standards. Although not shown, the comparisons between SO_x concentrations and the corresponding standards are similar to those for CO.

The results of comparing the impacts from CO and NO_x emissions for simultaneously conducted construction and operations activities are shown in Table G.14. The maximum construction impacts would result when construction took place at the corner of the storage site nearest the facility boundary point closest to the facility center. The operations emissions were assumed to be distributed uniformly over the entire storage site. Although the annual construction emissions are comparable to the corresponding operations emissions for both buildings and vaults, the construction impacts shown are considerably larger. Basically, this is the effect of concentrating the construction emissions in a small area closer to the boundary receptor point than is the average distance for the operations emissions. During most years, the construction would be farther from the boundary and have less impact. Even for the results shown in Table G.14, the combined construction and operations impacts are less than the applicable air quality standards.

The emissions from routine monitoring and maintenance following completion of the storage operations in all cases would be less than 25% as large as the operations emissions. Thus, in all cases, the maintenance air quality impacts would be less than 25% of the operations impacts alone.

Some of the estimated criteria pollutant impacts during the operations phase of long-term storage of UF_6 in yards, when both construction and operations would occur simultaneously, are shown in Table G.15. Construction would be the dominant contributor to most of the impacts, accounting for between 85% of the total for CO to nearly 100% for PM_{10}. The combined impacts

TABLE G.14 Maximum Air Quality Impacts from Construction Emissions for Long-Term Aboveground Building and Belowground Vault Storage of U_3O_8 Compared with Impacts from Operations Emissions

Pollutant/ Storage Option	Averaging Period	Maximum Concentration from Construction Emissions ($\mu g/m^3$)	Operations Concentration as Percent of Construction Concentration
CO			
Building	1-hour average	49	15
	8-hour average	8.1	22
Vault	1-hour average	170	8
	8-hour average	37	7
NO_x			
Building	Annual average	2.2	21
Vault	Annual average	12.4	7

TABLE G.15 Maximum Pollutant Concentrations at Facility Boundaries during Operations for the Long-Term Storage of Depleted UF_6 in Yards

Pollutant	Averaging Time	Pollutant Concentration ($\mu g/m^3$)		Maximum of Construction and Operations as Percent of Standard
		Construction	Operations	
CO	1 hour	8.2 –36	3.1 – 6.2	0.1
	8 hours	1.4 – 5.1	1.0 – 1.2	0.06
NO_x	Annual	0.14 – 1.4	0.014 – 0.026	1.4
PM_{10}	24 hours	7.5 – 31	0.012 – 0.013	21
	Annual	0.42 – 4.1	0.0014 – 0.0026	8

of construction and operations would be below the relevant standards, although closer examination of the likely PM_{10} impacts might be required if this option were to be implemented.

In the maintenance phase of UF_6 storage in yards, the impacts would be similar to those of operations without construction. The maintenance impacts for CO, NO_x, and PM_{10} would be 0.71, 0.76, and 0.77, respectively, of those listed for operations in Table G.15.

Only small quantities of HF would be released from the process stack, averaging 0.06 kg/yr during the operations phase and 0.012 kg/yr during the maintenance phase. The estimated maximum average annual HF concentration is about 3×10^{-6} $\mu g/m^3$.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue that would be affected by emissions data for the entire area around a proposed long-term storage site. The pollutants most related to ozone formation that would result from the long-term storage of depleted UF_6 are HC and NO_x. In later Phase II studies, when specific technologies and sites would be selected, the potential effects on ozone of these pollutants at a proposed site could be put in perspective by comparing them with the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region.

G.3.4 Water and Soil

The methodology used to determine water and soil impacts is presented in Appendix C and Tomasko (1997).

G.3.4.1 Surface Water

To evaluate construction impacts, it was conservatively assumed that construction would be completed in 1 year. Essentially negligible impacts to surface water would be expected for all long-term storage options.

G.3.4.1.1 Buildings

The total land requirements for aboveground storage in buildings would be greatest for storing depleted uranium as U_3O_8 (148 acres [60 ha]) (Table G.16). Of this area, about 70 acres (29 ha) would be disturbed, and 6 acres (2.4 ha) would be paved. This alteration of soil would impact surface waters by increasing the amount of runoff. On a sitewide scale, however, this amount of increased impermeable land would have a negligible impact on nearby rivers (0.1 to 0.4% of the and representative site areas available for runoff). In addition, there would be no measurable impacts to the existing floodplains.

TABLE G.16 Summary of Environmental Parameters for Long-Term Storage in Buildings

Option	Unit	Requirements		
		Storage as UF_6	Storage as U_3O_8	Storage as UO_2
Total land area	acres	131	148	79
Total disturbed land	acres	62	72	35
Total paved area	acres	5	6	4
Construction water	million gal/yr	0.5	0.6	0.3
Excavation	yd^3	157,000	183,000	81,000
Water	million gal/yr			
Phase I		1.2	1.4	1.1
Phase II		1.0	1.0	0.9
Wastewater	million gal/yr			
Construction		0.05	0.06	0.03
Phase I		1.1	1.2	1.1
Phase II		0.9	0.9	0.8

Water would be needed for constructing the storage buildings. As indicated in Table G.16, the total quantity of water ranges from about 0.3 million gal/yr (0.6 gpm) for the UO_2 storage option to about 0.6 million gal/yr (1.1 gpm) for storing depleted uranium as U_3O_8. If this water were obtained from a nearby river, the impact would be negligible (less than 0.00005% of the average flow).

During construction, wastewater would be discharged to nearby surface waters. About 0.05 million gal/yr (0.1 gpm) of water would be discharged for the U_3O_8 option (see Table G.16). The primary contaminants of concern would be construction chemicals, organics, and some suspended solids. By following good engineering practices (e.g., stockpiling materials away from surface water drainages, covering construction piles with tarps, and cleaning small chemical spills as soon as they occurred), concentrations in the wastewater would be expected to be very small and well within any regulatory standards. In addition, once in the nearby surface water, dilution would occur in excess of 20 million:1 for average flows. Because the levels of contamination from construction would be very low, impacts to sediment would also be negligible.

During Phase I, annual water use would range from 1.1 to 1.4 million gal/yr for the three storage forms (UF_6, UO_2, and U_3O_8) (Table G.16). For a constant rate of use, the maximum withdrawal from nearby surface water would be about 55 gpm. This amount of withdrawal

corresponds to less than 0.0001% of the average river flows. The impact of this increase in withdrawal on the flow system (particularly floodplains) would be negligible.

Impacts to surface water quality could also occur during Phase I and II. These impacts would result from releasing water containing chemicals or radionuclides. The maximum wastewater release of 1.2 million gal/yr (2.3 gpm) would occur during Phase I (Table G.16). This wastewater would contain low concentrations of pollutants that would be within National Pollutant Discharge Elimination System (NPDES) guidelines. Additional large dilution would occur in the receiving water.

Impacts to surface waters during Phase II would be even less than the impacts produced by Phase I operations because of smaller volumes of raw water used and wastewater released (Table G.16). Impacts to surface water would, therefore, be negligible.

None of the accident scenarios presented in LLNL (1997) would produce impacts to surface water. Accidents occurring within the concrete-bottomed buildings would be contained and isolated from surface water, and accidents in which the building fails would primarily produce potential impacts via the air pathway.

G.3.4.1.2 Vaults

The total land requirements for vault storage would be roughly similar to the requirements for building storage (Table G.17). The amount of increased impermeable land would have a negligible impact on nearby rivers. In addition, there would be no measurable impacts to floodplains.

The quantity of water needed for construction would be similar to that for constructing buildings (Table G.17). If this water were obtained from a nearby river, the impact would be negligible for any of the storage forms (less than 0.00001% of the average flows). During construction, wastewater volumes similar to the building option would be discharged to surface waters (U_3O_8 option; see Table G.17), and the impacts to surface waters would also be negligible.

During Phase I and Phase II operations, annual water use would be about two times greater than for the building option (Table G.17). The impact of this withdrawal on the flow system (particularly floodplains) would be negligible, as would the impacts to surface water.

None of the accident scenarios presented in LLNL (1997) would produce impacts to surface water. If an accident occurred within the vault it would be contained and isolated from surface water.

TABLE G.17 Summary of Environmental Parameters for Long-Term Storage in Vaults

Option	Unit	Physical Needs: Storage as U_3O_8	Physical Needs: Storage as UO_2
Total land area	acres	212	114
Total disturbed area	acres	86	40
Total paved area	acres	21	10
Excavation	million yd^3	1.7	0.75
Water			
Phase I	million gal/yr	1.1	1.2
Phase II	million gal/yr	0.8	0.9
Wastewater			
Construction	million gal/yr	0.8	0.4
Phase I	million gal/yr	1.1	1.0
Phase II	million gal/yr	0.9	0.8
Construction water	million gal/yr	0.8	0.4

G.3.4.1.3 Mine

Requirements for long-term storage in a mine are listed in Table G.18. These parameters are all similar to those for vault storage, and all potential impacts would be similar.

G.3.4.1.4 Yards

For long-term storage of depleted uranium as UF_6 in yards, 144 acres (58 ha) of land would be disturbed and 13 acres (5.3 ha) would be paved. This alteration of soil would impact local surface waters by increasing the amount of runoff. The amount of increased runoff, however, would be negligible on a sitewide scale because the land area affected would range from 0.25 to 1.5% of the representative site land areas available. In addition there would be no measurable impacts to the existing floodplains.

Water would be needed for constructing the long-term storage yards. Approximately 6.4 million gal/yr of water would be required. This amount of withdrawal would represent less than 0.000033% of average flows. The impact of this increase in withdrawal on the flow system (particularly floodplains) would be negligible.

TABLE G.18 Summary of Environmental Parameters for Long-Term Storage in a Mine

Option	Unit	Physical Needs		
		Storage as UF_6	Storage as U_3O_8	Storage as UO_2
Total land area	acres	96	124	74
Total disturbed area	acres	32	54	25
Total paved area	acres	3	3	3
Excavation	million yd^3	1.8	2.2	1.2
Water				
Phase I	million gal/yr	1.2	1.3	1.2
Phase II	million gal/yr	0.9	1.0	0.9
Wastewater				
Construction	million gal/yr	0.1	0.1	0.07
Phase I	million gal/yr	1.1	1.3	1.1
Phase II	million gal/yr	0.9	0.9	0.8
Underground area	acres	114	138	77
Construction water	million gal/yr	1.1	1.3	0.7

During construction of the storage yard, surface water quality could be impacted. The primary contaminants of concern would be chemicals used in construction, organic compounds, and some suspended solids. By following good engineering practices, concentrations in the wastewater would be expected to be very small and less than applicable U.S. Environmental Protection Agency (EPA) guidelines. Once the construction water mixed with surface water, dilution would occur. Depending on the volumetric release of water during construction, dilution would be about 1 million:1.

During normal operations, there would be no emissions that would impact surface water because all cylinders are assumed to be new at the start of the storage option, they would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, no impacts to surface water would result from accidents because no accidents are identified in LLNL (1997) that would produce emissions that would interact directly or indirectly with surface water.

G.3.4.2 Groundwater

The only groundwater impacts for long-term storage in buildings, vaults, or mines would occur during construction. Phase I and Phase II operations would produce no impacts because groundwater would not be used as a source for operations and there would be no direct discharges of wastewater to the aquifers. For vault construction, drains would be provided on the upgradient side of the facility to prevent groundwater from entering the facility and mobilizing any spilled contaminants. Accident sequences described in LLNL (1997) would also have no impacts on groundwater because the building, vault, or mine would isolate contaminants and eliminate any direct pathways to the underlying aquifers.

At any site, groundwater quality could be impacted by construction. For example, chemicals stored on the ground could be mobilized by precipitation and infiltrate to the underlying aquifers. By adopting good engineering and construction practices (e.g., covering material to prevent interaction with rain, promptly cleaning any chemical spills, and providing retention basins to catch and hold contaminated runoff), groundwater concentrations would be kept below EPA (1996) guidelines. Overall, impacts from construction would, therefore, be negligible. Phase I and Phase II operations would have no impacts because groundwater would not be used as a source for operations and there would be no direct discharges of wastewater to the aquifers.

The only groundwater impacts for long-term storage in yards would occur during construction. These impacts would primarily be to groundwater quality; impacts to the depth of groundwater, recharge, and flow direction would not be measurable on a sitewide scale because of the limited size of the facility. Impacts could, however, affect quality. For example, chemicals stored on the ground could be mobilized by precipitation and infiltrate to the underlying aquifers. By adopting good engineering and construction practices, impacts to quality would be minimized, and groundwater concentrations would be kept below EPA (1996) guidelines.

As with surface water, there would be no emissions that would impact groundwater during normal operations because all cylinders were assumed to be in good condition at the start of the storage option, they would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, no accident scenarios identified in LLNL (1997) would lead to direct or indirect groundwater contamination.

G.3.4.3 Soil

G.3.4.3.1 Buildings

The only impacts to soil from long-term storage in buildings would occur during construction. The maximum impact would occur for construction of the U_3O_8 building (Table G.16). Up to 148 acres (60 ha) of land (4.4 to 29% of the representative site land areas available) would be

disturbed, and 183,000 yd^3 (140,000 m^3) of soil would be excavated. These impacts would include modifications in the local topography, increased permeability and erosion potential in areas where the land surface is plowed, decreased permeability and erosion potential in areas where the soil is compacted by heavy equipment, and decreased soil quality in areas exposed to chemical alteration. On a sitewide scale, the impacts would be moderate; however, the impacts would be temporary. That is, with time the disturbed soil conditions would return to previous conditions everywhere except in paved lots. As discussed in Section G.3.4.1.1, this area would be about 6 acres (2.4 ha) (0.2 to 0.4% of the total land area available). On a sitewide scale, this impact would be negligible.

By following good engineering practices (e.g., disturbing as little soil as possible, contouring and reseeding disturbed land, scheduling activities to minimize land disturbance, controlling runoff, using tarps to prevent chemical/rainfall interaction, and cleaning any spills as soon as they occur), impacts to soils would be minimized.

G.3.4.3.2 Vaults

The only impacts to soil from long-term storage in vaults would occur during construction. The largest impact to soils would occur for construction of the U_3O_8 vault (Table G.16). Up to 212 acres (86 ha) of land (6 to 13% of the land area available) would be disturbed, and up to 1.7 million yd^3 (1.3 million m^3) of soil would be excavated. These impacts would include modifications in the local topography. If the excavated soil were spread evenly over the 212-acre (86-ha) facility, a mound 5 ft (1.5 m) deep would be created. This impact could be mitigated by trucking the soil off-site. Other impacts would include increased permeability and erosion potential in areas where the land surface is plowed or mounded, decreased permeability and erosion potential in areas where the soil is compacted by heavy equipment, and decreased soil quality in areas exposed to chemical alteration. On a sitewide scale, the impacts would be moderate; however, the impacts would, to a large extent, be temporary and readily mitigated. With time the disturbed soil conditions would be returned to existing conditions everywhere except in paved lots. As discussed in Section G.3.4.1.2, this area would be a maximum of 21 acres (8.5 ha) (0.6 to 1.2% of the total land area available). On a sitewide scale, this impact would be minor. By following good engineering practices, impacts to soils would be kept to a minimum.

G.3.4.3.3 Mine

The only impacts to soils from long-term storage in a mine would occur during construction. The maximum impact to soils would occur for construction of the U_3O_8 mine facility (Table G.16). Up to 124 acres (50 ha) of land (3.3 to 7.3% of the representative site land areas available) would be disturbed, and up to 2.4 million yd^3 (1.8 million m^3) of soil and rock would be excavated. These impacts would include modifications in topography (e.g., if the excavated material were spread evenly over the 124-acre (50-ha) facility, a mound 12 ft (3.7 m) high would be created; however, this impact could be mitigated by trucking the material off-site), increased permeability

and erosion potential in areas where the land surface is plowed or mounded, decreased permeability and erosion potential in areas where the soil is compacted by heavy equipment, and decreased soil quality in areas exposed to chemical alteration. Impacts would be moderate; however, the impacts would, to a large extent, be temporary and readily mitigated. That is, with time, the disturbed soil would be returned to previous conditions everywhere except in paved lots. This area would be about 3 acres (1.2 ha) (0.1 to 0.4% of the total land area available) and would result in a minor impact to soils. By following good engineering practices, impacts to soils would be kept to a minimum.

G.3.4.3.4 Yards

About 144 acres (58 ha) of land would be disturbed by construction of the long-term storage yard facility (3.8 to 8.5% of the land area available. Of this area, 13 acres (5.3 ha) would be paved (0.4 to 0.8% of the land area available). In addition, about 250,000 yd^3 (192,000 m^3) of soil would be excavated. Impacts from construction would include modifications in topography, increased permeability and erosion potential in areas where the soil would be broken, decreased permeability and erosion potential in areas where the soil would be compacted by heavy equipment or paving, and decreased soil quality in areas subjected to chemical loading. On a sitewide basis, the impacts would be moderate, but they would be mostly temporary. That is, with time, soil conditions would return to previous conditions everywhere except beneath paved lots, the 20 UF_6 storage pads, and associated buildings. By following good engineering practices, impacts to soils would be kept to a minimum.

There would be no emissions that would impact soils during normal operations because all cylinders would be inspected once every 4 years, and they would be replaced if any handling damage occurred. In addition, there are no identified accident scenarios that would lead to direct or indirect contamination.

G.3.5 Socioeconomics

Calculations for the analysis of socioeconomic impacts were based on detailed cost data developed for trial storage facilities, including the impacts of facility construction, operation and maintenance, emplacement and closure, and surveillance and monitoring activities. Impacts for each facility are presented for the peak year of construction and the first year of operations.

The potential socioeconomic impacts of long-term storage in yards, buildings, and vaults were estimated using the three representative sites. Because the sites that would be chosen for long-term storage in mines are not known, the analysis estimated the impacts of these facilities for a generic site. The impacts of long-term storage at the representative sites on regional economic activity was estimated for a region of influence (ROI): these impacts are presented in detail in Section G.3.5.1. The impacts of long-term storage at a generic site are presented in Section G.3.5.2. The methodology for assessing socioeconomic impacts is discussed in Appendix C.

Long-term storage would probably have a small impact on socioeconomic conditions in the ROIs surrounding the three sites described in Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8. This is partly because a major proportion of expenditures associated with procurement for the construction and operation of each technology option would flow outside of the ROI to other locations in the United States, reducing the concentration of local economic effects of the long-term storage yard.

Slight changes in employment and income would occur in each ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required to construct and operate a long-term storage facility, and other local investment associated with construction and operation. In addition to creating new (direct) jobs at each site, the facility would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at each site. Jobs and income created directly by a long-term storage facility, together with indirect activity in the ROI, would contribute slightly to reduction in unemployment in the ROI surrounding each site. Minimal impacts are expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of constructing and operating long-term storage facilities were assessed with regard to regional economic activity (measured in terms of employment and personal income) and population, housing, and local public revenues and expenditures. The results are presented as ranges to include impacts that would occur for a storage facility at each of the representative sites. Impacts for the three sites are presented for the peak year of construction and during the first year of operations. Table G.19 presents the potential range of impacts for long-term storage at the three representative sites.

G.3.5.1 Long-Term Storage as UF_6

During the peak year of construction of a UF_6 long-term storage yard or building, 100 to 200 direct jobs would be created at the site, and 80 to 310 additional jobs would be indirectly created in the ROI surrounding a representative site (Table G.19) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 180 and 510 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of $7 million to $15 million produced during the peak year. In the first year of operations of the facility, between 80 and 100 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI surrounding each site, with total income of $4 million in the first year. Construction and operation of a UF_6 storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the representative site ROI of 0.001 to 0.006 percentage points from 2006 through 2039.

Construction of a UF_6 storage facility would be expected to generate direct in-migration of 130 to 280 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROIs, bringing the total number of in-migrants to between 170 and 430 in the

TABLE G.19 Potential Socioeconomic Impacts of the Long-Term Storage Options for Yards, Buildings, and Vaults

Parameter	Long-Term Storage as UF_6		Long-Term Storage as UO_2		Long-Term Storage as U_3O_8	
	Construction[a]	Operations[b]	Construction[a]	Operations[b]	Construction[a]	Operations[b]
Economic activity in the ROI						
Direct jobs	100 – 200	50	120 – 140	70	170 – 210	60
Indirect jobs	80 – 310	30 – 50	100 – 190	30 – 60	140 – 280	40 – 70
Total jobs	180 – 510	80 – 100	220 –330	100 – 130	310 – 490	100 – 130
Income ($ million)						
Direct income	5 – 9	3	5 – 6	3	8 – 9	3 – 4
Total income	7 – 15	4	7 – 10	4	11 – 15	5 – 8
Population in-migration into the ROI	170 – 430	50 – 70	210 – 280	70 – 100	300 – 420	80 – 100
Housing demand						
Number of units in the ROI	60 – 160	20 – 30	80 – 100	30 – 40	110 – 150	30 – 40
Public finances						
Change in ROI fiscal balance (%)	<0.1 – 0.3	<0.01	0.1 – 0.2	<0.1 – 0.1	0.1 – 0.3	<0.1 – 0.1

[a] Impacts are for peak year of construction, either 2007 or 2008. Socioeconomic impacts from construction were assessed for 2007 through 2028.

[b] Impacts are the annual averages for the emplacement period (2009–2028). Annual averages for the surveillance and maintenance period (2029–2039) were estimated to be equal to or less than these values.

peak year (Table G.19). Operation of the facility would be expected to generate direct job in-migration of 40 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to between 50 and 70 in the first year of operations. Construction and operation of a UF_6 storage facility would result in an increase in the projected baseline compound annual average growth rate in representative site ROI populations of 0.001 to 0.01 percentage points from 2006 through 2039.

A UF_6 storage facility would generate a demand for 60 to 160 additional rental housing units during the peak year of construction (Table G.19), representing an impact of 3.5 to 8% on the projected number of vacant rental housing units at the representative sites. A demand for 20 to 30 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.2 to 0.5% on the number of vacant owner-occupied housing units at each site.

During the peak year of construction, between 170 and 430 persons would in-migrate into the ROI at each site, leading to an increase of less than 0.1 to 0.3% over ROI-forecasted baseline revenues and expenditures at the representative sites (Table G.19). In the first year of operations, 50 to 60 in-migrants would be expected, leading to an increase of less than 0.01% in local revenues and expenditures at the three sites.

G.3.5.2 Long-Term Storage as UO_2

During the peak year of construction of a UO_2 long-term storage building or vault, 120 to 140 direct jobs would be created at the site and 100 to 190 additional jobs indirectly in the ROI surrounding each site (Table G.19) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 220 and 330 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of $7 million to $10 million produced during the peak year. In the first year of operations of the facility, between 100 and 130 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI surrounding the site, with total income of $4 million in the first year. Construction and operation of a UO_2 storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the ROI of 0.01 to 0.02 percentage points from 2006 to 2039.

Construction of a UO_2 storage facility would be expected to generate direct in-migration of 160 to 190 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROIs, bringing the total number of in-migrants to between 210 and 280 in the peak year (Table G.19). Operation of the facility would be expected to generate direct job in-migration of between 11 and 70 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to between 70 and 100 in the first year of operations. Construction and operation of a UO_2 storage facility would result in an increase

in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 2006 to 2039.

A UO_2 storage facility would generate a demand for 80 to 100 additional rental housing units during the peak year of construction, representing an impact of 1.4 to 6.5% on the projected number of vacant rental housing units at the representative sites (Table G.19). A demand for 30 to 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.2 to 0.7% on the number of vacant owner-occupied housing units at each site.

During the peak year of construction, between 210 and 280 persons would in-migrate into the ROI for the site, leading to an increase of 0.1 to 0.2% over ROI-forecasted baseline revenues and expenditures at the representative sites (Table G.19). In the first year of operations, 70 to 100 in-migrants would be expected, leading to an increase of less than 0.1 to 0.1% in local revenues and expenditures at the sites.

G.3.5.3 Long-Term Storage as U_3O_8

During the peak year of construction of a U_3O_8 long-term storage building or vault, 170 to 210 direct jobs would be created at the site and 140 to 280 additional jobs indirectly in the ROI surrounding the site (Table G.19) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, between 310 and 490 jobs would be created. Construction activity would also produce direct and indirect income in the ROI, with total income of $11 million to $15 million produced during the peak year. In the first year of operations of the facility, between 100 and 130 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI surrounding the site, with total income of $5 million to $8 million in the first year. Construction and operation of a U_3O_8 storage facility would result in an increase in the projected baseline compound annual average growth rate in employment in the ROI of 0.001 to 0.003 percentage points from 2006 through 2039.

Construction of a U_3O_8 storage facility would be expected to generate direct in-migration of 230 to 290 in the peak year of construction. Additional indirect job in-migration would be expected into the site ROIs, bringing the total number of in-migrants to between 300 and 420 in the peak year (Table G.19). Operation of the facility would be expected to generate direct job in-migration of 60 to 70 in the first year. Additional indirect job in-migration into the ROI would also be expected, bringing the total number of in-migrants to between 80 and 100 in the first year of operations. Construction and operation of a U_3O_8 storage facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.001 to 0.005 percentage points from 2006 through 2039.

A U_3O_8 storage facility would generate a demand for 110 to 150 additional rental housing units during the peak year of construction, corresponding to an impact of 1.3 to 8.2% on the

projected number of vacant rental housing units at the representative sites (Table G.19). A demand for 30 to 40 additional owner-occupied housing units would be expected in the first year of operations, corresponding to an impact of 0.3 to 0.8% on the number of vacant owner-occupied housing units at the site.

During the peak year of construction, between 300 and 420 persons would in-migrate into the ROI at each site, leading to an increase of 0.1 to 0.3% over ROI-forecasted baseline revenues and expenditures at the representative sites (Table G.19). In the first year of operations, 80 to 100 in-migrants would be expected, leading to an increase of between less than 0.1 to 0.1% in local revenues and expenditures at the sites.

G.3.5.4 Long-Term Storage in a Mine

Construction-related impacts (engineering, construction, project management, and site preparation and restoration activities) and operations-related impacts (operation, emplacement and closure, and surveillance and maintenance activities) are shown in Table G.20 for storage in a mine. The location of a long-term storage mine has not yet been determined. The socioeconomic impacts of long-term storage in a mine were analyzed on a non-site-specific basis for a generic site. Impacts at the generic site are presented in terms of the impact of each storage option on direct (on-site) employment and income of construction and operation activities. Estimation of the indirect impacts that would occur off-site in the ROI around each facility would require site-specific information on

TABLE G.20 Potential Socioeconomic Impacts of Long-Term Storage in a Mine

Option/Parameter	Construction[a]	Operations[b]
Storage as UF_6		
Direct jobs	500	60
Direct income ($ million 1996)	29	3
Storage as U_3O_8		
Direct jobs	410	60
Direct income ($ million 1996)	19	3
Storage as UO_2		
Direct jobs	340	60
Direct income ($ million 1996)	20	4

[a] Impacts are for peak year of construction, 2007. Socioeconomic impacts from construction were assessed for 2007 through 2028.

[b] Impacts are the annual averages for the emplacement period (2009–2028). Annual averages for the surveillance and maintenance period (2029–2039) were estimated to be equal to or less than these values.

a variety of regional economic, demographic, housing, and jurisdictional characteristics and were therefore not included in the analysis. In addition, estimates of the relative impacts of direct employment and income at each facility compared with the local economic baseline are not provided (see Allison and Folga 1997).

G.3.6 Ecology

Moderate to large adverse impacts to ecological resources could result from construction of a facility for long-term storage as UF_6, U_3O_8, or UO_2. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a storage facility would be negligible.

G.3.6.1 Storage as UF_6

Site preparation for the construction of a facility to store UF_6 in buildings would require the disturbance of approximately 131 acres (53 ha), including the permanent replacement of about 62 acres (25 ha) of current land cover with structures and paved areas. Existing vegetation would be destroyed during land-clearing activities. The vegetation communities that would be eliminated by site preparation would depend on the location of the facility. Communities occurring on undeveloped land at the representative sites are relatively common and well represented in the vicinity of the sites; however, impacts to high-quality native plant communities might occur if facility construction required disturbance to vegetation communities outside of the currently fenced areas (see Section G.3.9 for a discussion of land use). Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 131 acres (53 ha) of undeveloped land would constitute a large adverse impact to vegetation. Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table G.21.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to quickly recolonize replanted areas near the storage facility following completion of construction. The permanent loss of 62 acres (25 ha) to 131 acres (53 ha) of habitat would not be expected to threaten the local population of any wildlife species since similar habitat would be available in the vicinity of the representative sites. However, habitat use in the vicinity of the facility may be reduced for some species due to the construction of a perimeter fence enclosing

TABLE G.21 Impacts to Ecological Resources from Construction of Long-Term Storage Facilities for Depleted Uranium

Option/Resource	Buildings	Vaults	Mine	Yards
Storage as UF_6				
Vegetation	Loss of 131 acres Large adverse impact	Not applicable[a]	Loss of 96 acres Moderate to large adverse impact	Loss of 144 acres Large adverse impact
Wildlife	Loss of 62 to 131 acres Moderate to large adverse impact	Not applicable	Loss of 32 to 96 acres Moderate adverse impact	Loss of 77 to 144 acres Large adverse impact
Aquatic species	Negligible impact	Not applicable	Negligible impact	Negligible impact
Wetlands	Potential adverse impact	Not applicable	Potential adverse impact	Potential adverse impact
Protected species	Potential adverse impact	Not applicable	Potential adverse impact	Potential adverse impact
Storage as U_3O_8				
Vegetation	Loss of 148 acres Large adverse impact	Loss of 212 acres Large adverse impact	Loss of 124 acres Large adverse impact	Not applicable[a]
Wildlife	Loss of 72 to 148 acres Large adverse impact	Loss of 86 to 212 acres Large adverse impact	Loss of 54 to 124 acres Large adverse impact	Not applicable
Aquatic species	Negligible impact	Negligible impact	Negligible impact	Not applicable
Wetlands	Potential adverse impact	Potential adverse impact	Potential adverse impact	Not applicable
Protected species	Potential adverse impact	Potential adverse impact	Potential adverse impact	Not applicable
Storage as UO_2				
Vegetation	Loss of 79 acres Moderate adverse impact	Loss of 114 acres Large adverse impact	Loss of 74 acres Moderate adverse impact	Not applicable[a]
Wildlife	Loss of 35 to 79 acres Moderate adverse impact	Loss of 40 to 114 acres Large adverse impact	Loss of 25 to 74 acres Moderate adverse impact	Not applicable
Aquatic species	Negligible impact	Negligible impact	Negligible impact	Not applicable
Wetlands	Potential adverse impact	Potential adverse impact	Potential adverse impact	Not applicable
Protected species	Potential adverse impact	Potential adverse impact	Potential adverse impact	Not applicable

[a] Long-term storage as UF_6 in vaults and long-term storage as U_3O_8 or UO_2 in yards were not considered.

a 131-acre (53-ha) area. Overall, construction of a facility for UF_6 storage would be considered a moderate to large adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section G.3.4). Thus, construction derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be filled or drained during construction. In addition, impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the storage facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Water Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any state or federally listed threatened or endangered species at any of the representative sites. Prior to construction of a storage facility, a survey for state and federally listed threatened, endangered, or candidate species, or species of special concern would be conducted so that, if possible, impacts to these species could be avoided. Where impacts were unavoidable, appropriate mitigation could be developed.

Small releases of HF would be expected to occur during operation of the building storage facility. The air concentration of HF from facility operations would be 0.00031 to 0.00081 $\mu g/m^3$, well below levels injurious to wildlife. Resulting impacts to wildlife would be negligible.

Impacts due to construction of a facility to store UF_6 in a mine would be similar to impacts from storage in buildings, although a smaller area would be affected. Facility construction would require the disturbance of approximately 96 acres (39 ha), including the permanent replacement of approximately 32 acres (13 ha) of current land cover with structures and paved areas (including rock spoil). A larger proportion of the mine storage facility would be available for wildlife habitat in comparison with the building storage facility. Species diversity and abundance, however, would be expected to be low because of human presence, proximity of buildings, and the relatively poor habitat quality of landscaped areas. Construction of a facility to store UF_6 in a mine would constitute a moderate to large adverse impact to vegetation and a moderate adverse impact to wildlife. Impacts due to facility construction are shown in Table G.21. Releases of contaminants are not expected to occur during operation of the mine storage facility, therefore, impacts to wildlife due to facility operation would be negligible.

Impacts due to construction of a facility to store UF_6 in yards would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 144 acres (58 ha), including the permanent replacement of approximately 90 acres (37 ha) with buildings and paved areas. Compared with the building storage facility, a smaller proportion of the yard storage facility would be available for wildlife habitat. Construction of a facility to store UF_6 in yards would constitute a large adverse impact to vegetation and wildlife. Potential impacts associated with facility construction are shown in Table G.21.

Small releases of HF, UO_2F_2, and U_3O_8 would be expected to occur during operation of the yard storage facility due to transfers of UF_6 from defective cylinders. The maximum annual average air concentration at a storage site boundary from operation of a yard storage facility would be approximately 2.7×10^{-6} μg/m^3 for HF, 5.3×10^{-7} μg/m^3 for UO_2F_2, and 1.8×10^{-9} μg/m^3 for U_3O_8. Impacts to wildlife from these emissions are expected to be negligible.

Storage facility accidents, as discussed in Section G.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on such factors as location of the accident, season, and meteorological conditions.

G.3.6.2 Storage as U_3O_8

The construction of a facility to store U_3O_8 in buildings would generally result in the types of impacts associated with UF_6 building storage. Site preparation for the construction of a facility to store U_3O_8 in buildings would require the disturbance of approximately 148 acres (60 ha), including the permanent replacement of approximately 72 acres (29 ha) of current land cover with structures and paved areas. Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 148 acres (60 ha) of undeveloped land would constitute a large adverse impact to vegetation. Releases of contaminants are not expected to occur during operation of the storage facility, therefore, impacts to biotic resources due to facility operation would be negligible. Impacts due to facility construction are shown in Table G.21.

The permanent loss of 72 to 148 acres (29 to 60 ha) of habitat would not be expected to threaten the local population of any wildlife species since similar habitat would be available in the vicinity of the representative sites. However, habitat use in the vicinity of the facility might be reduced for some species due to the construction of a perimeter fence enclosing a 148-acre (60-ha) area. Therefore, construction of a facility for U_3O_8 storage in buildings would be considered a large adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section G.3.4). Thus, construction derived impacts to aquatic biota would also be expected to be negligible.

Impacts due to construction of a facility to store U_3O_8 in vaults would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 212 acres (86 ha), including the permanent replacement of approximately 86 acres (35 ha) with structures and paved areas. A larger proportion of the vault storage facility would be available for wildlife habitat in comparison with the building storage facility. Species diversity and abundance, however, would be expected to be low because of human presence, proximity of buildings, and the relatively poor habitat quality of landscaped areas. Construction of a facility to store U_3O_8 in vaults would constitute a large adverse impact to vegetation and wildlife. The larger size of the facility also would increase the potential for

unavoidable direct and indirect impacts to wetlands due to facility location. Impacts due to facility construction are shown in Table G.21. Releases of contaminants are not expected to occur during operation of the vault storage facility, therefore, impacts to biotic resources due to facility operation would be negligible.

Impacts due to construction of a facility to store U_3O_8 in a mine would be similar to impacts from storage in buildings or vaults, although a smaller area would be affected. Facility construction would require the disturbance of approximately 124 acres (50 ha), including the permanent replacement of approximately 54 acres (22 ha) of current land cover with structures and paved areas (including rock spoil). A larger proportion of the mine storage facility would be available for wildlife habitat in comparison with the building storage facility. Species diversity and abundance, however, would be expected to be low because of human presence, proximity of buildings, and the relatively poor habitat quality of landscaped areas. Construction of a facility to store U_3O_8 in a mine would constitute a large adverse impact to vegetation and wildlife. Impacts due to facility construction are shown in Table G.21. Releases of contaminants are not expected to occur during operation of the mine storage facility, therefore, impacts to biotic resources due to facility operation would be negligible.

G.3.6.3 Storage as UO_2

The construction of a facility to store UO_2 in buildings would generally result in the types of impacts associated with UF_6 building storage. Site preparation for the construction of a facility to store UO_2 in buildings would require the disturbance of approximately 79 acres (32 ha), including the permanent replacement of approximately 35 acres (14 ha) with structures, including paved areas. Construction of the storage facility would not be expected to threaten the local population of any species. The loss of up to 79 acres (32 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Impacts due to facility construction are shown in Table G.21.

The permanent loss of 35 to 79 acres (14 to 32 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the representative sites. However, habitat use in the vicinity of the facility might be reduced for some species due to the construction of a perimeter fence enclosing a 79-acre (32-ha) area. Therefore, construction of a facility for UO_2 storage would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section G.3.4). Thus, construction derived impacts to aquatic biota would also be expected to be negligible.

Impacts due to construction of a facility to store UO_2 in vaults would be similar to impacts from storage in buildings, although a larger area would be affected. Facility construction would require the disturbance of approximately 114 acres (46 ha), including the permanent replacement of

approximately 40 acres (16 ha) of current land cover with structures and paved areas. A larger proportion of the vault storage facility would be available for wildlife habitat in comparison with the building storage facility. However, species diversity and population densities would be expected to be low because of human presence, proximity of buildings, and the relatively low habitat quality of landscaped areas. Construction of a facility to store UO_2 in vaults would constitute a large adverse impact to vegetation and wildlife. The larger size of the facility would also increase the potential for unavoidable proximity to wetlands and consequent direct and indirect impacts. Impacts due to facility construction are shown in Table G.21. Releases of contaminants are not expected to occur during operation of the vault storage facility, therefore, impacts to biotic resources due to facility operation would be negligible.

Impacts due to construction of a facility to store UO_2 in a mine would be similar to impacts from storage in buildings or vaults, although a smaller area would be affected. Facility construction would require the disturbance of approximately 74 acres (30 ha), including the permanent replacement of approximately 25 acres (10 ha) of current land cover with structures and paved areas (including rock spoil). A larger proportion of the mine storage facility would be available for wildlife habitat in comparison with the building storage facility. Species diversity and abundance, however, would be expected to be low because of human presence, proximity of buildings, and the relatively poor habitat quality of landscaped areas. Construction of a facility to store UO_2 in a mine would constitute a moderate adverse impact to vegetation and wildlife. Impacts due to facility construction are shown in Table G.21. Releases of contaminants are not expected to occur during operation of the mine storage facility, therefore, impacts to biotic resources due to facility operation would be negligible.

G.3.7 Waste Management

Impacts on waste management from wastes generated during the long-term storage of depleted UF_6 would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or on a regional or national scale.

G.3.7.1 Storage of UF_6 in Yards, Buildings, and Mines

G.3.7.1.1 Yards

Construction of the storage pads and associated support facilities would generate nonhazardous solid waste and sanitary wastewater. Construction would generate about 3,500 yd^3 (2,700 m^3) of concrete and other solid wastes. Because solid waste disposal facilities can generally be expanded as required, the impact of the construction wastes would be minimal at any site.

The operations to maintain and store depleted UF_6 cylinders would consist of inspections, stripping and repainting of the external coating of cylinders, and disposal of scrap metal from old steel cylinders. These operations would generate three primary radioactive waste streams: uranium-contaminated scrap metal (low-level radioactive waste [LLW]) from replaced cylinders, UO_2F_2 from replaced cylinders (LLW), and solid process residue (low-level mixed waste [LLMW]) from cylinder painting. In addition, long-term yard storage operations would generate nonhazardous solid CaF_2 waste and sanitary wastewater. The amount of waste generated would depend upon the time when the activities occurred. For each waste type, the amount of waste generated annually would be larger during Phase I of the operations (see Table G.22). The waste totals from Phase I were generally used for comparison with the site waste loads.

The 109 yd^3/yr (83 m^3/yr) of scrap metal LLW and the 0.17 yd^3/yr (0.13 m^3/yr) of uranyl fluoride generated during Phase I would add from 1 to 3.8% to representative site LLW generation (Table G.22). The maximum amount of LLW generated annually during the continued storage of depleted UF_6 at all three sites would represent less than 1% of the projected annual DOE LLW generation. The 46 yd^3/yr (35 m^3/yr) of LLMW generated during long-term yard storage of depleted UF_6 would add from less than 1 to 35% to the LLMW loads at the representative sites, but UF_6 would be less than 1% of the total nationwide LLMW load.

TABLE G.22 Estimated Annual Waste Loads from Long-Term Storage of UF_6 in Yards

	Waste Load of Depleted UF_6		
	Annual Load (m^3/yr)		Total Load (m^3)
Waste Type	2009-2028	2029-2039	2009-2039
Low-level waste			
Scrap metal	83	44	2,144
UO_2F_2	0.13	0.07	3.37
Low-level mixed waste (inorganic process residue)	8.8	35	561
Nonhazardous waste (CaF_2)	0.08	0.05	2.15
Sanitary wastewater	6,500	6,700	204,000

[a] NA = not applicable; NR = not reported.

Source: DOE (1997).

The 0.11 yd^3/yr (0.08 m^3/yr) of solid nonhazardous waste generated during Phase I would represent less than 1% of the annual waste loads at the representative sites. The 8,700 yd^3/yr (6,700 m^3/yr) of sanitary wastewater would represent less than 1.5% of the annual wastewater load of the sites.

Overall, the waste input resulting from the long-term yard storage of depleted UF_6 would have negligible impact on radioactive waste management capabilities at the representative sites. The impact on nonradioactive site waste management would also be negligible. The impacts of waste resulting from the long-term yard storage of depleted UF_6 on national waste management capabilities would be negligible.

G.3.7.1.2 Buildings and Mines

The wastes generated during construction of any of the different types of storage facilities would be typical of a large construction project. The only wastes would be construction debris and the sanitary wastes of the labor force. Estimates for the wastewater generated during construction of the different types of UF_6 storage facilities are shown in Table G.23.

Operation of the UF_6 storage facility would be divided into two phases. Phase I (2009-2028) would involve the receipt, inspection, and repackaging of the depleted uranium containers and relocation of these containers to the storage facility. The wastes generated during this operation would be sanitary wastes of the labor force and the empty containers from the repacking process.

Phase II operations (2029-2039) would involve cylinder inspection, removal, repackaging and replacing of damaged containers. Damaged cylinders were assumed to be LLW. Waste generated during this phase of operations would be sanitary wastes of the labor force and the empty failed

TABLE G.23 Estimated Total Wastewater Volumes from Construction of Long-Term Storage Facilities for UF_6, U_3O_8, and UO_2

Uranium Compound	Wastewater Volume (million L)			
	Buildings	Vaults	Mine	Yards
UF_6	4.0	N/A[a]	8.5	24.0
U_3O_8	4.7	6.2	10	N/A
UO_2	2.1	2.7	5.0	N/A

[a] N/A = data not available.

cylinders. The conversion of "heels" of UF_6 in damaged cylinders would result in UO_2F_2 waste (LLW) and a CaF_2 waste. The wastes expected from the storage of UF_6 are listed in Table G.24.

G.3.7.2 Storage of U_3O_8 and UO_2 in Buildings, Mines, and Vaults

The discussion of waste generation during construction and operations given in Section G.3.7.1.2 on storage of depleted UF_6 also applies to the storage of U_3O_8 and UO_2. Estimates of wastewater generation during construction of U_3O_8 and UO_2 long-term storage facilities are given in Table G.23. Estimates of waste generation during storage of U_3O_8 and UO_2 are given in Table G.24. No UO_2F_2 or CaF_2 wastes would be generated in the storing of these waste forms.

G.3.7.3 Summary

Overall, the LLW generated annually during the operation of the different types of storage facilities (buildings and vaults) would be small (less than 1%) compared with the expected annual LLW generation at the representative sites. The waste input resulting from the long-term storage of any of the three types of uranium forms would have minimal impact on radioactive waste management capabilities at the representative sites. The impact on nonradioactive waste management would also be minimal. The impacts of waste resulting from the long-term storage of any of the final uranium forms on national waste management capabilities would be negligible.

The impacts of the LLW resulting from long-term storage of any of the final uranium waste forms in a mine would be negligible (less than 1%) compared with national DOE LLW management capabilities.

G.3.8 Resource Requirements

Resource requirements include all materials necessary to construct and operate the storage facilities. The requirements discussed in this section are for the storage of the three chemical forms of depleted uranium only and do not include resources required for conversion to U_3O_8 or UO_2, which would be required for storage as an uranium oxide. Resource requirements for the conversion options are presented in Appendix F, Section F.3.8.

In general, the amount of resources is directly related to the magnitude of construction, with the greatest resources required for the development of an underground mine, and the least required for UF_6 storage in yards. Materials required could include concrete, sand, cement, and steel. In general, none of the construction resources identified are in short supply, and any impacts on the local economies would be small. No strategic and critical materials are projected to be consumed for either construction or operations phases.

TABLE G.24 Annual Waste Loads from Long-Term Storage of UF_6, U_3O_8, and UO_2 in Buildings, Vaults, and Mines

Time Period	Low-Level Waste (m^3/yr)	UO_2F_2 (LLW) (kg/yr)	CaF_2 (Nonhazardous) (kg/yr)	Wastewater (million L/yr)
Storage as UF_6				
Phase I				
Buildings	2.95	140	71	4.2
Vaults	NA[a]	NA	NA	NA
Mine	2.95	140	70	4.25
Phase II				
Buildings	0.2	8.8	4.4	3.4
Vaults	NA	NA	NA	NA
Mine	0.185	9.0	4.45	3.2
Storage as U_3O_8				
Phase I				
Buildings	1.05	NA	NA	4.4
Vaults	1.1	NA	NA	4.3
Mine	1.05	NA	NA	4.75
Phase II				
Buildings	0.05	NA	NA	3.4
Vaults	0.05	NA	NA	3.3
Mine	0.05	NA	NA	3.55
Storage as UO_2				
Phase I				
Buildings	0.75	NA	NA	4.0
Vaults	0.8	NA	NA	3.9
Mine	0.75	NA	NA	4.25
Phase II				
Buildings	0.04	NA	NA	3.1
Vaults	0.04	NA	NA	2.9
Mine	0.037	NA	NA	3.15

[a] NA = not applicable.

Energy resources during construction and operations would include the consumption of diesel fuel and gasoline for construction equipment and transportation vehicles. The anticipated requirements would appear to be small and not impact local or national supplies.

Significant quantities of electrical energy are projected to be required during construction of the mine storage facility because the majority of the construction equipment utilized in the underground portion are powered by electricity to avoid polluting the air in the underground work area. Similarly, a relatively higher annual consumption of electricity is projected during underground operations, compared with the other storage facility options. The required electricity would presumably be purchased from commercial utilities.

During the operations phase, no chemicals are projected to be required. The amount of natural gas would be relatively small and would be expected to be readily available.

Estimated utilities and materials required for constructing storage facilities for UF_6, U_3O_8, and UO_2 are listed in Table G.25 for the storage options. Estimated utilities and materials required for operating the storage facilities for UF_6, U_3O_8, and UO_2 are shown in Table G.26. The resource requirements are presented separately for Phase I operations, which would be concurrent with the construction period, and for Phase II operations.

G.3.9 Land Use

Land area requirements for each uranium chemical form and relevant storage option are presented in Table G.27. These data do not include acreage required for the construction phase for any of the storage options because development of land would be incremental and space required for material excavation storage, equipment staging, and construction material laydown areas would be available on adjacent undeveloped parcels. Consequently, areal needs for construction would not be greater than that for operations.

Although no site has been chosen for the storage of UF_6, UO_2, or U_3O_8, selection of a storage facility site at or near a location that is already dedicated to similar use could result in reduced land use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

G.3.9.1 Storage as UF_6

Except for potential impacts from disposal of rock spoil and excavated material in a mine, impacts to land use from the construction and operation of facilities dedicated to storage of depleted uranium in a UF_6 chemical form would be negligible and limited to clearing of required land, potential minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic.

TABLE G.25 Resource Requirements for Constructing UF_6, U_3O_8, and UO_2 Storage Facilities

		Total Consumption		
Utilities/Material	Unit	Yards/ Vaults[a]	Buildings	Mines
UF_6 Storage Facility				
Utilities				
Electricity	MWyr	0.40	5.4	840
Solids				
Concrete	m^3	59,000	69,000	140,000
Cement	metric tons	12,000	14,000	29,000
Macadam	m^3	3,100	3,100	1,600
Steel	metric tons	1,000	29,000	50,000
Liquids				
Diesel fuel	million L	0.06	10	340
Gasoline	thousand L	53	8.6	11
U_3O_8 Storage Facility				
Utilities				
Electricity	MWyr	6.3	5.4	1,000
Solids				
Concrete	m^3	82,000	110,000	170,000
Cement	metric tons	16,000	22,000	34,000
Macadam	m^3	3,400	12,000	1,700
Steel	metric tons	34,000	37,000	59,000
Liquids				
Diesel fuel	million L	12	150	410
Gasoline	thousand L	11	11	15
UO_2 Storage Facility				
Utilities				
Electricity	MWyr	3.0	2.5	490
Solids				
Concrete	m^3	37,000	48,000	85,000
Cement	metric tons	7,500	9,700	17,000
Macadam	m^3	2,200	5,600	1,500
Steel	metric tons	16,000	17,000	29,000
Liquids				
Diesel fuel	million L	5.3	66	200
Gasoline	thousand L	3.5	3.7	6.0

[a] UF_6 options include yards, buildings, and mines. U_3O_8 and UO_2 options include vaults, buildings and mines.

Sources: LLNL (1997); Folga (1996).

TABLE G.26 Resource Requirements for Operating UF_6, U_3O_8, and UO_2 Storage Facilities

		Annual Requirement					
		Yards		Buildings		Mines	
Utilities/Material	Unit	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
UF_6 Storage Facility							
Electricity	MWh	1,700	1,700	1,600	1,600	1,500	1,500
Natural gas	million scm	0.31	0.31	0.31	0.31	0.10	0.10
Diesel fuel	thousand L	57	60	52	0.02	25	0.01
Gasoline	thousand L	1.7	2.4	10	8	2.9	2.2
U_3O_8 Storage Facility							
Electricity	MWh	1,700	1,700	1,700	1,700	1,700	1,700
Natural gas	million scm	0.35	0.38	0.10	0.10	0.10	0.10
Diesel fuel	thousand L	65	0.02	120	0.04	14	0.004
Gasoline	thousand L	13	8.5	13	10	3.6	2.7
UO_2 Storage Facility							
Electricity	MWh	1,200	1,200	1,100	1,100	1,200	1,200
Natural gas	million scm	0.21	0.21	0.10	0.10	0.10	0.10
Diesel fuel	thousand L	39	0.01	93	0.04	14	0.005
Gasoline	thousand L	8.0	5.7	8.5	6.3	2.5	1.9

Source: LLNL (1997).

A storage building option would require 131 acres (53 ha) of land (see Table G.27). The storage yard option would require 144 acres (58 ha). The storage option utilizing a mine would require 96 acres (39 ha). The mine storage option would result in 1,990,000 yd^3 (1,520,000 m^3) of excavated material from the displacement of 114 underground acres (54 ha). Depending upon the location of the mine, disposal of such a large volume of material could result in land-use impacts ranging from changes in on-site topography to conflicts with existing local land-use plans. The amount of land required for the storage building option could result in potential land disturbance impacts, particularly if the site location featured land that was heavily wooded.

TABLE G.27 Land Requirements for the Long-Term Storage Options

	Land Requirement[a] (acres)				
				Mine	
Option	Yards	Buildings	Vaults	Aboveground	Underground
Storage as UF_6	144	131	N/A[b]	96	114
Storage as U_3O_8	N/A	148	212	124	138
Storage as UO_2	N/A	79	114	74	77

[a] There is no distinction between construction and operations because the storage areas would be cleared incrementally on the basis of need. Consequently, the acreage requirements listed here are the total number of acres required to meet the capabilities of the option.

[b] N/A = not applicable (option does not include this method of storage).

Source: LLNL (1997).

Road and rail access within a storage site, regardless of storage option, would be designed to minimize on-site traffic conflicts. For off-site traffic, potential impacts associated with construction vehicles could be encountered. The maximum labor force required for operation at a long-term storage facility, regardless of the storage option, would not be great enough to generate traffic impacts.

G.3.9.2 Storage as U_3O_8

Storage as U_3O_8 would require the greatest amount of land per option (see Table G.27) and would result in the greatest amount (2,350,000 yd^3 [1,800,000 m^3]) of excavated material and rock spoils. Disposal of the excavation material from a mine could result in minor land-use impacts that range from temporary disruptions of local traffic to minor land modification at the disposal site. Areal requirements for storage as U_3O_8 would range from 120 to 213 acres (48 to 86 ha). Consequently, the potential for land disturbance impacts would be greater than that expected for storage as either UF_6 or UO_2.

Road and rail access within a storage site, regardless of storage option, would be designed to minimize on-site traffic conflicts. For off-site traffic, only temporary minor impacts associated with construction vehicles could be encountered. The maximum labor force required for operation, regardless of the storage option, would not be great enough to generate traffic impacts.

G.3.9.3 Storage as UO_2

Storage as UO_2 would require the least amount of land per option (see Table G.27) and would result in the least amount (1,200,000 yd^3 [900,000 m^3]) of excavated material and rock spoils. Disposal of the excavation material from a mine could result in land-use impacts, but such impacts are expected to be negligible and of a lesser magnitude than would occur under storage as U_3O_8 or UF_6. Less land would have to be cleared for storage facilities (between 25 and 40 acres [10 and 16 ha]). Consequently, the potential for land disturbance impacts would be less than that expected for storage in either UF_6 or U_3O_8. The maximum labor force required for operations would not be great enough to generate off-site traffic impacts.

G.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the storage options considered in this PEIS were implemented include impacts to cultural resources and environmental justice, as well as impacts to the visual environment (e.g., aesthetics), recreational resources and noise levels, and impacts associated with decontamination and decommissioning of the storage facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS.

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APPENDIX H:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR THE MANUFACTURE AND USE OF URANIUM OXIDE AND URANIUM METAL

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NOTATION (APPENDIX H)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
HEPA	high-efficiency particulate air (filter)
HLW	high-level radioactive waste
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 µm or less

Chemicals

CO	carbon monoxide
HC	hydrocarbons
NO_x	nitrogen oxides
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

ft	foot (feet)	lb	pound(s)
g	gram(s)	µg	microgram(s)
gal	gallon(s)	µm	micrometer(s)
gpm	gallon(s) per minute	m	meter(s)
ha	hectare(s)	m^3	cubic meter(s)
km	kilometer(s)	mi^2	square mile(s)
km^2	square kilometer(s)	min	minute(s)

mrem	millirem(s)
MW	megawatt(s)
MWyr	megawatt year(s)
rem	roentgen equivalent man
s	second(s)
scf	standard cubic foot (feet)
ton(s)	short ton(s)
yd^3	cubic yard(s)
yr	year(s)

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APPENDIX H:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR THE MANUFACTURE AND USE OF URANIUM OXIDE AND URANIUM METAL

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the manufacture and use options considered in the PEIS. The discussion provides background information for the manufacture and use of oxide and metal, as well as a summary of the estimated environmental impacts associated with each option.

Manufacture and Use Options

The representative manufacture and use options analyzed in detail in the PEIS consider using depleted uranium as radiation shielding material. Even though uranium is radioactive itself, it can be used effectively to shield gamma radiation from highly radioactive material — such as spent nuclear fuel — because it is very dense. Two representative options are considered:

Uranium Oxide Shielding Option. This option considers the manufacture and use of uranium oxide storage casks for spent nuclear fuel using a uranium concrete material similar to conventional concrete but containing high-density uranium oxide (UO_2) in place of normal aggregate (typically gravel).

Uranium Metal Shielding Option. This option considers the manufacture and use of uranium metal casks for the storage, transport, and disposal of spent nuclear fuel (sometimes called a multi-purpose unit).

Several current and potential uses exist for depleted uranium. Depleted uranium could be mixed with highly enriched uranium from retired nuclear weapons to produce nuclear reactor fuel. This process is called blending, and, to date, only natural uranium has been considered for this application. Depleted uranium is currently used as a counterweight in high-performance aircraft. Such uses can be expected in the future, and there are other potential uses as counterweights on forklifts and as flywheels. Military applications of depleted uranium include use as tank armor, armor piercing projectiles (antitank weapons), and counterweights in missiles.

The two use alternatives evaluated in detail in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected as representative options for the purposes of comparing the potential environmental impacts of broad alternative management strategies. These options were selected in part because a recent market study suggests that the largest potential market for depleted uranium currently appears to be in shielding applications (Kaplan 1995). However, the

selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses, as appropriate.

Shielding is any material that is placed between a source of radiation and people, equipment, or other objects, in order to absorb the radiation and thereby reduce radiation exposure. Common shielding materials include concrete, steel, water, and lead. For shielding gamma radiation sources, the more dense a material is, the more effective it is as a shield. Therefore, even though uranium is radioactive itself, it can be used effectively to shield more highly penetrating radiation because of its density. Uranium is one of the most dense materials known, being 1.6 times more dense than lead.

The PEIS evaluates two options for the manufacture and use of depleted uranium shielding: (1) the uranium oxide option, which is based on the use of dense uranium dioxide (UO_2); and (2) the uranium metal option, based on the use of uranium metal. Both options assume that the depleted uranium would be used as the primary shielding material in containers (called "casks") used to store spent nuclear fuel. Spent nuclear fuel is the highly radioactive "used" fuel produced in nuclear power plants. Although spent nuclear fuel is most commonly shielded by water in large storage pools, there is a growing need for heavily shielded storage casks. A typical storage cask is a cylindrical container about 15 ft (4.5 m) high and 5 ft (1.5 m) in diameter (see Figure H.1). For both options, the cask designs are based on existing designs, and assume that the uranium shielding material would be enclosed between stainless steel (or equivalent) shells (Lawrence Livermore National Laboratory [LLNL] 1997).

The uranium oxide option assumes that depleted uranium in the form of high density UO_2 would be used for the manufacture of depleted uranium concrete for shielding in spent nuclear fuel storage casks. This uranium concrete material, which substitutes dense UO_2 for the coarse aggregate (typically gravel) in conventional concrete, is known as DUCRETE. As a shielding material, DUCRETE offers size and weight advantages compared to conventional concrete. Shielding made of DUCRETE would typically require less than half the thickness of shielding made from concrete to obtain the same effect.

The uranium metal option assumes that depleted uranium in the form of metal would be used for the manufacture of shielding in a spent nuclear fuel cask that could be used not only for storage, but also for transportation and disposal. This type of cask is commonly called a multi-purpose unit. No assumptions were made regarding the fate of the uranium oxide or uranium metal casks after use. The empty casks could be recycled, stored, or disposed of as low-level radioactive waste (LLW).

For assessment purposes, the manufacture of depleted uranium shielded casks was assumed to take place at a stand-alone industrial plant dedicated to the cask fabrication process. In general,

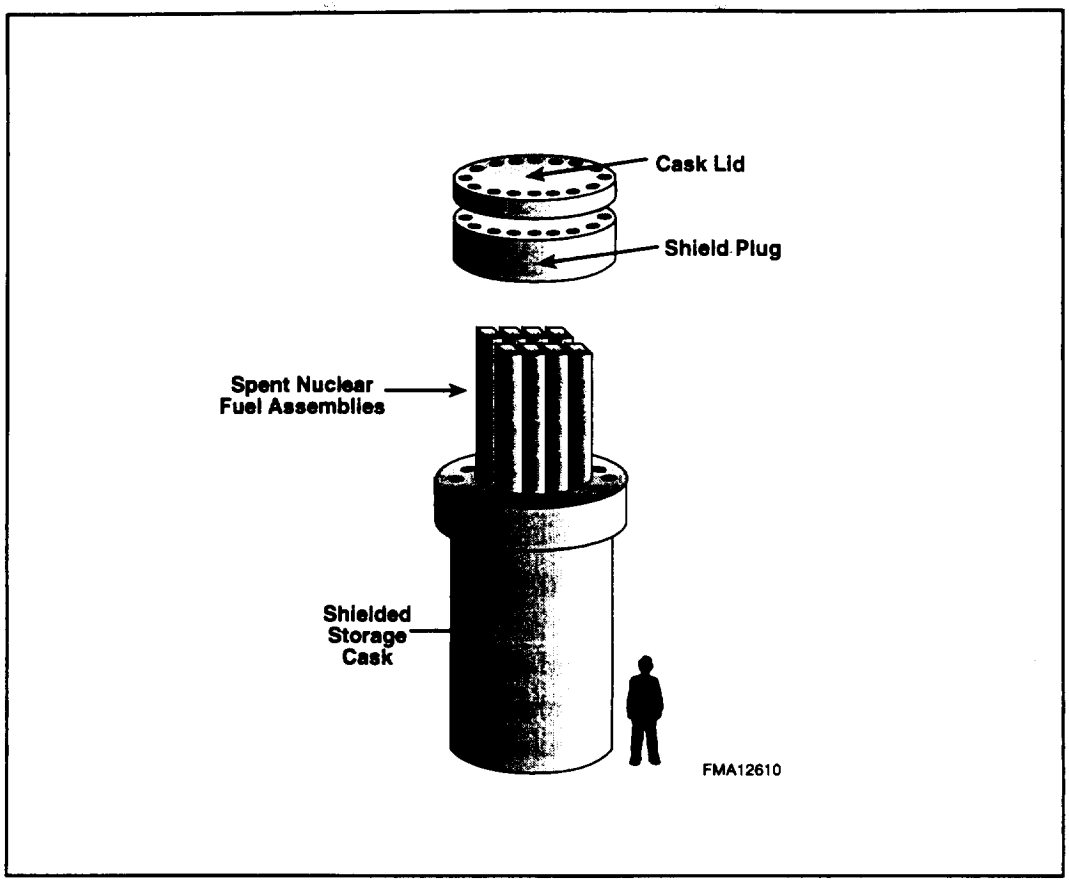

FIGURE H.1 Representative Spent Nuclear Fuel Storage Cask (Shielding is typically provided by concrete, DUCRETE [concrete with depleted UO_2], or uranium metal.)

the plant would be capable of receiving packages of depleted uranium (either UO_2 or metal) on trucks or railcars from a conversion facility, fabricating shielded casks, and storing the casks until shipment by rail to a user, such as a nuclear power plant. At the user facility, the casks would be used to store spent nuclear fuel.

The potential impacts from a manufacturing facility were analyzed for generic dry and wet environmental settings. The conditions at the dry environmental setting would be typical of a site in the western United States, and the conditions at the wet environmental setting would be typical of a site in the eastern United States.

In general, potential environmental impacts would occur (1) during construction of the cask manufacturing facility, (2) during routine operation of the cask manufacturing facility, and (3) as a result of potential manufacturing plant accidents. The potential impacts during construction would be generally limited to the duration of the construction period and would result from typical land-clearing and construction activities. Potential impacts during operations would result from handling the incoming containers of depleted uranium and from small emissions of uranium compounds to

the air and water. Impacts might also occur from potential manufacturing accidents that may result in the release of hazardous materials to the environment. Impacts during the use of depleted uranium shielded casks were not quantified in the PEIS. In general, the potential impacts associated with any structural components of a depleted uranium cask would be negligible compared with the potential impacts associated with the spent nuclear fuel stored within the casks during use. Excluding accidents, no release of depleted uranium material would occur during use.

The potential environmental impacts presented in this chapter were evaluated based on the information described in the engineering analysis report (LLNL 1997). For each manufacture and use option, the engineering analysis report provides preconceptual manufacturing facility design data, including descriptions of facility layouts; shielding cask design details; resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios.

H.1 SUMMARY OF MANUFACTURE AND USE OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with two manufacture and use options: (1) a uranium oxide shielding option and (2) a uranium metal shielding option. The assessment of impacts was limited to the potential impacts from construction and operation of cask manufacturing facilities. Additional discussion and details related to the assessment results for individual areas of impact are provided in Section H.3.

Potential environmental impacts from the two manufacture and use options are summarized in Table H.1. Based on the information in Table H.1 and Section H.3, the following conclusions can be drawn:

- For both manufacture and use options, potential human health and safety impacts to workers and the public would be small during construction and normal operations. The consequences of accidents involving release of radioactive or chemical materials would be low. About 1 fatality during construction and operations was estimated from an on-the-job occupational accident.

- For both options, potential impacts other than human health and safety tend to be small and similar between the options.

H.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the options considered in the assessment of manufacture and use impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report contains much more

TABLE H.1 Summary of Manufacture and Use Option Impacts

Impacts from Manufacture and Use of Oxide Shielding	Impacts from Manufacture and Use of Uranium Metal Shielding
Human Health – Normal Operations: Radiological	
Involved Workers: Total collective dose: 460 person-rem Total number of LCFs: 0.2	**Involved Workers:** Total collective dose: 100 person-rem Total number of LCFs: 0.04
Noninvolved Workers: Annual dose to MEI : $6.1 \times 10^{-5} - 2.8 \times 10^{-4}$ mrem/yr Annual cancer risk to MEI: $2 \times 10^{-11} - 1 \times 10^{-10}$ per year Total collective dose: $2.0 \times 10^{-5} - 2.5 \times 10^{-4}$ person-rem Total number of LCFs: $8 \times 10^{-9} - 1 \times 10^{-7}$ LCF	**Noninvolved Workers:** Annual dose to MEI : $1.3 \times 10^{-4} - 6.4 \times 10^{-4}$ mrem/yr Annual cancer risk to MEI: $5 \times 10^{-11} - 3 \times 10^{-10}$ per year Total collective dose : $1.2 \times 10^{-4} - 1.5 \times 10^{-3}$ person-rem Total number of LCFs: $5 \times 10^{-8} - 6 \times 10^{-7}$ LCF
General Public: Annual dose to MEI: $1.9 \times 10^{-4} - 8.7 \times 10^{-4}$ mrem/yr Annual cancer risk to MEI: $1 \times 10^{-10} - 4 \times 10^{-10}$ per year Total collective dose to population within 50 miles: 0.00098 – 0.12 person-rem Total number of LCFs in population within 50 miles: $5 \times 10^{-7} - 6 \times 10^{-5}$ LCF	**General Public:** Annual dose to MEI: $3.8 \times 10^{-4} - 1.9 \times 10^{-3}$ mrem/yr Annual cancer risk to MEI: $2 \times 10^{-10} - 1 \times 10^{-9}$ per year Total collective dose to population within 50 miles: 0.0059 – 0.73 person-rem Total number of LCFs in population within 50 miles: $3 \times 10^{-6} - 4 \times 10^{-4}$ LCF
Human Health – Normal Operations: Chemical	
Noninvolved Workers: No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts

TABLE H.1 (Cont.)

Impacts from Manufacture and Use of Oxide Shielding	Impacts from Manufacture and Use of Uranium Metal Shielding
Human Health – Accidents: Radiological	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: less than 1 in 1,000,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.077 rem	Dose to MEI: 0.23 rem
Risk of LCF to MEI: 0.00003 per year	Risk of LCF to MEI: 0.00009 per year
Collective dose: 0.029 person-rem	Collective dose: 0.087 person-rem
Number of LCFs: 0.00001	Number of LCFs: 0.00003
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.0023 rem	Dose to MEI: 0.007 rem
Risk of LCF to MEI: 1×10^{-6} per year	Risk of LCF to MEI: 4×10^{-6} per year
Collective dose to population within 50 miles: 0.32 person-rem	Collective dose to population within 50 miles: 1.9 person-rem
Number of LCFs among population within 50 miles: 0.0002 LCF	Number of LCFs among population within 50 miles: 0.001 LCF
Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: less than 1 in 1,000,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 4 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 2 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 1 person

TABLE H.1 (Cont.)

Impacts from Manufacture and Use of Oxide Shielding	Impacts from Manufacture and Use of Uranium Metal Shielding
Human Health — Accidents: Physical Hazards	
Construction and Operations: **All Workers:** Approximately 1 fatality, approximately 640 injuries	**Construction and Operations:** **All Workers:** Approximately 1 fatality, approximately 670 injuries
Air Quality	
Construction: Concentrations of criteria pollutants all 9% or less of respective standards	**Construction:** Concentrations of criteria pollutants all 9% or less of respective standards
Operations: Pollutant concentrations 4% or less of values during construction	**Operations:** Pollutant concentrations 4% or less of values during construction
Water[a]	
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
Soil[a]	
Construction: Negligible but temporary impacts	**Construction:** Negligible but temporary impacts
Operations: No impacts	**Operations:** No impacts
Socioeconomics	
Construction: Potentially moderate impacts on employment and income	**Construction:** Potentially moderate impacts on employment and income
Operations: Potentially moderate impacts on employment and income	**Operations:** Potentially moderate impacts on employment and income
Ecology	
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife
Operations: Negligible impacts	**Operations:** Negligible impacts
Waste Management	
Negligible impacts on regional or national waste management operations	Negligible impacts on regional or national waste management operations

TABLE H.1 (Cont.)

Impacts from Manufacture and Use of Oxide Shielding	Impacts from Manufacture and Use of Uranium Metal Shielding
Resource Requirements	
No impacts from resource requirements (such as electricity or materials) would be expected on the local or national scale	No impacts from resource requirements (such as electricity or materials) would be expected on the local or national scale
Land Use	
Use of approximately 90 acres; potential moderate impacts, including traffic impacts	Use of approximately 90 acres; potential moderate impacts, including traffic impacts

[a] Impacts if the generic site was large relative to the proposed facility and was located near a river where minimum flow was large relative to water use.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 μm or less; ROI = region of influence.

detailed information, including descriptions of manufacturing facility layouts; shielding cask design details; resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios. The manufacture and use options assume that depleted uranium in the form of UO_2 or metal would be shipped to the manufacturing plant from a conversion facility. The environmental impacts associated with the conversion process are provided in Appendix F.

H.2.1 Uranium Oxide Shielding Option

The uranium oxide shielding option would require a total site area of about 90 acres (37 ha), of which 32 acres (13 ha) would be disturbed or cleared. The manufacturing facility would receive high-density UO_2 from a conversion plant, and the partially fabricated stainless steel shells and other shielding cask components from a supplier. The steel cask shell would be fabricated using conventional industry practices, including welding, machining and final assembly. At the cask manufacturing facility, uranium oxide shielding would be prepared using high-shear mixing for evenly combining the high-density UO_2 and concrete components. The mixture would then be poured between an inner and outer steel cask shell. Final assembly of the shielding cask would be performed after the mixture cured. The oxide shielding composition would be nominally 74% UO_2, 11% sand, 10% cement and additives, and the remainder water. Each cask would contain about 50 tons (45 metric tons) of UO_2, with about 480 casks being manufactured each year. The casks would then be sent to a user, such as a nuclear power plant.

H.2.2 Uranium Metal Shielding Option

The metal shielding option would require a total site area of about 90 acres (37 ha), of which 36 acres (15 ha) would be disturbed or cleared. The manufacturing facility would receive uranium metal ingots (or alloy) from a conversion plant, and partially fabricated stainless steel or titanium alloy shells and other shielding cask components from a supplier. The inner and outer steel shells of the casks would be assembled using standard operations, such as welding, machining and final assembly. In a separate building, the uranium metal would be melted and directly cast between the inner and outer shells of the assembled cask. After cooling, final assembly of the shielding cask would be carried out. Each finished shielding cask would contain about 47 tons (43 metric tons) of uranium metal, with about 453 casks being manufactured each year.

H.2.3 Manufacture and Use Options Considered But Not Analyzed

Several manufacture and use options were not analyzed in depth in the engineering analysis report: (1) use of depleted uranium in light water reactor fuel, (2) use of depleted uranium as fuel in advanced breeder reactors, and (3) dense material applications other than radiation shielding. As discussed more fully in Section 2.3.2 of the PEIS, these uses are either too uncertain at this time for full analysis or are represented by the options analyzed in the PEIS.

H.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the manufacture and use options, including impacts from construction and facility operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C.

The environmental impacts from the manufacture and use options were evaluated based on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to the assessment of impacts:

- Shielding cask manufacturing facilities would operate over a 20-year period, from 2009 through 2028, using either depleted uranium oxide or metal from the DOE-generated inventory. Preoperation of manufacturing facilities would occur between 1999 and 2008, with actual construction requiring 7 years.

- The uranium oxide and uranium metal cask manufacturing plants would produce 480 and 453 casks per year, respectively, over the operational period.

- The cask manufacturing facilities were assumed to be stand-alone facilities built for the specific purpose of fabricating casks. The manufacturing facilities

would receive depleted uranium in the form of UO_2 or metal from a conversion facility.

- Potential impacts from a manufacturing facility were analyzed for generic dry and wet environmental settings and for generic rural and urban settings. The historical meteorological conditions for five actual "dry" locations in the southwestern United States and five actual "wet" locations in the central and southeastern United States were averaged to develop estimates for the generic settings. The generic rural setting was assumed to have a population density corresponding to 15 persons/mi^2 (6 persons/km^2); the generic urban setting was assumed to have a population density corresponding to 700 persons/mi^2 (275 persons/km^2).

- The assessment of impacts was limited to potential impacts from the construction and operation of a cask manufacturing facility. Impacts during the use of depleted uranium shielded casks have not been estimated in the PEIS because the impacts associated with the depleted uranium cask components would be negligible compared with the potential impacts associated with the spent nuclear fuel within a cask and because no release of depleted uranium material would occur during use. Use of spent nuclear fuel storage casks would be subject to DOE or U.S. Nuclear Regulatory Commission (NRC) review and approval.

- The impacts presented herein for manufacturing of oxide- and metal-shielded containers would be representative of any impacts associated with manufacture of other products that contain depleted uranium because none of the other potential uses would consume as much depleted UF_6 inventory as the oxide and metal container use.

- Because of existing regulations in the United States, it is highly unlikely that products containing depleted uranium would be available for unrestricted use at this time. Impacts to the general public from restricted use applications would be negligible. Impacts to the workers from uranium oxide or uranium metal casks at the user locations (e.g., commercial nuclear power generators) would depend largely on the particular application but would be less than those to workers at the manufacturing facilities. Any commercial use of depleted uranium would take place under an NRC license or a waiver from the NRC. Potential impacts from such use would have to be analyzed before a license or waiver could be obtained.

H.3.1 Human Health — Normal Operations

H.3.1.1 Radiological Impacts

Radiological impacts were assessed for involved workers, noninvolved workers, and the general public. Impacts to involved workers would result primarily from exposures to external radiation in the vicinity of uranium material for both options considered. The average radiation dose would be less than 110 mrem/yr. Impacts to noninvolved workers and the general public would result from release of uranium compounds to the environment. The maximum radiation dose would be very small, less than 0.002 mrem/yr. The estimated radiation doses and cancer risks are listed in Tables H.2 and H.3, respectively. Detailed discussions of the methodologies used in radiological impact analyses are provided in Appendix C and Cheng et al. (1997).

TABLE H.2 Radiological Doses from Manufacture and Use Options under Normal Operations

	Dose to Receptor[a]					
	Involved Worker[b]		Noninvolved Worker[c]		General Public	
Shielding Option	Average Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[d] (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
Uranium oxide casks	110	23	6.1×10^{-5} – 2.8×10^{-4}	1.0×10^{-6} – 1.2×10^{-5}	1.9×10^{-4} – 8.7×10^{-4}	4.9×10^{-5} – 6.1×10^{-3}
Uranium metal casks	23	5.0	1.3×10^{-4} – 6.4×10^{-4}	6.2×10^{-6} – 7.5×10^{-5}	3.8×10^{-4} – 1.9×10^{-3}	3.0×10^{-4} – 3.7×10^{-2}

[a] Impacts are reported as ranges, which result from differences for five generic dry and wet environmental settings.

[b] Involved workers are those workers directly involved with the handling of materials. Results are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[c] Noninvolved workers are individuals who do not participate in material-handling activities, such as managers and secretaries. The number of noninvolved workers would be about 200 for both uranium oxide casks and uranium metal casks.

[d] The MEI for the noninvolved workers was assumed to be located on-site at the location that would yield the largest dose from airborne emissions, including doses from inhalation, external radiation, and incidental ingestion of soil.

[e] The MEI for the general public was assumed to be located off-site at the point that would yield the largest dose from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

[f] The collective dose was estimated for the off-site population within a 50-mile (80-km) radius around the facility. The range of collective doses results from differences in dry and wet locations surrounded by a rural (about 120,000 people) or urban (about 5,600,000 people) population. The exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk and soil.

TABLE H.3 Latent Cancer Risks from Manufacture and Use Options under Normal Operations

	Risk to Receptor[a]					
	Involved Worker[b]		Noninvolved Worker[c]		General Public	
Shielding Option	Average Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[d] (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
Uranium oxide casks	4×10^{-5}	9×10^{-3}	2×10^{-11} – 1×10^{-10}	4×10^{-10} – 5×10^{-9}	1×10^{-10} – 4×10^{-10}	2×10^{-8} – 3×10^{-6}
Uranium metal casks	9×10^{-6}	2×10^{-3}	5×10^{-11} – 3×10^{-10}	2×10^{-9} – 3×10^{-8}	2×10^{-10} – 1×10^{-9}	2×10^{-7} – 2×10^{-5}

[a] Impacts are reported as ranges, which result from differences for five generic dry and wet environmental settings.

[b] Involved workers are those workers directly involved with the handling of materials. Results are presented as average individual risk and collective risk for the worker population.

[c] Noninvolved workers are individuals who do not participate in material-handling activities, such as managers and secretaries. The number of noninvolved workers is about 200 for both uranium oxide casks and uranium metal casks.

[d] The MEI for the noninvolved workers was assumed to be located on-site at the location that would yield the largest risk from airborne emissions, including risks from inhalation, external radiation, and incidental ingestion of soil.

[e] The MEI for the general public was assumed to be located off-site at the point that would yield the largest risk from exposures through inhalation, external radiation, and ingestion of plant foods, meat, milk, soil, and drinking water.

[f] The collective risk was estimated for the population within a 50-mile (80-km) radius around the facility. The range of collective risks results from differences in dry and wet locations surrounded by a rural (about 120,000 people) or urban (about 5,600,000 people) population. The exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk and soil.

H.3.1.1.1 Impacts from Manufacturing

Uranium Oxide. For the uranium oxide option, the collective dose to involved workers was estimated to be approximately 23 person-rem/yr for a total of 220 workers, which corresponds to about 0.009 additional latent cancer fatality (LCF) per year among workers (i.e., 1 LCF would be expected in 110 years of operation). The average involved worker dose was estimated to be about 110 mrem/yr, well below the regulatory limit of 5,000 mrem/yr specified for workers (10 *Code of Federal Regulations* [CFR] Part 835). The average risk to an involved worker of developing an LCF would be about 4×10^{-5} per year (one chance in 25,000 per year).

Radiation doses to noninvolved workers and members of the general public would depend on the location of the facility and would be very small because of the small amount of uranium released. The radiation dose to the maximally exposed individual (MEI) of noninvolved workers would be less than 2.8×10^{-4} mrem/yr, whereas the dose to the MEI of the general public would be less than 8.7×10^{-4} mrem/yr.

Uranium Metal. Because of the smaller volume handled and better self shielding characteristics of uranium metal (the density of uranium metal is about twice that of uranium oxide), the manufacturing of uranium metal casks would result in less radiation exposures to involved workers than the manufacturing of uranium oxide casks. The collective dose to involved workers was estimated to be about 5.0 person-rem/yr for approximately 220 workers. The average dose received by an involved worker would be about 23 mrem/yr, corresponding to an LCF risk of 9×10^{-6} per year (1 chance in 110,000 per year).

Radiation exposures to noninvolved workers and members of the general public from the uranium metal facility would be greater than those from the uranium oxide facility because of the higher emission rate of uranium. However, the radiation doses to the MEIs would be very small, less than 6.4×10^{-4} mrem/yr for noninvolved workers and less than 1.9×10^{-3} mrem/yr for the general public.

H.3.1.1.2 Impacts from Use

The spent nuclear fuel shielding casks made with uranium metal or uranium oxide would have the same shielding capability as conventional casks made with concrete, lead, or other shielding material. Although depleted uranium would be incorporated into the manufactured casks, the resulting exposure to personnel from the depleted uranium would be negligible when compared with the exposures from the spent nuclear fuel stored in the cask.

H.3.1.2 Chemical Impacts

Potential chemical impacts to human health from normal operations would result primarily from uranium releases from the manufacturing facilities. Risks from normal operations were quantified on the basis of calculated hazard indexes. Information on the exposure assumptions, health effects assumptions, reference doses used for uranium compounds, and calculational methods used in the chemical impact analysis is provided in Appendix C and Cheng et al. (1997).

H.3.1.2.1 Impacts from Manufacturing

Airborne emissions of uranium compounds from the metal facility would be more than 5 times greater than uranium emissions from the uranium oxide facility (LLNL 1997). Therefore, chemical exposures for the noninvolved workers and off-site general public would be higher due to releases from the metal facility. However, human health impacts would still be negligible for the noninvolved workers and off-site public for both manufacture and use options.

Uranium Oxide. Estimates of the impacts to human health from hazardous chemicals during operations at the uranium oxide facility are summarized in Table H.4. The overall hazard indices for chemical impacts to the noninvolved worker MEI were estimated to be less than

TABLE H.4 Chemical Impacts to Human Health from Manufacture and Use Options under Normal Operations

	Impacts to Receptor[a]			
	Noninvolved Workers[b]		General Public	
Shielding Option	Hazard Index for MEI[c,d]	Collective Risk[e] (ind. at risk/yr)	Hazard Index for MEI[c,f]	Collective Risk[e] (ind. at risk/yr)
Uranium oxide casks	$7.7 \times 10^{-9} - 3.4 \times 10^{-8}$	–	$6.2 \times 10^{-7} - 2.9 \times 10^{-6}$	–
Uranium metal casks	$1.6 \times 10^{-8} - 7.9 \times 10^{-8}$	–	$1.4 \times 10^{-6} - 6.7 \times 10^{-6}$	–

[a] Impacts are reported as ranges, which result from differences for five generic dry and wet environmental settings.

[b] Noninvolved workers are individuals who do not participate in material-handling activities, such as managers and secretaries.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] The MEI for the noninvolved workers was assumed to be located on-site at the location that would yield the largest exposure from airborne emissions, including exposures through inhalation and incidental ingestion of soil.

[e] Calculation of collective risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[f] The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposures through inhalation and ingestion of soil and drinking water.

3.4×10^{-8} for all dry and wet representative locations. Because these values are considerably below the threshold for adverse effects (i.e., the ratio of intake to reference dose is less than 1), no health effects would be expected. The overall hazard indices for chemical impacts to the general public MEI are estimated to be less than 2.9×10^{-6} for all dry and wet representative sites. These values are also considerably below the threshold for adverse effects.

Uranium Metal. Estimates of the hazardous chemical human health impacts resulting from operations at the uranium metal facility are summarized in Table H.4. Hazard indices are approximately 2 times higher for the uranium metal option than for the uranium oxide option but still many orders of magnitude below the threshold for adverse effects.

H.3.1.2.2 Impacts from Use

Only the operations of the two types of manufacturing facilities would result in airborne and waterborne emissions of uranium; the use of shielding casks made with uranium metal or uranium oxide would not be expected to release any materials and, therefore, would not result in any impacts to the noninvolved workers and general public.

H.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table H.5. The following sections present the results for the radiological and chemical health impacts of the highest consequence accident in each frequency category. Results for all accidents listed in Table H.5 are presented in Policastro et al. (1997). A detailed description of the methodology and assumptions used in the calculations is also provided in Appendix C and Policastro et al. (1997).

H.3.2.1 Radiological Impacts

The radiological doses to various receptors for the accidents that give the highest dose from each frequency category are listed in Table H.6. The LCF risks for these accidents are given in Table H.7. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions (wet and dry) and two different population distributions (rural and urban) were considered for each manufacture and use option. The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 230 mrem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the NRC (1994).

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table H.7] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the manufacture and use accidents.

H.3.2.2 Chemical Impacts

The accidents considered in this section are listed in Table H.5. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables H.8 and H.9. The results are expressed as (1) number of persons with potential for adverse effects and (2) number of persons with potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of noninvolved workers and population) (Policastro et al. 1997). The numbers of noninvolved workers and members of the

TABLE H.5 Accidents Considered for the Manufacture and Use Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Manufacture and Use as Oxide Shielding					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the plant	A single UO_2 drum is damaged by a forklift and spills its contents onto the ground inside the UO_2 cask manufacturing plant.	UO_2	7.3×10^{-7}	Puff	Stack
Mixer/melter charge accident	Mishandling of the input load to the oxide mixer results in an airborne release of the input drum contents.	UO_2	0.000073	Puff	Stack
Mixer/melter operational accident	Failure of the oxide mixer during operation results in an airborne release of the mixer contents.	UO_2	0.00015	Puff	Stack
Mixer/melter discharge accident	Failure during discharge of the oxide mixers results in an airborne release.	UO_2	0.00044	Puff	Stack
Shield failure after casting	After the cask annulus has been filled with depleted uranium, it fails due to rupture or chemical reactivity.	UO_2	9.7×10^{-6}	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The UO_2 cask manufacturing plant is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	UO_2	0.33	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the UO_2 cask manufacturing plant structure and confinement systems.	UO_2	1.6	0.5	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire/explosion/chemical reagent contact inside the mixers	A leak or rupture of the oxide mixers results in a fire and/or explosion, but the HEPA filtration system is not affected.	UO_2	0.00044	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

TABLE H.5 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Manufacture and Use as Metal Shielding					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the plant	A pallet of uranium metal billets is damaged by a forklift and spills its contents onto the ground inside the uranium metal cask manufacturing plant.	U_3O_8	0.0012	Puff	Stack
Mixer/melter charge accident	Mishandling of the input load to the uranium furnace results in an airborne release of the input billets.	U_3O_8	0.00009	Puff	Stack
Mixer/melter operational accident	Failure of the uranium furnace during operation results in an airborne release of the furnace contents.	U_3O_8	0.0004	Puff	Stack
Mixer/melter discharge accident	Failure during discharge of the uranium furnace results in an airborne release.	U_3O_8	0.0004	Puff	Stack
Shield failure after casting	After the cask annulus has been filled with molten depleted uranium it fails due to rupture or chemical reactivity.	U_3O_8	0.00059	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The uranium metal cask manufacturing plant is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	U_3O_8	0.05	30	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the uranium metal cask manufacturing plant structure and confinement systems.	U_3O_8	0.05	0.5	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire/explosion/chemical reagent contact inside the cask annulus	The molten uranium within a cask annulus is oxidized, resulting in a fire and/or explosion, but the HEPA filtration system is not affected.	U_3O_8	0.0059	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Uranium metal furnace failure	A large seismic event or beyond-design-basis event causes failure of eight furnaces feeding one cask.	UO_2	35	Puff	Ground

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

Notation: HEPA = high-efficiency particulate air; NA = not applicable; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

TABLE H.6 Estimated Radiological Doses per Accident Occurrence for the Manufacture and Use Options

Option/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Manufacture and Use as Oxide Shielding									
Mixer/melter discharge accident	L	1.5×10^{-8}	1.3×10^{-7}	1.5×10^{-8}	2.7×10^{-5}	4.5×10^{-12}	3.6×10^{-11}	7.6×10^{-10}	2.7×10^{-7}
Earthquake	U	7.7×10^{-2}	2.9×10^{-2}	2.3×10^{-3}	3.2×10^{-1}	3.2×10^{-3}	1.2×10^{-3}	9.2×10^{-5}	1.1×10^{-3}
Fire/explosion/chemical reagent contact inside the mixers	EU	1.5×10^{-8}	1.2×10^{-7}	1.5×10^{-8}	2.7×10^{-5}	4.4×10^{-12}	3.6×10^{-11}	7.5×10^{-10}	2.7×10^{-7}
Manufacture and Use as Metal Shielding									
Mishandling/drop of drum/billet inside	L	3.9×10^{-8}	3.3×10^{-7}	4.0×10^{-8}	7.0×10^{-5}	1.2×10^{-11}	9.4×10^{-11}	2.0×10^{-9}	7.1×10^{-7}
Earthquake	U	1.1×10^{-2}	4.3×10^{-3}	3.4×10^{-4}	4.6×10^{-2}	4.7×10^{-4}	1.8×10^{-4}	1.3×10^{-5}	1.6×10^{-4}
Fire/explosion/chemical reagent contact inside the cask annulus	EU	1.9×10^{-7}	1.6×10^{-6}	2.0×10^{-7}	3.5×10^{-4}	5.8×10^{-11}	4.7×10^{-10}	9.8×10^{-9}	3.5×10^{-6}
Uranium metal furnace failure	I	2.3×10^{-1}	8.7×10^{-2}	7.0×10^{-3}	1.9	2.3×10^{-1}	8.7×10^{-2}	5.5×10^{-3}	4.2×10^{-2}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($>10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($<10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

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TABLE H.7 Estimated Radiological Health Risks per Accident Occurrence for the Manufacture and Use Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Manufacture and Use as Oxide Shielding									
Mixer/melter discharge accident	L	6×10^{-12}	5×10^{-11}	8×10^{-12}	1×10^{-8}	2×10^{-15}	1×10^{-14}	4×10^{-13}	1×10^{-10}
Earthquake	U	3×10^{-5}	1×10^{-5}	1×10^{-6}	2×10^{-4}	1×10^{-6}	5×10^{-7}	5×10^{-8}	5×10^{-7}
Fire/explosion/chemical reagent contact inside the mixers	EU	6×10^{-12}	5×10^{-11}	8×10^{-12}	1×10^{-8}	2×10^{-15}	1×10^{-14}	4×10^{-13}	1×10^{-10}
Manufacture and Use as Metal Shielding									
Mishandling/drop of drum/billet inside	L	2×10^{-11}	1×10^{-10}	2×10^{-11}	4×10^{-8}	5×10^{-15}	4×10^{-14}	1×10^{-12}	4×10^{-10}
Earthquake	U	4×10^{-6}	2×10^{-6}	2×10^{-7}	2×10^{-5}	2×10^{-7}	7×10^{-8}	7×10^{-9}	8×10^{-8}
Fire/explosion/chemical contact reagent inside the cask annulus	EU	8×10^{-11}	7×10^{-10}	1×10^{-10}	2×10^{-7}	2×10^{-14}	2×10^{-13}	5×10^{-12}	2×10^{-9}
Uranium metal furnace failure	I	9×10^{-5}	3×10^{-5}	4×10^{-6}	1×10^{-3}	9×10^{-5}	3×10^{-5}	3×10^{-6}	2×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

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TABLE H.8 Number of Persons with Potential for Adverse Effects from Accidents under the Manufacture and Use Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Manufacture and Use as Oxide Shielding									
Mixer/melter discharge accident[f]	L	No	0	No/No	0/0	No	0	No/No	0/0
Tornado[f,g]	U	No	0	No/No	0/0	NA	NA	NA	NA
Fire/explosion/chemical reagent contact inside mixers[f]	EU	No	0	No/No	0/0	No	0	No/No	0/0
Manufacture and Use as Metal Shielding									
Mishandle/drop of drum/billet inside[f]	L	No	0	No/No	0/0	No	0	No/No	0/0
Earthquake	U	No	0	No/No	0/0	No	0	No/No	0/0
Fire/explosion/chemical reagent contact inside cask annulus[f]	EU	No	0	No/No	0/0	No	0	No/No	0/0
Uranium metal furnace failure	I	Yes	4	No/Yes	0/1	Yes[h]	0	No/Yes[h]	0/0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect different meteorological conditions at the time of the accidents. In general, maximum risks would occur under meteorological conditions of F stability and 1 m/s wind speed, whereas minimum risks would occur under D stability and 4 m/s wind speed. Results for the general public MEI are for rural/urban locations, respectively.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] These accidents would result in the largest plume sizes, although no people would be affected.

[g] Meteorological conditions for the tornado scenario were considered to be D stability with 20 m/s wind speed. NA = not applicable.

[h] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because generic worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE H.9 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Manufacture and Use Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Manufacture and Use as Oxide Shielding									
Mixer/melter discharge accident[f]	L	No	0	No/No	0/0	No	0	No/No	0/0
Tornado[f,g]	U	No	0	No/No	0/0	NA	NA	NA	NA
For/explosion/chemical reagent contact inside mixers[f]	EU	No	0	No/No	0/0	No	0	No/No	0/0
Manufacture and Use as Metal Shielding									
Mishandle/drop of drum/billet inside[f]	L	No	0	No/No	0/0	No	0	No/No	0/0
Earthquake[f]	U	No	0	No/No	0/0	No	0	No/No	0/0
Fire/explosion/chemical reagent contact inside cask annulus[f]	EU	No	0	No/No	0/0	No	0	No/No	0/0
Uranium metal furnace failure	I	Yes	2	No/Yes	0/0	No	0	No/Yes[h]	0/0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect different meteorological conditions at the time of the accidents. In general, maximum risks would occur under meteorological conditions of F stability and 1 m/s wind speed, whereas minimum risks would occur under D stability and 4 m/s wind speed. Results for the general public MEI are for rural/urban locations, respectively.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] These accidents would result in the largest plume sizes, although no people would be affected.

[g] Meteorological conditions for the tornado scenario were considered to be D stability with 20 m/s wind speed. NA = not applicable.

[h] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because generic worker and general public population distributions were used, which did not show receptors at the MEI locations.

off-site public represent the impacts if the associated accident was assumed to occur. These results of the chemical impact analysis may be summarized as follows:

- If the accidents identified in Tables H.8 and H.9 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 1, and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1 (maximums corresponding to failure of the uranium metal furnace).

- If the accidents identified in Tables H.8 and H.9 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 4, and the number of nonvinvolved workers with potential for irreversible adverse effects would range from 0 to 2 (maximums corresponding to failure of the uranium metal furnace).

- The impacts for the uranium metal shielding option would be slightly higher than those for uranium oxide applications. However, the overall impacts for the manufacture and use options would be very small compared with other options.

- For the most severe accident (uranium metal furnace failure), the noninvolved worker MEI would experience potential adverse effects and potential irreversible adverse effects, whereas the general public MEI would experience no adverse impacts at the rural site. If an urban site were chosen for this activity, a small number of both the noninvolved worker and the public MEIs could be affected in terms of both health criteria. The reduced impacts to the public MEI compared with the worker MEI were based on dispersion of the chemical release with downwind distance. For the other accidents assessed, neither the worker nor the public MEI would experience adverse effects.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009–2028). The results indicated that the maximum risk values would be less than 1 for all accidents.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table H.9 would involve small releases of uranium oxide and potential exposure to uranium compounds. If the accidents occurred, exposures are estimated to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Thus, for workers and members of the general public experiencing ranges of 0 to 2 and 0 to 1 irreversible adverse effects, respectively, 0 deaths would be expected.

H.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all manufacturing facility workers from the fabrication of uranium oxide and uranium metal shielding was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used for the construction and operational phases, respectively, of the manufacturing facility lifetime.

Because manufacturing activities would be quite labor-intensive, relatively high injury incidence rates are predicted, with about one fatality expected over the lifetime of facility operations. There is little difference in impacts between the uranium oxide and metal shielding options, although the fatality and incidence rates for the metal option would be slightly higher.

The estimated number of worker fatalities for the uranium oxide shielding option is 0.76 for the construction and operational phases combined (Table H.10). The estimated number of injuries over the lifetime of the uranium oxide facility is about 640.

The estimated number of worker fatalities for the uranium metal shielding option is 0.85 for the construction and operational phases combined (Table H.10). The estimated number of injuries over the lifetime of the metal facility is about 670.

TABLE H.10 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Manufacture and Use Options

	Impacts to All Manufacturing Facility Workers[a]			
	Incidence of Fatalities[b]		Incidence of Injuries[b]	
Shielding Option	Construction	Operations	Construction	Operations
Uranium oxide casks	0.38	0.38	140	500
Uranium metal casks	0.48	0.37	180	490

[a] All construction and operational workers at the manufacturing facilities were included in physical hazard risk calculations.

[b] The incidence of fatalities and incidence of injuries were calculated as the number of full-time-equivalent employees times the annual fatality rate times the number of years. Only injuries involving lost workdays were estimated. Injury and fatality incidence rates used in the calculations were taken from National Safety Council (1995).

H.3.3 Air Quality

The methodology used to analyze the air quality impacts from both uranium oxide and uranium metal manufacturing and use options is provided in Appendix C and Tschanz (1997). The pollutant concentrations at several distances from the center of the facility were estimated because of uncertainty regarding the size and location of the generic manufacturing facility. Estimates at 750 m from the center of the manufacturing facilities are comparable to estimates for options based on representative environmental settings (i.e., conversion and long-term storage options using the three current storage sites as representative of those settings).

For both options, by far the largest emissions, and hence impacts on air quality, would occur during construction of the manufacturing facility. Table H.11 presents a comparison of some of the pollutant impacts from construction of the two types of manufacturing facilities at a generic wet environmental setting. The estimated pollutant concentrations — carbon monoxide (CO), nitrogen oxides (NO_x), and PM_{10} (particulate matter with a mean diameter of 10 μm or less) — are all 9% or less of the applicable air quality standards, even at the closest distance from the emissions point. The ranges of impacts for the generic wet setting (as represented by the results in Table H.11) are greater than those estimated for a generic dry setting, and the uncertainties of the wet setting impacts are also greater.

The area source emissions during operation of the manufacturing facility for either option would be smaller than during construction. For both types of facility, operations would emit about 4% as much CO and NO_x and about 1.4% as much PM_{10} as would be emitted during construction. The impacts from these low emissions would be negligible.

The quantities of uranium oxide emitted during operation of either manufacturing facility are estimated to be quite small. The uranium oxide facility would emit only 8 g/yr of uranium as UO_2, which corresponds to an annual average concentration of about 1.6×10^{-7} μg/m^3 at a distance of 3,300 ft (1,000 m). The approximately 50 g/yr of uranium in triuranium octaoxide (U_3O_8) emitted by the uranium metal facility would produce an annual average uranium concentration of 9.9×10^{-7} μg/m^3 at 3,300 ft (1,000 m). Impacts on air quality would be negligible for both options.

No quantitative estimate was made of the impacts of operations on ozone conditions in the atmosphere. Ozone formation is a regional issue that would be affected by emissions for the entire area around a proposed manufacturing site. The pollutants most relevant to ozone formation that would result from the manufacturing options are hydrocarbons (HC) and NO_x. In later Phase II studies, when specific technologies and sites would be selected, the potential effects of these pollutants released from a proposed facility at a specific site could be evaluated relative to the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the total regional emissions would be unlikely to alter the ozone attainment status of the region.

TABLE H.11 Estimated Pollutant Emissions during Construction of a Shielding Manufacturing Facility in a Wet Environmental Setting[a]

Option/ Pollutant Distance/ from Source	Estimated Maximum Pollutant Emissions[b]							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range ($\mu g/m^3$)	Fraction of Standard[c]	Range ($\mu g/m^3$)	Fraction of Standard[c]	Range ($\mu g/m^3$)	Fraction of Standard[c]	Range ($\mu g/m^3$)	Fraction of Standard[c]
Uranium oxide								
CO								
750 m	78 – 150	0.0038	13 – 30	0.0030	–	–	–	–
1,000 m	71 –120	0.0030	10 – 23	0.0023	–	–	–	–
1,500 m	58 – 89	0.0022	6.5 – 14	0.0014	–	–	–	–
NO_x								
750 m	–	–	–	–	–	–	3.3 – 8.5	0.085
1,000 m	–	–	–	–	–	–	1.8 – 4.6	0.046
1,500 m	–	–	–	–	–	–	0.60 – 2.2	0.022
PM_{10}								
750 m	–	–	–	–	1.8 – 4.6	0.031	0.25 – 0.61	0.012
1,000 m	–	–	–	–	1.4 – 3.3	0.022	0.13 – 0.33	0.0066
1,500 m	–	–	–	–	0.81 – 2.2	0.015	0.062 – 0.16	0.0032
Uranium metal								
CO								
750 m	83 – 160	0.0040	14 – 32	0.0032	–	–	–	–
1,000 m	76 – 128	0.0032	11 – 24	0.0024	–	–	–	–
1,500 m	62 – 95	0.0024	6.9 – 15	0.0015	–	–	–	–
NO_x								
750 m	–	–	–	–	–	–	3.5 – 9.1	0.091
1,000 m	–	–	–	–	–	–	1.9 – 4.9	0.049
1,500 m	–	–	–	–	–	–	0.64 – 2.3	0.023
PM_{10}								
750 m	–	–	–	–	1.8 – 4.7	0.031	0.26 – 0.62	0.012
1,000 m	–	–	–	–	1.4 – 3.4	0.023	0.13 – 0.34	0.0068
1,500 m	–	–	–	–	0.83 – 2.3	0.015	0.063 – 0.16	0.0032

[a] Results for a generic wet setting bound the results for a generic dry setting.

[b] A hyphen (–) indicates that no standard is available for that averaging period.

[c] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

H.3.4 Water and Soil

The methodology used to determine water and soil impacts is presented in Appendix C and Tomasko (1997).

The environmental resource needs for the manufacturing options are summarized in Table H.12. The resource requirements (in particular, the paved area, volume of excavated material, and water usage) would be greater for the uranium metal option than for the uranium oxide option. Because the manufacture and use option is based on a generic site without a specified location and description, impacts could not be assessed on a site-specific basis; however, the impacts to surface

TABLE H.12 Summary of Environmental Parameters for the Manufacture and Use Options

		Requirements	
Shielding Option	Unit	Construction	Operations[a]
Uranium oxide			
Land area	acres	90	–
Disturbed land	acres	54	–
Building area	acres	14	–
Paved area	acres	15	–
Pond area	acres	2.7	–
Excavated material	yd^3	175,000	–
Hauled material	yd^3	85,500	–
Annual water	million gal/yr	35	7.5
Wastewater	million gal/yr	7.9	4.8
Uranium metal			
Land area	acres	90	–
Disturbed land	acres	54	–
Building area	acres	15	–
Paved area	acres	18	–
Pond area	acres	2.7	–
Excavated material	yd^3	180,000	–
Hauled material	yd^3	88,000	–
Annual water	million gal/yr	43	7.4
Wastewater	million gal/yr	8.5	5.0

[a] A hyphen (–) indicates no environmental resource needs.

water, groundwater, and soil would be smaller for the uranium oxide option because of its smaller resource requirements.

If the manufacture and use facility were located on a site having an area that was large compared with the size of the facility, and if the facility was near a river having a minimum flow that was large compared with annual water use and wastewater discharge, impacts to surface water, groundwater, and soil would be negligible. Negligible impacts would occur because a large site and large river could provide sufficient resource buffering to mitigate the effects produced by construction and operation of the facility.

On the other hand, if the site or the minimum flow in the river were small relative to the resource requirements, impacts would be larger. For example, if the minimum flow in the river was 500 gpm, the net annual water withdrawal would be about 15% of the flow. The impact of this relative withdrawal could produce moderate to large impacts to existing floodplains.

Similarly, if the facility was located in an urban area, paving 18 acres (7 ha) and constructing buildings on another 15 acres (6 ha) could seriously impact the local carrying capacity of storm-water runoff and produce local flooding. In addition, the paving and construction of the facility on a 90-acre (36-ha) site would produce moderate to large impacts to local soil permeability and erosion potential.

No process water effluents would be anticipated from the manufacturing facility (LLNL 1997), so no impacts to surface water quality would be expected. There are no accidents identified in the engineering analysis report (LLNL 1997) that would directly impact surface water. Secondary impacts resulting from deposition of airborne contaminants would not be measurable because of the low concentrations of deposited material.

H.3.5 Socioeconomics

Because the location of a shielding manufacturing facility has not yet been determined, the socioeconomic impacts of the shielding manufacturing options were analyzed on a non-site-specific basis for a generic site. The potential impacts of each facility on direct employment and direct income in the peak year of construction and in first year of operations are shown in Table H.13. Discussion of the assessment methodology is presented in Appendix C and Allison and Folga (1997).

Construction of a UO_2 shielding manufacturing facility would create 160 direct jobs and $7 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operations.

TABLE H.13 Potential Socioeconomic Impacts from Construction and Operation of the Shielding Manufacturing Facilities

Option/Parameter	Construction[a]	Operations[b]
Manufacture from UO_2		
Direct employment	160	470
Direct income ($ million 1996)	7	33
Manufacture from metal		
Direct employment	190	470
Direct income ($ million 1996)	9	33

[a] Impacts during the peak year of construction, 2007. Preoperations were assumed to occur from 1999 through 2008, with actual construction requiring 7 years.

[b] Impacts are the annual averages for operations for the period 2009 through 2028.

Construction of a metal shielding manufacturing facility would create 190 direct jobs and $9 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operations.

H.3.6 Ecology

Moderate adverse impacts to ecological resources could result from construction of a shielding manufacturing facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to facility operation would be negligible. Discussion of the methodology used to assess ecological impacts is presented in Appendix C.

H.3.6.1 Uranium Oxide

Site preparation for the construction of a uranium oxide shielding manufacturing facility would require the disturbance of approximately 54 acres (22 ha), including the permanent replacement of approximately 32 acres (13 ha) with structures, paved areas, and a storm-water pond. Existing vegetation would be destroyed during land-clearing activities. The facility would be included within a 90-acre (36-ha) area consisting of buildings, roads, and landscaped areas, which would be maintained as a controlled access area. The specific vegetation communities that would be eliminated by site preparation would depend on the location selected for the facility. The loss of

54 acres (22 ha) of undeveloped land and limited vegetation community development on the remainder of the 90-acre site would constitute a moderate adverse impact to vegetation. Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts from facility construction are summarized in Table H.14.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. Mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities, and thus competition for food and nesting sites, would increase in these areas, potentially reducing the survivability or reproductive capacity of displaced individuals. Some wildlife species would be expected to recolonize replanted areas near the manufacturing facility following completion of construction. The permanent loss of 32 to 90 acres (13 to 36 ha) of habitat due to the construction of a facility for manufacture of uranium oxide shielding would be considered a moderate adverse impact to wildlife.

Wetlands could potentially be eliminated or otherwise impacted during construction. Impacts to wetlands and aquatic habitats due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur. Unavoidable impacts to wetlands would require a

TABLE H.14 Impacts to Ecological Resources from Construction of the Manufacturing Facility

Option/Resource	Type of Impact	Degree of Impact
Uranium oxide		
Vegetation	Loss of 54 acres	Moderate adverse impact
Wildlife	Loss of 32 to 90 acres	Moderate adverse impact
Wetlands	Potential loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Potential adverse impact
Protected species	Potential destruction, habitat loss	Potential adverse impact
Uranium metal		
Vegetation	Loss of 54 acres	Moderate adverse impact
Wildlife	Loss of 36 to 90 acres	Moderate adverse impact
Wetlands	Potential loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Potential adverse impact
Protected species	Potential destruction, habitat loss	Potential adverse impact

Clean Water Act Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Prior to construction of a manufacturing facility, a survey for state and federally listed threatened, endangered, or candidate species, or species of special concern would be conducted. Impacts to these species could thus be avoided, or, where impacts were unavoidable, mitigation could be developed.

Ecological resources in the vicinity of the manufacturing facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section H.3.3). The maximum annual air concentration of UO_2 would be approximately 1.6×10^{-7} $\mu g/m^3$. Consequent impacts to biota would be expected to be negligible.

The manufacturing process would require withdrawal of water from surface waters or groundwater, as well as discharge of wastewater. Depending on the facility location, such withdrawal and discharge could potentially alter water levels (Section H.3.4). The altered water levels could, in turn, impact aquatic ecosystems, including wetlands, especially those located along the periphery of the affected surface water bodies.

Facility accidents, as discussed in Section H.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of the accident, season, and meteorological conditions.

H.3.6.2 Uranium Metal

The construction of a facility for the manufacture of depleted uranium metal shielding would generally result in the types of impacts associated with the manufacture of uranium oxide shielding. However, site preparation for the construction of a metal shielding manufacturing facility would require the disturbance of approximately 54 acres (22 ha), including the permanent replacement of approximately 36 acres (15 ha) of current land cover with structures, paved areas, and a storm-water pond. The facility would be included within a 90-acre (36-ha) area consisting of buildings, roads, and landscaped areas, which would be maintained as a controlled access area. The loss of 54 acres (22 ha) of undeveloped land and limited vegetation community development on the remainder of the 90-acre (36-ha) site would constitute a moderate adverse impact to vegetation.

The permanent loss of 36 to 90 acres (15 to 36 ha) of habitat would be considered a moderate adverse impact to wildlife. Impacts to ecological resources from operation of the uranium metal manufacturing facility would be similar to those due to operation of the uranium oxide facility.

H.3.7 Waste Management

For both options, the construction and operation of a depleted uranium shielding manufacture facility would generate LLW, hazardous waste, and nonhazardous waste. The LLW would consist of surface contaminated metals; noncombustible, noncompactible solids; dry active wastes; spent high-efficiency particulate air (HEPA) filters; and incinerator ash. Hazardous wastes generated would include paints, thinners, solvents, phenol, mercury (lamps), sulfuric acid, naphtha, lead (batteries), and pesticides.

Because the uranium oxide or uranium metal facility was assumed to be constructed at a generic, uncontaminated site, no radioactive waste would be generated during construction. About 94 and 105 yd^3 (72 and 80 m^3) of hazardous waste would be generated during construction for the uranium oxide and metal shielding facilities, respectively. These wastes would be sent to existing commercial treatment and disposal facilities. Nonhazardous waste generated during construction would be expected to total about 78,000 and 92,000 yd^3 (60,000 and 70,000 m^3), respectively, for the two options.

All radioactive wastes generated during operation of the uranium oxide or uranium metal facility would be routed to the facility waste management station. This part of the facility would include a grouting station and an incinerator. Failed mixers from a uranium oxide facility would be sent directly to disposal; all other facility wastes would be grouted. Spent HEPA filters would be drummed for disposal, and dry active waste would be incinerated, with the resulting ash grouted for disposal. Table H.15 lists expected LLW generation. The annual generation of 165 and 850 yd^3 (126 and 650 m^3) of LLW requiring disposal represents about 600 and 3,200 drums, respectively, per year and would represent about 0.2 and 1% of the projected annual LLW treatment volume for all DOE facilities nationwide (see Appendix C, Section C.10). All of the radioactive waste would be categorized as Class A by the NRC and would be suitable for near-surface disposal. Unlike the uranium oxide option, solidified ash waste from the uranium metal facility might require disposal in a special cell or mine. Hazardous wastes generated during operations are expected to be about 4 times the volume generated during construction. About 275 to 330 tons (250 to 300 metric tons) of nonhazardous waste would be generated annually and would be sent to commercial landfills.

No assumptions were made regarding the fate of the oxide- and metal-shielded casks after use. The empty casks could be recycled, stored, or disposed of as LLW.

TABLE H.15 Summary of Waste Volumes from the Manufacture of Depleted Uranium Shielding

Waste Type	Unit	Waste Volume	
		Uranium Oxide	Uranium Metal
Construction[a]			
Hazardous	m^3	71.6	79.5
Nonhazardous	m^3	60,000	70,000
Operations[b]			
Low-level waste	m^3/yr	126	650
Hazardous	m^3/yr	286	318
Nonhazardous	metric tons/yr	250	300

[a] Total volumes generated during the entire 7-year construction period.

[b] Annual volumes generated over normal operating lifetime of 20 years.

H.3.8 Resource Requirements

Resource requirements for the two manufacture and use options are presented in this section. These resource requirements are for the manufacturing of depleted uranium shielding only and do not include resources required for conversion to uranium oxide or uranium metal. Resource requirements for conversion are presented in Appendix F, Section F.3.8.

Estimated utilities and materials required for constructing a shielding manufacturing facility are listed in Table H.16 for the uranium oxide and uranium metal options (LLNL 1997). These required materials and chemicals are readily available and are not considered rare or unique. The total quantities of commonly used construction materials is not expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) are projected to be consumed during construction. Energy resources used during construction would include diesel fuel and gasoline for construction equipment and transportation vehicles. The required electricity would presumably be purchased from commercial utilities.

Energy resources required for operating the two types of shielding manufacturing facilities are shown in Table H.17. No strategic and critical materials (e.g., Monel or Inconel) are projected to be consumed for either construction or operations phases. Energy resources during operations would include the consumption of diesel fuel for operations equipment (including backup electrical generators) and natural gas for space heating. Small amounts of diesel fuel and natural gas are

TABLE H.16 Resource Requirements for Construction of Shielding Manufacturing Facilities

		Requirements	
Utility/Resource	Unit	Uranium Oxide	Uranium Metal
Utilities			
Electricity	MW-yr	4.7	4.9
Solids			
Concrete	yd^3	60,000	62,000
Steel	tons	11,600	12,000
Liquids			
Diesel fuel	million gal	0.61	0.63
Gasoline	million gal	0.2	0.2

Source: LLNL (1997).

TABLE H.17 Resource Requirements for Operation of Shielding Manufacturing Facilities

		Annual Requirement	
Resource	Unit	Uranium Oxide	Uranium Metal
Electricity	MW	3.8	4.7
Diesel fuel	gal	2,000	2,000
Natural gas	million scf	20	32

Source: LLNL (1997).

projected to be used. The required electricity would presumably be purchased from commercial utilities.

H.3.9 Land Use

The assessment of potential land-use impacts for the manufacturing and use options was based on a determination of areal requirements for each option and the potential for incompatibility. The uranium oxide and uranium metal options would result in similar moderate land-use impacts. Both facilities would have a total site requirement of 90 acres (36 ha), of which 54 acres (22 ha) would be disturbed or cleared (LLNL 1997). Although the uranium oxide facility would produce a slightly smaller volume of excavated material than the uranium metal facility, topographical modifications of on-site land could result under both options.

No site has been chosen for a uranium oxide or uranium metal facility, but selection of a site at or near a location that is already dedicated to or zoned for similar use could result in reduced land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land. Traffic patterns could experience potentially moderate level-of-service impacts from the peak year construction labor force. Any such traffic impacts, however, would be greatly reduced once post-construction operations begin.

H.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the manufacture and use options considered in this PEIS were implemented include impacts to cultural resources and environmental justice, as well as the visual environment (e.g., aesthetics), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of the manufacturing facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier *National Environmental Policy Act* (NEPA) documentation when specific sites are considered;

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS.

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APPENDIX I:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR DISPOSAL OF OXIDE

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NOTATION (APPENDIX I)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

BEMR	*The 1996 Baseline Environmental Management Report*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
LCF	latent cancer fatality
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
MCL	maximum contaminant level
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 μm or less
Rf	retardation factor
WM PEIS	*Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*

Chemicals

CO	carbon monoxide
HC	hydrocarbons
NO_x	nitrogen oxides
SO_x	sulfur oxides
UF_6	uranium hexafluoride
UO_2	uranium dioxide
$UO_3 \cdot H_2O$	schoepite (hydrous uranium oxide)
U_3O_8	triuranium octaoxide (uranyl uranate)

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UNITS OF MEASURE

cm	centimeter(s)
d	day(s)
ft	foot (feet)
ft^3	cubic foot (feet)
g	gram(s)
gal	gallon(s)
gpm	gallon(s) per minute
ha	hectare(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
lb	pound(s)
µg	microgram(s)
µm	micrometer(s)
m	meter(s)
m^3	cubic meter(s)
mi^2	square mile(s)
min	minute(s)
mrem	millirem(s)
MWh	megawatt-hour(s)
pCi	picocurie(s)
ppm	part(s) per million
rad	radiation absorbed dose(s)
rem	roentgen equivalent man
s	second(s)
scf	standard cubic foot (feet)
ton(s)	short ton(s)
yd^3	cubic yard(s)
yr	year(s)

APPENDIX I:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR DISPOSAL OF OXIDE

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the disposal options considered in the PEIS. The discussion provides background information for these options, as well as a summary of the estimated environmental impacts associated with each option.

Disposal Options

Depleted uranium material would be disposed of as low-level radioactive waste. The disposal options assessed in the PEIS were defined on the basis of the chemical form of the uranium and the type of disposal facility. The following disposal options were considered:

Disposal as U_3O_8. Depleted uranium could be disposed of as U_3O_8, either ungrouted (bulk) or grouted U_3O_8, following conversion. The disposal facilities considered included shallow earthen structures, belowground vaults, and an underground mine.

Disposal as UO_2. Similar to U_3O_8, depleted uranium could be disposed of as UO_2 following conversion, either in ungrouted or grouted form. The disposal facilities considered were the same as those considered for U_3O_8: shallow earthen structures, belowground vaults, and an underground mine.

Disposal is defined as the emplacement of material in a manner designed to ensure its isolation for the foreseeable future. For the PEIS disposal options, depleted uranium was assumed to be disposed of belowground as low-level radioactive waste beginning in 2009. Compared with long-term storage, disposal is considered permanent, with no intent to retrieve the material for future use. In fact, considerable and deliberate effort would be required to regain access to the material following disposal. Low-level radioactive waste disposal in burial facilities has been practiced in the United States for over 50 years.

The disposal options considered in the PEIS are defined by the chemical form of the depleted uranium to be disposed of and by the type of disposal facility. Two chemical forms of uranium oxides were evaluated: triuranium octaoxide (U_3O_8) and uranium dioxide (UO_2). These forms were considered because of their chemical stability; UF_6 and uranium metal are not considered acceptable forms because they are chemically reactive (Lawrence Livermore National Laboratory [LLNL] 1997). Three types of disposal facilities were considered for each chemical form: (1) shallow earthen structures (engineered "trenches"), (2) vaults, and (3) an underground mine. The chemical

forms and disposal options are summarized in Table I.1. Each type of disposal facility is described in Section I.2.

For each of the uranium oxides, two physical waste forms were considered in the PEIS, ungrouted and grouted. Ungrouted waste refers to U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process. This bulk material would be disposed of in either 55-gal (208-L) drums for U_3O_8 or 30-gal (110-L) drums for UO_2. Grouted waste refers to the solid material obtained by mixing the uranium oxides with cement and repackaging it in drums. Grouting is intended to increase structural strength and stability of the waste, and reduce the leaching rate of the waste in water. However, because cement is added to the uranium oxide, grouting would increase the total volume requiring disposal. Grouting of waste was assumed to occur at the disposal facility.

In general, disposal facilities would be stand-alone, single-purpose facilities consisting of a central receiving building/warehouse (called the wasteform facility) and several disposal units. Depending on the option, the disposal units would be a series of shallow earthen structures, vaults, or underground mine tunnels (called drifts). Activities at the disposal facility would include receipt of containers of depleted uranium oxide by truck or railcar, inspection of the containers, grouting the material if necessary, and placement of the containers into the disposal units. The disposal unit would then be backfilled with soil, sand, gravel, or other material and covered with multiple layers of natural material (such as clay) designed to minimize infiltration of water for long periods of time. The disposal facilities would be designed to protect the waste from the environment and prevent potential releases of material to the environment. Following disposal of the last containers, the disposal facility would be closed and then monitored and maintained for a period of time consistent with regulatory and license requirements.

The potential environmental impacts from the disposal options were evaluated on the basis of information provided in the engineering analysis report (LLNL 1997). For each disposal option, the engineering analysis report provides preconceptual facility design data, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and

TABLE I.1 Summary of Depleted Uranium Chemical Forms and Disposal Options Considered

	Disposal Option Considered		
Physical/ Chemical Form	Shallow Earthen Structure	Vault	Mine
Grouted U_3O_8	Yes	Yes	Yes
Ungrouted U_3O_8	Yes	Yes	Yes
Grouted UO_2	Yes	Yes	Yes
Ungrouted UO_2	Yes	Yes	Yes

descriptions of potential accident scenarios. This report also contains additional discussion of issues related to low-level radioactive waste (LLW) disposal and discusses the results of previous assessments of the long-term impacts of uranium disposal.

The potential environmental impacts from disposal would differ from those for the other options considered in the PEIS. Whereas the impacts from the other options would generally occur during the operational period of the facilities considered (40 years or less), the impacts from disposal might occur hundreds to thousands of years after the facility had ceased operating. Thus, disposal impacts were estimated for two phases: (1) the operational phase, which includes construction of the facility and the period in which waste would be actively placed into disposal units, and (2) the post-closure phase, which considers hundreds of years in the future, beyond the time that any engineered disposal facilities would be expected to function as designed. The environmental impacts for the operational phase are presented in Section I.3, and those for the post-closure phase are presented in Section I.4.

Potential impacts during the operational phase, which would include construction activities and the handling of waste containers as they were placed into disposal units, would primarily affect workers. In addition, some potential impacts to the public would occur from air emissions during grouting of the waste. The potential impacts during the post-closure phase would affect only the public and would follow the eventual release of material from the disposal facility to the environment. For assessment purposes, all disposal facilities were assumed to fail, or release waste to the environment, at the end of an institutional control period (failure was assumed to occur around the year 2140, 100 years after site closure). Because of the infiltration of water, uranium would ultimately migrate through the soil, eventually contaminating the groundwater and potentially exposing members of the public. Post-closure impacts were estimated at 1,000 years after the disposal facilities were assumed to fail.

The potential environmental impacts from the disposal options were not determined on a site-specific basis because the location of a disposal facility would not be decided until sometime in the future. Instead, for assessment purposes, two generic environmental settings were defined, a generic dry setting and a generic wet setting. The conditions of the dry setting would be typical of a site in the arid western United States, and the conditions of the wet setting would be typical of a site in the eastern United States.

The estimated impacts associated with the disposal options are subject to a great deal of uncertainty, especially for the post-closure period. The degree of uncertainty in the disposal impacts is greater than that for the other categories of options in the PEIS, because disposal impacts consider an extremely long period of time and depend on predicting the behavior of the waste material as it interacts with soil and water in a complex and changing environment. Consequently, the estimated disposal impacts are very dependent on the assumptions made for the assessment, including such key factors as soil characteristics, water infiltration rates, depth to underlying groundwater table, chemistry of different uranium compounds, and locations of future human receptors. These factors

could vary widely depending on site-specific conditions. Therefore, a range of these factors was selected for analysis to represent the range of actual conditions that could occur.

I.1 SUMMARY OF DISPOSAL OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with the disposal of depleted uranium oxides in shallow earthen structures, vaults, and a mine during two distinct phases: (1) the operational phase and (2) the post-closure phase. Analysis of the operational phase included facility construction and the time during which waste would be actively placed in disposal units (2009 through 2028). Analysis of the post-closure phase considered potential impacts 1,000 years after the disposal units fail (i.e., release uranium material to the environment). For each phase, impacts were estimated for both generic wet and dry environmental settings. Additional discussion and details related to the assessment methodologies and results for each area of impact are provided in Section I.3 for the operational phase and Section I.4 for the post-closure phase.

For the operational phase, the potential environmental impacts for disposal of U_3O_8 and UO_2 are summarized in Tables I.2 and I.3, respectively. Within each table, the potential impacts are presented first for the grouted form and then for the ungrouted form. The following is a general summary of potential environmental impacts during the operational phase:

- ***Potential Adverse Impacts.*** Potential adverse impacts during the operational phase would be small and generally similar for all options. Minor to moderate impacts would occur during construction activities, although these impacts would be temporary and easily mitigated by common engineering and construction practices. Impacts during waste emplacement activities also would be small and limited to involved and noninvolved workers.

- ***Wet or Dry Environmental Setting.*** In general, potential impacts would be similar for generic wet and dry environmental settings during the operational phase.

- ***U_3O_8 or UO_2.*** The potential disposal impacts tend to be slightly larger for U_3O_8 than for UO_2 because the volume of U_3O_8 would be greater and most environmental impacts tend to be proportional to the volume.

- ***Grouted or Ungrouted Waste.*** For both U_3O_8 and UO_2, the disposal of grouted waste would result in larger impacts than disposal of ungrouted waste during the operational phase for two reasons: (1) grouting increases the volume of waste requiring disposal (by about 50%) and (2) grouting operations result in small emissions of uranium material to the air and water.

TABLE I.2 Summary of Disposal Option Impacts for U_3O_8 during the Operational Phase[a]

A. Grouted

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in a Mine
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 480 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 520 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 720 person-rem Total number of LCFs: 0.3 LCF
Noninvolved Workers: Annual dose to MEI : 0.0021 – 0.0088 mrem/yr Annual cancer risk to MEI: $8 \times 10^{-10} - 4 \times 10^{-9}$ per year Total collective dose: 0.00054 – 0.0035 person-rem Total number of LCFs: $2 \times 10^{-7} - 1 \times 10^{-6}$ LCF	**Noninvolved Workers:** Annual dose to MEI : 0.0021 – 0.0088 mrem/yr Annual cancer risk to MEI: $8 \times 10^{-10} - 4 \times 10^{-9}$ per year Total collective dose: 0.00059 – 0.0038 person-rem Total number of LCFs: $2 \times 10^{-7} - 2 \times 10^{-6}$ LCF	**Noninvolved Workers:** Annual dose to MEI : 0.00084 – 0.0085 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-10} - 3 \times 10^{-9}$ per year Total collective dose: 0.00057 – 0.0036 person-rem Total number of LCFs: $2 \times 10^{-7} - 1 \times 10^{-6}$ LCF
General Public: Annual dose to MEI: 0.0061 – 0.026 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} - 1 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem Total number of LCFs in population within 50 miles: $2 \times 10^{-5} - 6 \times 10^{-5}$ LCF	**General Public:** Annual dose to MEI: 0.0060 – 0.020 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} - 1 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem Total number of LCFs in population within 50 miles: $2 \times 10^{-5} - 6 \times 10^{-5}$ LCF	**General Public:** Annual dose to MEI: 0.0061 – 0.026 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} - 1 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.037 – 0.11 person-rem Total number of LCFs in population within 50 miles: $2 \times 10^{-5} - 6 \times 10^{-5}$ LCF
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 140 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 140 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 140 rem
Risk of LCF to MEI: 0.06	Risk of LCF to MEI: 0.06	Risk of LCF to MEI: 0.06
Collective dose: 6.1 person-rem	Collective dose: 6.1 person-rem	Collective dose: 6.1 person-rem
Number of LCFs: 0.002	Number of LCFs: 0.002	Number of LCFs: 0.002
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem
Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}
Collective dose to population within 50 miles: 1.5 person-rem	Collective dose to population within 50 miles: 1.5 person-rem	Collective dose to population within 50 miles: 1.5 person-rem
Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: **All Workers:** Less than 1 (0.26) fatality, approximately 210 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.44) fatality, approximately 300 injuries	**Construction and Operations:** **All Workers** Approximately 1 fatality, approximately 450 injuries
Air Quality		
Construction: Annual NO_x concentration potentially as large as 3% of standard; other criteria pollutant concentrations between 0.2 and 2% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 13% of standard; other criteria pollutant concentration between 0.3 and 4% of respective standards	**Construction:** All pollutant concentrations below 0.1% of respective standards
Operations: Annual NO_x concentration potentially as large as 7% of standard; other criteria pollutant concentrations between 0.3 and 3% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 37% of standard; other criteria pollutant concentrations between 0.8 and 10% of respective standards	**Operations:** All pollutant concentrations below 0.02% of respective standards
Water [b]		
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
Soil [b]		
Construction: Negligible, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Construction: Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income

TABLE I.2 (Cont.)

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in a Mine
	Ecology	
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential large impacts to vegetation and wildlife	**Construction:** Potential large impacts to vegetation and wildlife
Operations: Potential adverse impacts to aquatic biota	**Operations:** Potential adverse impacts to aquatic biota	**Operations:** Potential adverse impacts to aquatic biota
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 85 acres; potential moderate impacts	Use of approximately 149 acres; potential moderate impacts	Use of approximately 471 acres; potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction
B. Ungrouted		
Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
	Human Health – Normal Operations: Radiological	
Involved Workers: Total collective dose: 280 person-rem	**Involved Workers:** Total collective dose: 300 person-rem	**Involved Workers:** Total collective dose: 360 person-rem
Total number of LCFs: 0.1 LCF	Total number of LCFs: 0.1 LCF	Total number of LCFs: 0.1 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts
	Human Health – Normal Operations: Chemical	
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE I.2 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 130 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 130 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 130 rem
Risk of LCF to MEI: 0.05	Risk of LCF to MEI: 0.05	Risk of LCF to MEI: 0.05
Collective dose: 5.6 person-rem	Collective dose: 5.6 person-rem	Collective dose: 5.6 person-rem
Number of LCFs: 0.002	Number of LCFs: 0.002	Number of LCFs: 0.002
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 1 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 1 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 1 rem
Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}	Risk of LCF to MEI: 5×10^{-4}
Collective dose to population within 50 miles: 1.3 person-rem	Collective dose to population within 50 miles: 1.3 person-rem	Collective dose to population within 50 miles: 1.3 person-rem
Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF	Number of LCFs in population within 50 miles: 0.0007 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person	Number of persons with potential for adverse effects: 1 person
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 1 person
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.2 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: **All Workers:** Less than 1 (0.13) fatality, approximately 90 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.22) fatality, approximately 140 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.53) fatality, approximately 240 injuries
Air Quality		
Construction: Annual NO_x concentration potentially as large as 1.3% of standard; all other criteria pollutant concentrations between 0.07 and 0.6% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 3.5% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards	**Construction:** All pollutant concentrations below 0.1% of respective standards
Operations: Annual NO_x concentration potentially as large as 2.3% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 10% of standard; all other criteria pollutant concentrations between 0.3 and 3% of respective standards	**Operations:** All pollutant concentrations below 0.02% of respective standards
Water[b]		
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
Soil[b]		
Construction: Negligible, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Construction: Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income

TABLE I.2 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
	Ecology	
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife	**Construction:** Potential large impacts to vegetation and wildlife
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** Negligible impacts
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 46 acres; negligible impacts	Use of approximately 75 acres; potential moderate impacts	Use of approximately 232 acres; potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

[a] Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

[b] Impacts are based on a site that would be large compared to the area of the facility, with a nearby river having a minimum flow that would be large compared to water use and discharge requirements.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides; ROI = region of influence.

TABLE I.3 Summary of Disposal Option Impacts for UO_2 during the Operational Phase[a]

A. Grouted

Impacts from Disposal as Grouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Grouted UO_2 in Vaults	Impacts from Disposal as Grouted UO_2 in a Mine
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 420 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 440 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 480 person-rem Total number of LCFs: 0.2 LCF
Noninvolved Workers: Annual dose to MEI : 0.0032 – 0.017 mrem/yr Annual cancer risk to MEI: $1 \times 10^{-9} - 7 \times 10^{-9}$ per year Total collective dose: 0.00055 – 0.0036 person-rem Total number of LCFs: $2 \times 10^{-7} - 1 \times 10^{-6}$ LCF	**Noninvolved Workers:** Annual dose to MEI : 0.0037 – 0.017 mrem/yr Annual cancer risk to MEI: $1 \times 10^{-9} - 7 \times 10^{-9}$ per year Total collective dose: 0.00061 – 0.0040 person-rem Total number of LCFs: $2 \times 10^{-7} - 2 \times 10^{-6}$ LCF	**Noninvolved Workers:** Annual dose to MEI : 0.0016 – 0.016 mrem/yr Annual cancer risk to MEI: $6 \times 10^{-10} - 6 \times 10^{-9}$ per year Total collective dose: 0.00055 – 0.0036 person-rem Total number of LCFs: $2 \times 10^{-7} - 1 \times 10^{-6}$ LCF
General Public: Annual dose to MEI: 0.012 – 0.050 mrem/yr Annual cancer risk to MEI: $6 \times 10^{-9} - 2 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem Total number of LCFs in population within 50 miles: $4 \times 10^{-5} - 1 \times 10^{-4}$ LCF	**General Public:** Annual dose to MEI: 0.012 – 0.050 mrem/yr Annual cancer risk to MEI: $6 \times 10^{-9} - 2 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem Total number of LCFs in population within 50 miles: $4 \times 10^{-5} - 1 \times 10^{-4}$ LCF	**General Public:** Annual dose to MEI: 0.012 – 0.050 mrem/yr Annual cancer risk to MEI: $6 \times 10^{-9} - 2 \times 10^{-8}$ per year Total collective dose to population within 50 miles: 0.071 – 0.21 person-rem Total number of LCFs in population within 50 miles: $4 \times 10^{-5} - 1 \times 10^{-4}$ LCF
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Grouted UO_2 in Vaults	Impacts from Disposal as Grouted UO_2 in a Mine
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.27 rem
Risk of LCF to MEI: 1×10^{-4}	Risk of LCF to MEI: 1×10^{-4}	Risk of LCF to MEI: 1×10^{-4}
Collective dose: 0.011 person-rem	Collective dose: 0.011 person-rem	Collective dose: 0.011 person-rem
Number of LCFs: 5×10^{-6}	Number of LCFs: 5×10^{-6}	Number of LCFs: 5×10^{-6}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.0021 rem
Risk of LCF to MEI: 1×10^{-6}	Risk of LCF to MEI: 1×10^{-6}	Risk of LCF to MEI: 1×10^{-6}
Collective dose to population within 50 miles: 0.0027 person-rem	Collective dose to population within 50 miles: 0.0027 person-rem	Collective dose to population within 50 miles: 0.0027 person-rem
Number of LCFs in population within 50 miles: 1×10^{-6} LCF	Number of LCFs in population within 50 miles: 1×10^{-6} LCF	Number of LCFs in population within 50 miles: 1×10^{-6} LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Grouted UO_2 in Vaults	Impacts from Disposal as Grouted UO_2 in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: **All Workers:** Less than 1 (0.23) fatality, approximately 180 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.26) fatality, approximately 190 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.50) fatality, approximately 280 injuries
Air Quality		
Construction: Annual NO_x concentration potentially as large as 0.9% of standard; all other criteria pollutant concentrations between 0.05 and 0.6% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 1% of standard; all other criteria pollutant concentrations between 0.04 and 0.4% of respective standards	**Construction:** All pollutant concentrations less than 10% of concentrations from shallow earthen structure construction
Operations: Annual NO_x concentration potentially as large as 1.8% of standard; all other criteria pollutant concentrations between 0.1 and 1.1% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 5.6% of standard; all other criteria pollutant concentrations between 0.2 and 2% of respective standards	**Operations:** All pollutant concentrations about 10% of those from mine construction
Water[b]		
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
Soil[b]		
Construction: Negligible, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Construction: Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income	**Construction:** Potential moderate impacts on employment and income
Operations: Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income	**Operations:** Potential moderate impacts on employment and income

TABLE I.3 (Cont.)

Impacts from Disposal as Grouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Grouted UO_2 in Vaults	Impacts from Disposal as Grouted UO_2 in a Mine
	Ecology	
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife	**Construction:** Potential large impacts to vegetation and wildlife
Operations: Potential adverse impacts to aquatic biota	**Operations:** Potential adverse impacts to aquatic biota	**Operations:** Potential adverse impacts to aquatic biota
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 39 acres; negligible impacts	Use of approximately 41 acres; negligible impacts	Use of approximately 149 acres; potential moderate impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction
B. Ungrouted		
Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
	Human Health – Normal Operations: Radiological	
Involved Workers: Total collective dose: 170 person-rem Total number of LCFs: 0.07 LCF	**Involved Workers:** Total collective dose: 220 person-rem Total number of LCFs: 0.09 LCF	**Involved Workers:** Total collective dose: 240 person-rem Total number of LCFs: 0.09 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts
	Human Health – Normal Operations: Chemical	
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE I.3 (Cont.)

Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
	Human Health – Accidents: Radiological	
Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.22 rem
Risk of LCF to MEI: 9×10^{-5}	Risk of LCF to MEI: 9×10^{-5}	Risk of LCF to MEI: 9×10^{-5}
Collective dose: 12 person-rem	Collective dose: 12 person-rem	Collective dose: 12 person-rem
Number of LCFs: 0.005	Number of LCFs: 0.005	Number of LCFs: 0.005
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.0017 rem
Risk of LCF to MEI: 8×10^{-7}	Risk of LCF to MEI: 8×10^{-7}	Risk of LCF to MEI: 8×10^{-7}
Collective dose to population within 50 miles: 0.046 person-rem	Collective dose to population within 50 miles: 0.046 person-rem	Collective dose to population within 50 miles: 0.046 person-rem
Number of LCFs in population within 50 miles: 2×10^{-5} LCF	Number of LCFs in population within 50 miles: 2×10^{-5} LCF	Number of LCFs in population within 50 miles: 2×10^{-5} LCF
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years	Bounding accident frequency: 1 in 100 years to 1 in 100,000 years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons	Number of persons with potential for adverse effects: 0 persons
Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 0 persons

TABLE I.3 (Cont.)

Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
Human Health — Accidents: Physical Hazards		
Construction and Operations: **All Workers:** Less than 1 (0.13) fatality, approximately 90 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.15) fatality, approximately 110 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.33) fatality, approximately 170 injuries
Air Quality		
Construction: Annual NO_x concentration potentially as large as 0.6% of standard; all other criteria pollutant concentrations between 0.04 and 0.4% of respective standards	**Construction:** Annual NO_x concentration potentially as large as 0.6% of standard; all other criteria pollutant concentrations between 0.03 and 0.3% of respective standards	**Construction:** All pollutant concentrations less than 10% of concentration from shallow earthen structure construction
Operations: Annual NO_x concentration potentially as large as 1.3% of standard; all other criteria pollutant concentrations between 0.08 and 0.8% of respective standards	**Operations:** Annual NO_x concentration potentially as large as 3.3% of standard; all other criteria pollutant concentrations between 0.1 and 1.3% of respective standards	**Operations:** All pollutant concentrations about 10% of those from mine construction
Water[b]		
Construction: Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Negligible impacts to surface water and groundwater
Operations: None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater	**Operations:** None to negligible impacts to surface water and groundwater
Soil[b]		
Construction: Negligible, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts	**Construction:** Moderate to large, but temporary, impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Potential moderate impacts on employment and income	Potential moderate impacts on employment and income	Potential moderate impacts on employment and income
Ecology		
Construction: Potential moderate impacts to vegetation and wildlife	**Construction:** Potential moderate impacts to vegetation and wildlife	**Construction:** Potential large impacts to vegetation and wildlife
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** Negligible impacts

TABLE I.3 (Cont.)

Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 28 acres; negligible impacts	Use of approximately 28 acres; negligible impacts	Use of approximately 102 acres; potential moderate impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

[a] Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

[b] Impacts are based on a site that would be large compared to the area of the facility, with a nearby river having a minimum flow that would be large compared to water use and discharge requirements.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides; ROI = region of influence.

- ***Shallow Earthen Structure, Vault, or Mine.*** The potential impacts are essentially similar for disposal in a shallow earthen structure, vault, or mine. However, disposal in a mine could create slightly larger potential impacts if excavation of the mine was required (use of an existing mine would minimize impacts).

For the post-closure phase, the potential environmental impacts for disposal of U_3O_8 and UO_2 are summarized in Tables I.4 and I.5, respectively. Impacts were calculated for a post-failure time of 1,000 years. The potential impacts estimated for the post-closure phase are subject to a great deal of uncertainty because of the extremely long time period considered and the dependence of predictions on the behavior of the waste material as it interacts with soil and water in a distant future environment. The post-closure impacts would depend greatly on the specific disposal facility design and site-specific characteristics. Because of these uncertainties, the assessment assumptions are generally selected to produce conservative estimates of impact, that is, they tend to overestimate the expected impact. Changes in key disposal assumptions could yield significantly different results (see Section I.4).

The following is presented as a general summary of potential environmental impacts during the post-closure phase (from information in Tables I.4 and I.5 and Section I.4):

- ***Potential Adverse Impacts.*** For all disposal options, potentially large impacts to human health and groundwater quality could occur within 1,000 years after failure of a facility in a wet setting, whereas essentially no impacts would occur for a dry setting in the same time frame. Potential impacts would result primarily from the contamination of groundwater. The maximum dose to an individual assumed to live at the edge of the disposal site and use the contaminated water was estimated to be about 110 mrem/yr, which would exceed the 25-mrem/yr limit specified in 10 *Code of Federal Regulations* [CFR] Part 61 and DOE Order 5820.2A. (For comparison, the average dose to an individual from background radiation is about 360 mrem/yr.) Possible exposures (on the order of 10 rem/yr) could occur for shallow earthen structures and vaults if the cover material were to erode and expose the uranium material; however, this would not occur until several thousand years later, and the exposure could be eliminated by adding new cover material to the top of the waste area.

- ***Wet or Dry Environmental Setting.*** The potential impacts would be significantly greater in a wet setting than a dry setting. Essentially no impacts would be expected in a dry setting for more than 1,000 years because of the low water infiltration rate and greater depth to the water table.

TABLE I.4 Summary of Disposal Option Impacts for U_3O_8 during the Post-Closure Phase[a,b]

A. Grouted

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 49 – 72 mrem/yr	**General Public:** Annual dose to MEI: 57 – 84 mrem/yr	**General Public:** Annual dose to MEI: 1 – 110 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 4 \times 10^{-5}$ per year	Annual cancer risk to MEI: $3 \times 10^{-5} - 4 \times 10^{-4}$ per year	Annual cancer risk to MEI: $4 \times 10^{-7} - 5 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined
Human Health: Chemical		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
Water		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
Ecology		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

B. Ungrouted

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 41 – 60 mrem/yr	**General Public:** Annual dose to MEI: 48 – 70 mrem/yr	**General Public:** Annual dose to MEI: 1 – 93 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $2 \times 10^{-5} - 4 \times 10^{-5}$ per year	Annual cancer risk to MEI: $4 \times 10^{-7} - 5 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined

TABLE I.4 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
	Human Health: Chemical	
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
	Water	
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
	Ecology	
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

[a] Impacts for the post-closure phase were calculated for a time 1,000 years after each disposal facility was assumed to fail. Impacts are presented for a generic wet setting; no impacts would be expected within 1,000 years in a dry setting.

[b] All disposal facilities would be designed to contain the waste material for at least hundreds of years. Shallow earthen structures would be expected to last several hundred years before failure; vaults and mines would be expected to last several hundreds to thousands of years before failure.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual.

TABLE I.5 Summary of Disposal Option Impacts for UO_2 during the Post-Closure Phase[a,b]

A. Grouted

Impacts from Disposal as Grouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Grouted UO_2 in Vaults	Impacts from Disposal as Grouted UO_2 in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 37 – 54 mrem/yr	**General Public:** Annual dose to MEI: 38 – 56 mrem/yr	**General Public:** Annual dose to MEI: 1 – 84 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $3 \times 10^{-7} - 4 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined
Human Health: Chemical		
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
Water		
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
Ecology		
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

B. Ungrouted

Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
Human Health: Radiological		
General Public: Annual dose to MEI: 34 – 50 mrem/yr	**General Public:** Annual dose to MEI: 34 – 50 mrem/yr	**General Public:** Annual dose to MEI: 1 – 77 mrem/yr
Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $2 \times 10^{-5} - 3 \times 10^{-5}$ per year	Annual cancer risk to MEI: $2 \times 10^{-7} - 4 \times 10^{-5}$ per year
Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined	Collective dose to population within 50 miles: not determined
Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined	Number of LCFs in population within 50 miles: not determined

TABLE I.5 (Cont.)

Impacts from Disposal as Ungrouted UO_2 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted UO_2 in Vaults	Impacts from Disposal as Ungrouted UO_2 in a Mine
	Human Health: Chemical	
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
	Water	
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
	Ecology	
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

[a] Impacts for the post-closure phase were calculated for a time 1,000 years after each disposal facility was assumed to fail. Impacts are presented for a generic wet setting; no impacts would be expected within 1,000 years in a dry setting.

[b] All disposal facilities would be designed to contain the waste material for at least hundreds of years. Shallow earthen structures would be expected to last several hundred years before failure; vaults and mines would be expected to last several hundreds to thousands of years before failure.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual.

- ***U_3O_8 or UO_2.*** Overall, the potential environmental impacts tend to be slightly larger for U_3O_8 than for UO_2 because the volume of U_3O_8 requiring disposal would be greater than that for UO_2. A larger volume essentially exposes a greater area of waste to infiltrating water.

- ***Grouted or Ungrouted Waste.*** For both U_3O_8 and UO_2, the disposal of grouted waste would have larger environmental impacts than disposal of ungrouted waste once the waste was exposed to the environment because grouting would increase the waste volume. However, further studies using site-specific soil characteristics are necessary to determine the effect of grouting on long-term waste mobility. Grouting might reduce the dissolution rate of the waste and subsequent leaching of uranium into the groundwater in the first several hundred years after failure. However, over longer periods the grouted form would be expected to deteriorate and, because of the long half-life of uranium, the performance of grouted and ungrouted waste would be essentially the same. Depending on soil properties and characteristics of the grout material, it is also possible that grouting could increase the solubility of the uranium material by providing a carbonate-rich environment.

- ***Shallow Earthen Structure, Vault, or Mine.*** Because of the long time periods considered and the fact that the calculations were performed for a time of 1,000 years *after* each facility was assumed to fail, the potential impacts are very similar for disposal in a shallow earthen structure, vault, or mine. However, shallow earthen structures would be expected to contain the waste material for a period of at least several hundred years before failure, whereas vaults and a mine would be expected to last even longer — from several hundred years to a thousand years or more. Therefore, vault and mine disposal would provide greater protection of waste in a wet environment. In addition, a vault and a mine would be expected to provide additional protection against erosion of the cover material (and possible surface exposure of the waste material) compared to shallow earthen structures. The exact time that any disposal facility would perform as designed would depend on the specific facility design and site characteristics.

I.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the different disposal options considered in the assessment of disposal impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, such as descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

The three disposal options considered are (1) shallow earthen structures (engineered "trenches"), (2) vaults, and (3) an underground mine. For each option, the U_3O_8 and UO_2 would be packaged for disposal as follows:

- U_3O_8 would be disposed of in 55-gal (208-L) drums. If ungrouted, approximately 714,000 drums would be required; if grouted, approximately 1,500,000 drums would be required.

- UO_2 would be disposed of in 30-gal (110-L) drums. These small drums would be used because of the greater density of UO_2 — a filled 30-gal (110-L) drum would weigh about 2,350 lb (1,070 kg). If ungrouted, approximately 420,000 drums would be required; if grouted, approximately 630,000 drums would be required.

All disposal options would include a central wasteform facility where drums of uranium oxide would be received from the conversion facility and prepared for disposal. The wasteform facility would include an administration building, a receiving warehouse, and cementing/curing/short-term storage buildings (if necessary). Grouting of waste would be performed by mechanically mixing the uranium oxide with cement in large tanks and then pouring the mixture into drums. Once prepared for disposal (if necessary), drums would be moved into disposal units. For the grouted U_3O_8 option, the area of the wasteform facility would be approximately 9 acres (3.6 ha); for the grouted UO_2 option, the area would be about 6 acres (2.4 ha). For ungrouted disposal options, only about 4 acres (1.6 ha) would be required because the facilities for grouting, curing, and additional short-term storage would not be needed. The unique features of each disposal option are described in Sections I.2.1 through I.2.3.

I.2.1 Disposal in Shallow Earthen Structures

Shallow earthen structures, commonly referred to as engineered trenches, are among the most commonly used forms of low-level waste disposal, especially in dry climates. Shallow earthen structures would be excavated to a depth of about 26 ft (8 m), with the length and width determined by site conditions and the annual volume of waste to be disposed of. Disposal in shallow earthen structures would consist of placing waste on a stable structural pad with barrier walls constructed of compacted clay. Clay would be used because it prevents the walls from collapsing or caving in, and it presents a relatively impermeable barrier to waste migration. The waste containers (i.e., drums) would be tightly stacked three pallets high in the bottom of the structure with forklifts. Any open space between containers would be filled with earth, sand, gravel, or other similar material as each layer of drums was placed. After the structure was filled, a 6 ft (2 m) thick cap composed of engineered fill dirt and clay would be placed on top and compacted. The cap would be mounded at least 3 ft (1 m) above the local grade and sloped to minimize the potential for water infiltration. Disposal of ungrouted and grouted U_3O_8 would require about 42 acres (17 ha) and 76 acres (31 ha),

respectively. Disposal of ungrouted and grouted UO_2 would require about 24 acres (10 ha) and 33 acres (14 ha), respectively.

I.2.2 Disposal in Vaults

Vaults for disposal would be similar to those described previously for the storage options (Appendix G, Section G.2.3), except that each vault would be divided into five sections, each section approximately 66 ft (20 m) long by 26 ft (8 m) wide and 13 ft (4 m) tall. As opposed to shallow earthen structures, the walls and floor of a vault would be constructed of reinforced concrete. A crane would be used to place drums within each section. Once a vault was full, any open space between containers would be filled with earth, sand, gravel, or other similar material. A permanent roof slab of reinforced concrete that completely covers the vault would be installed after all five sections were filled. A cap of engineered fill dirt and clay would be placed on top of the concrete cover and compacted. The cap would be mounded above the local grade and sloped to minimize the potential for water infiltration. Disposal of ungrouted and grouted U_3O_8 would require about 71 and 140 acres (28 and 56 ha), respectively. Disposal of ungrouted and grouted UO_2 would require about 24 and 35 acres (10 and 15 ha), respectively.

I.2.3 Disposal in a Mine

An underground mine disposal facility would be a repository for permanent deep geological disposal. A mined disposal facility could possibly use a previously existing mine, or be constructed for the sole purpose of waste disposal. For purposes of comparing alternatives, the conservative assumption of constructing a new mine was assessed for this PEIS. A mine disposal facility would consist of surface facilities that provide space for waste receiving and inspection (the wasteform facility), and shafts and ramps for access to and ventilation of the underground portion of the repository. The underground portion would consist of tunnels (called "drifts") for the transport and disposal of waste underground. The dimensions of the drifts would be similar to those described previously for the storage options (Section G.2.4), except that each drift would have a width of 21 ft (6.5 m). Waste containers would be placed in drifts and backfilled. Disposal of ungrouted and grouted U_3O_8 would require about 228 acres (91 ha) and 462 acres (185 ha) of underground disposal space, respectively. Disposal of ungrouted and grouted UO_2 would require about 98 acres (39 ha) and 143 acres (57 ha), respectively.

I.2.4 Disposal Technologies and Chemical Forms Considered But Not Analyzed

Disposal of depleted uranium metal was not considered because uranium metal is not as chemically stable as U_3O_8 or UO_2. Uranium metal is subject to surface oxidation. Similarly, disposal of UF_6 and UF_4 were not considered because they react with water to form HF, which is a hazardous

and corrosive chemical that would degrade the containment for the waste material. These characteristics are considered unacceptable for disposal.

I.3 IMPACTS OF OPTIONS — OPERATIONAL PHASE

Potential impacts analyzed for the operational phase of the disposal options included impacts occurring during facility construction and during the 20-year period when the waste material would be actively placed into disposal units. (The potential environmental impacts for the post-closure period, after the disposal facility ceased operations, are presented in Section I.4). The estimated impacts are discussed for each area of impact. Information related to the assessment methodologies is provided in Appendix C.

The environmental impacts from the operational phase were evaluated based on the information described in the engineering analysis report (LLNL 1997). The following general assumptions apply to the assessment of impacts:

- Impacts during the operational phase include those from preliminary facility construction and the 20-year period (2008 to 2028) when waste material (i.e., depleted uranium oxide from the DOE-generated inventory) would be actively placed into disposal units. Construction of disposal units would continue over the 20-year period while waste material was being received.

- Ungrouted U_3O_8 and ungrouted UO_2 would be disposed of directly without additional processing at the disposal facility. Consequently, no air or water emissions would be associated with normal (nonaccident) operations, except for exhaust emissions from equipment used during disposal.

- Grouting of U_3O_8 and UO_2 would occur at the disposal facility and consist of mixing the uranium material with cement and pouring it into drums. Grouting operations would result in the release of small amounts of uranium material to the air and water during normal operations.

- The potential impacts from disposal were analyzed for generic dry and wet environmental settings. The historical meteorological conditions for five actual "dry" locations in the southwestern United States and five actual "wet" locations in the central and southeastern United States were used to develop estimates for the generic sites. It was assumed that a disposal facility would not be located in an urban area. Therefore, analyses for both dry and wet environmental settings assumed a rural population density corresponding to 15 persons/mi^2 (6 persons/km^2).

The potential environmental impacts from the disposal options were not evaluated on a site-specific basis because the location of a disposal facility would not be chosen until sometime in the future (see Chapter 3). A more detailed assessment of site considerations would be addressed, as appropriate, as part of the Phase II reviews of the programmatic *National Environmental Policy Act* (NEPA) approach.

I.3.1 Human Health — Normal Operations

I.3.1.1 Radiological Impacts

Radiological impacts during normal operations of the facility were estimated for involved workers, noninvolved workers, and members of the general public. External radiation resulting from the handling and shipping of uranium materials would be the major source of exposure for involved workers. Because grouted waste would increase the total volume of waste substantially, thereby increasing the number of waste containers for handling and shipping, impacts to involved workers would be greater from grouted waste than ungrouted waste. Variations in exposures for the three disposal types considered (shallow earthen structures, vaults, or mine) would be caused by different practices for different technologies. Disposal in a mine would require transport of waste containers from the ground surface to the underground cavities, whereas disposal in shallow earthen structures and vaults would require filling and capping efforts to cover the waste containers with dirt, cement, and/or other engineering materials. In general, average radiation exposure of involved workers would be less than 630 mrem/yr.

Exposures for noninvolved workers and the general public would result from releases of uranium compounds from the grouting facility. Radiation doses from both airborne and waterborne pathways would be less than 0.05 mrem/yr and would tend to be similar between dry and wet environmental settings.

The estimated results for different disposal options are listed in Tables I.6 and I.7. Detailed discussions of the methodology used in the radiological impact analyses are provided in Appendix C and Cheng et al. (1997).

I.3.1.1.1 Disposal as U_3O_8

The total collective doses to involved workers from grouted waste would be nearly twice those from ungrouted waste, ranging from approximately 24 person-rem/yr for 85 workers for shallow earthen structures to 36 person-rem/yr for 87 workers for a mine. The corresponding collective cancer risks for grouted waste would be about 1×10^{-2} fatalities per year (1 additional latent cancer fatality [LCF] in 100 years). The estimated average individual doses to involved workers range from 210 mrem/yr (disposal in vaults) to 410 mrem/yr (disposal in a mine) for grouted

TABLE I.6 Radiological Doses from Disposal Options for Normal Operations

Option/Location[a]	Dose to Receptor: Involved Worker[b] Average Dose (mrem/yr)	Involved Worker[b] Collective Dose (person-rem/yr)	Noninvolved Worker[c] MEI Dose (mrem/yr)	Noninvolved Worker[c] Collective Dose (person-rem/yr)	General Public[d] MEI Dose (mrem/yr)	General Public[d] Collective Dose (person-rem/yr)
Disposal as Grouted U_3O_8						
Shallow earthen structure						
Dry	290	24	3.2×10^{-3} – 5.1×10^{-3}	8.1×10^{-5} – 1.2×10^{-4}	9.0×10^{-3} – 1.6×10^{-2}	2.1×10^{-3} – 3.9×10^{-3}
Wet	290	24	2.1×10^{-3} – 8.8×10^{-3}	2.7×10^{-5} – 1.7×10^{-4}	6.1×10^{-3} – 2.6×10^{-2}	1.9×10^{-3} – 5.4×10^{-3}
Vault						
Dry	210	26	3.2×10^{-3} – 5.1×10^{-3}	8.9×10^{-5} – 1.3×10^{-4}	4.7×10^{-3} – 1.4×10^{-2}	2.1×10^{-3} – 3.9×10^{-3}
Wet	210	26	2.1×10^{-3} – 8.8×10^{-3}	3.0×10^{-5} – 1.9×10^{-4}	6.0×10^{-3} – 2.0×10^{-2}	1.9×10^{-3} – 5.4×10^{-3}
Mine						
Dry	410	36	3.0×10^{-3} – 4.7×10^{-3}	8.5×10^{-5} – 1.3×10^{-4}	6.7×10^{-3} – 1.6×10^{-2}	2.1×10^{-3} – 3.9×10^{-3}
Wet	410	36	8.4×10^{-4} – 8.5×10^{-3}	2.8×10^{-5} – 1.8×10^{-4}	6.1×10^{-3} – 2.6×10^{-2}	1.9×10^{-3} – 5.4×10^{-3}
Disposal as Ungrouted U_3O_8						
Shallow earthen structure						
Dry	550	14	0	0	0	0
Wet	550	14	0	0	0	0
Vault						
Dry	330	15	0	0	0	0
Wet	330	15	0	0	0	0
Mine						
Dry	630	18	0	0	0	0
Wet	630	18	0	0	0	0

TABLE I.6 (Cont.)

Option/Location[a]	Dose to Receptor: Involved Worker[b] Average Dose (mrem/yr)	Involved Worker[b] Collective Dose (person-rem/yr)	Noninvolved Worker[c] MEI Dose (mrem/yr)	Noninvolved Worker[c] Collective Dose (person-rem/yr)	General Public[d] MEI Dose (mrem/yr)	General Public[d] Collective Dose (person-rem/yr)
Disposal as Grouted UO_2						
Shallow earthen structure						
Dry	300	21	6.0×10^{-3} – 9.8×10^{-3}	8.3×10^{-5} – 1.2×10^{-4}	1.7×10^{-2} – 3.0×10^{-2}	3.9×10^{-3} – 7.5×10^{-3}
Wet	300	21	3.2×10^{-3} – 1.7×10^{-2}	2.8×10^{-5} – 1.8×10^{-4}	1.2×10^{-2} – 5.0×10^{-2}	3.6×10^{-3} – 1.0×10^{-2}
Vault						
Dry	300	22	6.0×10^{-3} – 9.8×10^{-3}	9.1×10^{-5} – 1.4×10^{-4}	1.3×10^{-2} – 3.0×10^{-2}	3.9×10^{-3} – 7.5×10^{-3}
Wet	300	22	3.7×10^{-3} – 1.7×10^{-2}	3.0×10^{-5} – 2.0×10^{-4}	1.2×10^{-2} – 5.0×10^{-2}	3.6×10^{-3} – 1.0×10^{-2}
Mine						
Dry	330	24	5.7×10^{-3} – 8.9×10^{-3}	8.3×10^{-5} – 1.2×10^{-4}	1.3×10^{-2} – 3.0×10^{-2}	3.9×10^{-3} – 7.5×10^{-3}
Wet	330	24	1.6×10^{-3} – 1.6×10^{-2}	2.8×10^{-5} – 1.8×10^{-4}	1.2×10^{-2} – 5.0×10^{-2}	3.6×10^{-3} – 1.0×10^{-2}
Disposal as Ungrouted UO_2						
Shallow earthen structure						
Dry	360	8.3	0	0	0	0
Wet	360	8.3	0	0	0	0
Vault						
Dry	430	11	0	0	0	0
Wet	430	11	0	0	0	0
Mine						
Dry	470	12	0	0	0	0
Wet	470	12	0	0	0	0

[a] Two generic environmental settings were considered for each option, corresponding to a dry environment and wet environment, respectively.

[b] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[c] Noninvolved workers are individuals who do not participate in material-handing activities, such as employees in the administration building. The number of noninvolved workers would be approximately 44.

[d] The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the disposal site. A rural environment with a population density of 6 persons/km^2 and a total population of 120,000 was assumed. Impacts to the MEI were assessed from both airborne and waterborne emissions; impacts to the total population were assessed from airborne emissions only.

TABLE I.7 Latent Cancer Risks from Disposal Options for Normal Operations

Option/Location[a]	Risk to Receptor: Involved Worker[b] Average Risk (risk/yr)	Involved Worker[b] Collective Risk (fatalities/yr)	Noninvolved Worker[c] MEI Risk (risk/yr)	Noninvolved Worker[c] Collective Risk (fatalities/yr)	General Public[d] MEI Risk (risk/yr)	General Public[d] Collective Risk (fatalities/yr)
Disposal as Grouted U_3O_8						
Shallow earthen structure						
Dry	1×10^{-4}	1×10^{-2}	1×10^{-9}–2×10^{-9}	3×10^{-8}–5×10^{-8}	4×10^{-9}–8×10^{-9}	1×10^{-6}–2×10^{-6}
Wet	1×10^{-4}	1×10^{-2}	8×10^{-10}–4×10^{-9}	1×10^{-8}–7×10^{-8}	3×10^{-9}–1×10^{-8}	9×10^{-7}–3×10^{-6}
Vault						
Dry	8×10^{-5}	1×10^{-2}	1×10^{-9}–2×10^{-9}	4×10^{-8}–5×10^{-8}	2×10^{-9}–7×10^{-9}	1×10^{-6}–2×10^{-6}
Wet	8×10^{-5}	1×10^{-2}	8×10^{-10}–4×10^{-9}	1×10^{-8}–8×10^{-8}	3×10^{-9}–1×10^{-8}	9×10^{-7}–3×10^{-6}
Mine						
Dry	2×10^{-4}	1×10^{-2}	1×10^{-9}–2×10^{-9}	3×10^{-8}–5×10^{-8}	3×10^{-9}–8×10^{-9}	1×10^{-6}–2×10^{-6}
Wet	2×10^{-4}	1×10^{-2}	3×10^{-10}–3×10^{-9}	1×10^{-8}–7×10^{-8}	3×10^{-9}–1×10^{-8}	9×10^{-7}–3×10^{-6}
Disposal as Ungrouted U_3O_8						
Shallow earthen structure						
Dry	2×10^{-4}	6×10^{-3}	0	0	0	0
Wet	2×10^{-4}	6×10^{-3}	0	0	0	0
Vault						
Dry	1×10^{-4}	6×10^{-3}	0	0	0	0
Wet	1×10^{-4}	6×10^{-3}	0	0	0	0
Mine						
Dry	3×10^{-4}	7×10^{-3}	0	0	0	0
Wet	3×10^{-4}	7×10^{-3}	0	0	0	0

TABLE I.7 (Cont.)

Option/Location[a]	Risk to Receptor: Involved Worker[b] Average Risk (risk/yr)	Involved Worker[b] Collective Risk (fatalities/yr)	Noninvolved Worker[c] MEI Risk (risk/yr)	Noninvolved Worker[c] Collective Risk (fatalities/yr)	General Public[d] MEI Risk (risk/yr)	General Public[d] Collective Risk (fatalities/yr)
Disposal as Grouted UO_2						
Shallow earthen structure						
Dry	1×10^{-4}	8×10^{-3}	2×10^{-9} – 4×10^{-9}	3×10^{-8} – 5×10^{-8}	9×10^{-9} – 2×10^{-8}	2×10^{-6} – 4×10^{-6}
Wet	1×10^{-4}	8×10^{-3}	1×10^{-9} – 7×10^{-9}	1×10^{-8} – 7×10^{-8}	6×10^{-9} – 2×10^{-8}	2×10^{-6} – 5×10^{-6}
Vault						
Dry	1×10^{-4}	9×10^{-3}	2×10^{-9} – 4×10^{-9}	4×10^{-8} – 5×10^{-8}	6×10^{-9} – 2×10^{-8}	2×10^{-6} – 4×10^{-6}
Wet	1×10^{-4}	9×10^{-3}	1×10^{-9} – 7×10^{-9}	1×10^{-8} – 8×10^{-8}	6×10^{-9} – 2×10^{-8}	2×10^{-6} – 5×10^{-6}
Mine						
Dry	1×10^{-4}	1×10^{-2}	2×10^{-9} – 4×10^{-9}	3×10^{-8} – 5×10^{-8}	6×10^{-9} – 2×10^{-8}	2×10^{-6} – 4×10^{-6}
Wet	1×10^{-4}	1×10^{-2}	6×10^{-10} – 6×10^{-9}	1×10^{-8} – 7×10^{-8}	6×10^{-9} – 2×10^{-8}	2×10^{-6} – 5×10^{-6}
Disposal as Ungrouted UO_2						
Shallow earthen structure						
Dry	1×10^{-4}	3×10^{-3}	0	0	0	0
Wet	1×10^{-4}	3×10^{-3}	0	0	0	0
Vault						
Dry	2×10^{-4}	4×10^{-3}	0	0	0	0
Wet	2×10^{-4}	4×10^{-3}	0	0	0	0
Mine						
Dry	2×10^{-4}	5×10^{-3}	0	0	0	0
Wet	2×10^{-4}	5×10^{-3}	0	0	0	0

[a] Two generic environmental settings were considered for each option, corresponding to a dry environment and wet environment, respectively.

[b] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population.

[c] Noninvolved workers are individuals who do not participate in material-handling activities, such as employees in the administration building. The number of noninvolved workers would be approximately 44.

[d] The off-site general public is defined as residents who live within a radius of 50 miles (80 km) around the disposal site. A rural environment with a population density of 6 persons/km^2 and a total population of 120,000 was assumed. Impacts to the MEI were assessed from both airborne and waterborne emissions; impacts to the total population were assessed from airborne emissions only.

waste. Average worker doses for ungrouted waste range from 330 to 630 mrem/yr. Potential exposures of involved workers would be well below the radiation dose limit of 5,000 mrem/yr (10 CFR Part 835).

Radiation exposures of noninvolved workers would occur only for disposal of grouted waste. The radiation dose to the maximally exposed individual (MEI) would be less than 0.0088 mrem/yr, a small fraction of the dose limit of 10 mrem/yr from airborne emissions (10 CFR Part 61). The collective dose for noninvolved workers would be less than 0.0002 person-rem/yr for a total of approximately 43 workers.

The estimated maximum individual dose to the off-site general public is less than 0.026 mrem/yr for grouted waste, which corresponds to a cancer risk of 1 in 80 million per year. For a collective population of 120,000 persons within 50 miles (80 km) of the site, the estimated number of LCFs is less than 3×10^{-6} per year (1 fatality in 300,000 years).

I.3.1.1.2 Disposal as UO_2

Compared with the disposal of U_3O_8, disposal of UO_2 would result in less collective exposures of involved workers because of the smaller volume of waste involved. Grouted UO_2 would result in larger collective worker doses than ungrouted UO_2, with the collective dose ranging from 21 to 24 person-rem/yr for approximately 72 workers. The average individual dose to involved workers for grouted waste ranges from 300 to 330 mrem/yr. Although ungrouted waste would result in less collective exposure, the number of involved workers (about 25) would also be less. As a result, the average worker dose would be greater for ungrouted waste than grouted waste. The estimated average individual worker dose ranges from 360 mrem/yr to 470 mrem/yr. For all disposal types considered, the average radiation doses to involved workers would be well below the dose limit of 5,000 mrem/yr. The estimated maximum individual dose to noninvolved workers is less than 0.017 mrem/yr, and the estimated collective dose is less than 0.0002 person-rem/yr. The number of noninvolved workers would be approximately 44.

The maximum individual dose to the off-site general public would be less than 0.050 mrem/yr, which corresponds to a cancer risk of 1 in 40 million per year. For the assumed rural collective population of 120,000 persons within 50 miles (80 km) of the site, the number of LCFs would be less than 5×10^{-6} per year (1 fatality in 200,000 years of operation).

I.3.1.2 Chemical Impacts

Potential chemical impacts to human health from normal operations at the disposal facilities would result primarily from exposure to the insoluble uranium compounds, UO_2 and U_3O_8. Risks from normal operations were quantified on the basis of calculated hazard indices. Additional information on the exposure assumptions, health effects assumptions, reference doses used for

uranium compounds, and calculational methods used in the chemical impact analysis are provided in Appendix C and Cheng et al. (1997).

Chemical impacts during the operational phase of the disposal facilities were calculated for noninvolved workers and the general public. Exposures of noninvolved workers and the general public to low levels of airborne emissions could occur from mixing uranium with cement and other grouting materials in the wasteform facility. Three disposal types (shallow earthen structures, vaults, and mines) were considered for U_3O_8 and UO_2 as both grouted and ungrouted wastes in generic dry and wet environmental settings.

Human health impacts from exposures to hazardous chemicals during normal operations of the U_3O_8 or UO_2 disposal facilities are summarized in Table I.8. Two waste forms were evaluated for U_3O_8 and UO_2: grouted and ungrouted. For grouted wastes, the range of chemical exposures to the noninvolved workers and general public would result primarily from differences between the locations and types of disposal facilities. The hazard indices for all disposal options are four orders of magnitude less than 1, the level for which potential adverse health effects could occur from normal operations. No impacts would occur for disposal of ungrouted U_3O_8 or UO_2 because airborne emissions would not be expected (LLNL 1997).

I.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table I.9. The following sections present the results for radiological and chemical health impacts of the highest consequence accident in each frequency category. Results for all accidents listed in Table I.9 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C and Policastro et al. (1997).

I.3.2.1 Radiological Impacts

The radiological doses to various receptors for the accidents that give the highest dose from each frequency category are listed in Table I.10. The LCF risks for these accidents are given in Table I.11. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions (wet and dry) were evaluated for each disposal option (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of

TABLE I.8 Chemical Impacts to Human Health for the Disposal Options under Normal Operations

Option	Impacts to Receptor[a]			
	Noninvolved Workers[b]		General Public	
	Hazard Index for MEI[c]	Population Risk[d] (ind. at risk/yr)	Hazard Index for MEI[c]	Population Risk[d] (ind. at risk/yr)
Disposal as Grouted U_3O_8				
Shallow earthen structure				
Dry	3.9×10^{-7} – 6.3×10^{-7}	–	3.1×10^{-5} – 5.3×10^{-5}	–
Wet	2.5×10^{-7} – 1.1×10^{-6}	–	2.1×10^{-5} – 8.9×10^{-5}	–
Vault				
Dry	3.9×10^{-7} – 6.3×10^{-7}	–	1.6×10^{-5} – 3.8×10^{-5}	–
Wet	3.1×10^{-7} – 1.1×10^{-6}	–	2.0×10^{-5} – 6.6×10^{-5}	–
Mine				
Dry	3.6×10^{-7} – 5.4×10^{-7}	–	3.3×10^{-5} – 5.3×10^{-5}	–
Wet	1.0×10^{-7} – 1.1×10^{-6}	–	2.1×10^{-5} – 9.1×10^{-5}	–
Disposal as Ungrouted U_3O_8				
Shallow earthen structure				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–
Vault				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–
Mine				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–

TABLE I.8 (Cont.)

Option	Impacts to Receptor[a]			
	Noninvolved Workers[b]		General Public	
	Hazard Index for MEI[c]	Population Risk[d] (ind. at risk/yr)	Hazard Index for MEI[c]	Population Risk[d] (ind. at risk/yr)
Disposal as Grouted UO_2				
Shallow earthen structure				
Dry	7.2×10^{-7} – 1.2×10^{-6}	–	5.7×10^{-5} – 9.7×10^{-5}	–
Wet	3.8×10^{-7} – 2.0×10^{-6}	–	3.9×10^{-5} – 1.6×10^{-4}	–
Vault				
Dry	7.2×10^{-7} – 1.2×10^{-6}	–	6.0×10^{-5} – 9.7×10^{-5}	–
Wet	4.6×10^{-7} – 2.0×10^{-6}	–	3.9×10^{-5} – 1.7×10^{-4}	–
Mine				
Dry	6.5×10^{-7} – 9.9×10^{-7}	–	6.0×10^{-5} – 9.7×10^{-5}	–
Wet	1.9×10^{-7} – 1.8×10^{-6}	–	3.9×10^{-5} – 1.7×10^{-4}	–
Disposal as Ungrouted UO_2				
Shallow earthen structure				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–
Vault				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–
Mine				
Dry	~ 0	–	~ 0	–
Wet	~ 0	–	~ 0	–

[a] The range of impacts represent variations in meteorological conditions at the generic wet and dry environmental settings.

[b] Noninvolved workers are individuals who do not participate in material-handling activities, such as employees in the administration building.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

TABLE I.9 Accidents Considered for the Disposal Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Disposal as Grouted U_3O_8					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the product receiving area	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the ground inside the product receiving area.	U_3O_8	0.00028	Puff	Stack
Mishandling/drop of drum/ billet outside	A single U_3O_8 drum is damaged by a forklift and spills its contents outside without HEPA filtration.	U_3O_8	0.000066	Puff	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The product receiving area and cement mixing area are damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	U_3O_8	400	Puff	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the product receiving area and cement mixing area structures and confinement systems.	U_3O_8	770	Puff	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire/explosion inside the product mixing area	A fire or explosion within the product mixing area affects the contents of a single pallet of drums.	U_3O_8	0.0017	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Disposal as Ungrouted U_3O_8					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the product receiving area	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the ground inside the product receiving area.	U_3O_8	0.00028	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The product receiving area is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	U_3O_8	370	Puff	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the product receiving structure and confinement systems.	U_3O_8	740	Puff	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

TABLE I.9 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Disposal as Grouted UO_2					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside the product receiving area	A single UO_2 drum is damaged by a forklift and spills its contents onto the ground inside the product receiving area.	UO_2	0.00011	Puff	Stack
Mishandling/drop of drum/ billet outside	A single UO_2 drum is damaged by a forklift and spills its contents outside without HEPA filtration.	UO_2	0.00015	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The product receiving area and cement mixing area are damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	UO_2	0.73	Puff	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the product receiving area and cement mixing area structures and confinement systems.	UO_2	2.1	Puff	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Fire/explosion inside the product mixing area	A fire or explosion within the product mixing area affects the contents of a single pallet of drums.	UO_2	0.00068	Puff	Stack
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA
Disposal as Ungrouted UO_2					
Likely Accidents (frequency: 1 or more times in 100 years)					
Mishandling/drop of drum/ billet inside product receiving area	A single UO_2 drum is damaged by a forklift and spills its contents onto the ground inside the product receiving area.	UO_2	0.00011	Puff	Stack
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Earthquake	The product receiving area is damaged during a design-basis earthquake, resulting in failure of the structure and confinement systems.	UO_2	0.59	Puff	Ground
Tornado	A major tornado and associated tornado missiles result in failure of the product receiving structure and confinement systems.	UO_2	1.2	Puff	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude severe flooding.	No release	NA	NA	NA

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

Notation: HEPA = high-efficiency particulate air; NA = not applicable; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

TABLE I.10 Estimated Radiological Doses per Accident Occurrence for the Disposal Options

Option/Accident[a]	Frequency Category[b]	Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Disposal as Grouted U_3O_8									
Mishandling/drop of drum/billet outside	L	4.1×10^{-7}	3.7×10^{-8}	1.3×10^{-8}	7.6×10^{-8}	4.1×10^{-7}	3.7×10^{-8}	1.0×10^{-8}	7.6×10^{-8}
Earthquake	U	1.4×10^{2}	6.1	1.1	1.5	1.3×10^{1}	1.1	2.9×10^{-1}	8.7×10^{-1}
Fire or explosion inside the product mixing area	EU	5.5×10^{-8}	1.1×10^{-7}	5.7×10^{-8}	2.2×10^{-6}	1.6×10^{-11}	3.1×10^{-11}	2.8×10^{-9}	1.0×10^{-6}
Disposal as Ungrouted U_3O_8									
Mishandling/drop of drum inside the product receiving area	L	9.0×10^{-9}	1.8×10^{-8}	9.3×10^{-9}	3.6×10^{-7}	2.7×10^{-12}	5.1×10^{-12}	4.6×10^{-10}	1.6×10^{-7}
Earthquake	U	1.3×10^{2}	5.6	1.0	1.3	1.2×10^{1}	9.8×10^{-1}	2.7×10^{-1}	8.0×10^{-1}
Disposal as Grouted UO_2									
Mishandling/drop of drum/billet outside	L	9.8×10^{-7}	8.7×10^{-8}	3.0×10^{-8}	1.8×10^{-7}	9.8×10^{-7}	8.7×10^{-8}	2.4×10^{-8}	1.8×10^{-7}
Earthquake	U	2.7×10^{-1}	1.1×10^{-2}	2.1×10^{-3}	2.7×10^{-3}	2.4×10^{-2}	2.0×10^{-3}	5.5×10^{-4}	1.6×10^{-3}
Fire or explosion inside the product mixing area	EU	2.3×10^{-8}	4.5×10^{-8}	2.4×10^{-8}	9.1×10^{-7}	6.8×10^{-12}	1.3×10^{-11}	1.2×10^{-9}	4.2×10^{-7}
Disposal as Ungrouted UO_2									
Mishandling/drop of drum inside the product receiving area	L	3.7×10^{-9}	7.3×10^{-9}	3.8×10^{-9}	1.5×10^{-7}	1.1×10^{-12}	2.1×10^{-12}	1.9×10^{-10}	6.7×10^{-8}
Earthquake	U	2.2×10^{-1}	9.3×10^{-3}	1.7×10^{-3}	2.2×10^{-3}	1.9×10^{-2}	1.6×10^{-3}	4.4×10^{-4}	1.3×10^{-3}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

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TABLE I.11 Estimated Radiological Health Risks per Accident Occurrence for the Disposal Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Disposal as Grouted U_3O_8									
Mishandling/drop of drum/billet outside	L	2×10^{-10}	1×10^{-11}	6×10^{-12}	4×10^{-11}	2×10^{-10}	1×10^{-11}	5×10^{-12}	4×10^{-11}
Earthquake	U	6×10^{-2}	2×10^{-3}	5×10^{-4}	7×10^{-4}	5×10^{-3}	4×10^{-4}	1×10^{-4}	4×10^{-4}
Fire or explosion inside the product mixing area	EU	2×10^{-11}	4×10^{-11}	3×10^{-11}	1×10^{-9}	7×10^{-15}	1×10^{-14}	1×10^{-12}	5×10^{-10}
Disposal as Ungrouted U_3O_8									
Mishandling/drop of drum inside the product receiving area	L	4×10^{-12}	7×10^{-12}	5×10^{-12}	2×10^{-10}	1×10^{-15}	2×10^{-15}	2×10^{-13}	8×10^{-11}
Earthquake	U	5×10^{-2}	2×10^{-3}	5×10^{-4}	7×10^{-4}	5×10^{-3}	4×10^{-4}	1×10^{-4}	4×10^{-4}
Disposal as Grouted UO_2									
Mishandling/drop of drum/billet outside	L	4×10^{-10}	3×10^{-11}	1×10^{-11}	9×10^{-11}	4×10^{-10}	3×10^{-11}	1×10^{-11}	9×10^{-11}
Earthquake	U	1×10^{-4}	5×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-5}	8×10^{-7}	3×10^{-7}	8×10^{-7}
Fire or explosion inside the product mixing area	EU	9×10^{-12}	2×10^{-11}	1×10^{-11}	5×10^{-10}	3×10^{-15}	5×10^{-15}	6×10^{-13}	2×10^{-10}
Disposal as Ungrouted UO_2									
Mishandling/drop of drum inside the product receiving area	L	1×10^{-12}	3×10^{-12}	2×10^{-12}	7×10^{-11}	4×10^{-16}	8×10^{-16}	9×10^{-14}	3×10^{-11}
Earthquake	U	9×10^{-5}	4×10^{-6}	8×10^{-7}	1×10^{-6}	8×10^{-6}	7×10^{-7}	2×10^{-7}	7×10^{-7}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

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occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- Except for the impacts to a noninvolved worker MEI from an earthquake accident, the maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 1.1 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- For an earthquake accident, the potential dose to the noninvolved worker MEI would range from 0.22 to 140 rem, depending on the option implemented for uranium disposal. The NRC recommendations are not directly applicable to workers but are used in this instance as a guideline to indicate potential for health effects. A dose of 140 rem could result in temporary adverse health effects to the MEI worker.

- The overall radiological risk to worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table I.11] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the disposal accidents.

I.3.2.2 Chemical Impacts

The accidents assessed in this section are listed in Table I.9. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables I.12 and I.13. Results are presented as (1) number of people with the potential for adverse effects and (2) number of people with the potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of noninvolved workers and off-site population) (Policastro et al. 1997). The number of workers and members of the off-site public represent the impacts if the associated accident was assumed to occur. These impacts may be summarized as follows:

- If the accidents identified in Tables I.12 and I.13 did occur, the number of persons in the off-site population with potential for adverse effects and irreversible adverse effects would range from 0 to 1 (MEI), the maximum corresponding to an earthquake accident. The number of workers with potential for adverse effects and irreversible adverse effects would range from 0 to 1, the maximum also corresponding to the earthquake accident.

TABLE I.12 Number of Persons with Potential for Adverse Effects from Accidents under the Disposal Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Disposal as Grouted U_3O_8									
Mishandle/drop of drum/billet outside[f]	L	No	0	No	0	No	0	No	0
Earthquake	U	Yes	1	Yes[g]	0	Yes	1	No	0
Fire/explosion inside[f]	EU	No	0	No	0	No	0	No	0
Disposal as Grouted UO_2									
Mishandle/drop of drum/billet outside[f]	L	No	0	No	0	No	0	No	0
Earthquake[f]	U	No	0	No	0	No	0	No	0
Fire/explosion inside[f]	EU	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (noninvolved workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] These accidents would result in the largest plume sizes, although no people would be affected.

[g] MEI locations were evaluated at 100 m from ground-level releases for noninvolved workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because generic worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE I.13 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Disposal Options[a]

Option/Accident[b]	Frequency Category[c]	Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Disposal as Grouted U_3O_8									
Mishandle/drop of drum/billet outside[f]	L	No	0	No	0	No	0	No	0
Earthquake	U	Yes	1	Yes[g]	0	No	0	No	0
Fire/explosion inside[f]	EU	No	0	No	0	No	0	No	0
Disposal as Grouted UO_2									
Mishandle/drop of drum/billet outside[f]	L	No	0	No	0	No	0	No	0
Earthquake[f]	U	No	0	No	0	No	0	No	0
Fire/explosion inside[f]	EU	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (noninvolved workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] These accidents would result in the largest plume sizes, although no people would be affected.

[g] MEI locations were evaluated at 100 m from ground-level releases for noninvolved workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because generic worker and general public population distributions were used, which did not show receptors at the MEI locations.

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- There would be no difference in accident consequences for disposal as UO_2 or U_3O_8 in shallow earthen structures, vaults, or a mine.

- The largest impacts would be caused by an earthquake in the product receiving and cement mixing areas. Accidents involving stack emissions would have very small impacts compared with accidents involving releases at ground level due to the large dilution (and lower source terms) involved with the stack emissions.

- For the earthquake accident, the noninvolved worker and the public MEIs could experience potential for both adverse effects and irreversible adverse effects. For all other accidents, the worker and general public MEIs would experience neither potential adverse effects nor potential irreversible adverse effects.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009 through 2028). The results indicated that the maximum risk values would be less than 1 for all accidents. These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. The bounding case accidents shown in Table I.13 would involve releases of uranium oxide and potential exposure to uranium compounds. If the accident occurred, exposures are estimated to result in death for 1% or fewer of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Thus, for noninvolved workers and members of the general public experiencing a range of 0 to 1 irreversible adverse effects, 0 deaths would be expected.

I.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries to all disposal facility workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used, respectively, for the construction and operational components of the disposal facility activities.

One fatality due to accidental physical trauma would be predicted under the grouted U_3O_8 mine disposal option. The risk of a fatality for this option is almost twice as great as the risk for the

other options; this difference is due mainly to the increased risk associated with construction of the large mine that would be needed for the entire inventory of grouted U_3O_8. Mitigation of risks from construction, loading, and closure of mines can be accomplished to a certain extent by instituting safety measures and by conducting thorough safety training programs for personnel.

Estimated fatalities range from 0.13 to 0.94, and injury incidences range from 90 to 450 (see Table I.14). Except for the grouted U_3O_8 mine disposal option discussed above, the other options are fairly comparable with respect to predicted fatalities and injuries due to physical trauma.

I.3.3 Air Quality

The methodology used to analyze air quality impacts from disposal options is provided in Appendix C and Tschanz (1997). The pollutant concentrations at several distances from the center of the facility were estimated because of uncertainty regarding the size and location of the generic disposal facility. Estimates at 2,460 ft (750 m) from the center of the disposal facilities are comparable to the estimates for options based on representative environmental settings (i.e., conversion and long-term storage options using the three current storage sites as representative of those settings). The shortest distances from the centers of the representative sites to their boundaries range from 2,300 to 2,600 ft (700 to 800 m).

Pollutant emissions would result from construction of the wasteform facility and construction of the disposal areas/facilities. The annual emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10}), with a mean diameter of 10 μm or less) resulting from construction of the wasteform facility and from construction of disposal areas/facilities are shown in Table I.15 for disposal of grouted U_3O_8 in either shallow earthen structures or vaults. The criteria pollutant emissions from construction of facilities for the other disposal options and for operation of the facilities are related to those in Table I.15 by the scaling factors listed in Table I.16. For example, the CO emissions from operations for disposal of grouted UO_2 in shallow earthen structures would be 0.74 × 1.55 tons/yr, or 1.14 tons/yr (1.05 metric tons/yr). Operation of the wasteform facility would also produce 1.08 and 0.59 lb/yr (0.50 and 0.27 kg/yr) of uranium emissions for the grouted UO_2 and grouted U_3O_8 options, respectively.

The largest pollutant concentrations would result from the operation of vaults for disposal of grouted U_3O_8. The estimated NO_x concentrations for operation of this option are shown in the bottom half of Table I.17. The concentrations of CO, HC, SO_x, and PM_{10} are 0.21, 0.075, 0.065, and 0.070 times as large, respectively, as those for NO_x. The results show that the ranges of impacts would be larger for a wet environmental setting than for a dry setting, and in fact the ranges of dry setting impacts fall within those for the wet setting. At 2,460 ft (750 m), the maximum annual NO_x concentration during operations might be as large as 37% of the 100 $\mu g/m^3$ standard. The other

TABLE I.14 Potential Impacts to Human Health from Physical Hazards under Accident Conditions for the Disposal Options

Option	Impacts to All Disposal Facility Workers[a]					
	Fatality Incidence[b]			Injury Incidence[b]		
	Wasteform Facility	Disposal Facility	Total	Wasteform Facility	Disposal Facility	Total
Disposal as Grouted U_3O_8						
Shallow earthen structure	0.15	0.11	0.26	130	80	210
Vault	0.15	0.29	0.44	130	170	300
Mine	0.15	0.78	0.94	130	320	450
Disposal as Ungrouted U_3O_8						
Shallow earthen structure	0.06	0.08	0.13	50	40	90
Vault	0.06	0.17	0.22	50	90	140
Mine	0.06	0.47	0.53	50	190	240
Disposal as Grouted UO_2						
Shallow earthen structure	0.15	0.08	0.23	120	50	180
Vault	0.15	0.11	0.26	120	70	190
Mine	0.15	0.36	0.50	120	160	280
Disposal as Ungrouted UO_2						
Shallow earthen structure	0.06	0.07	0.13	50	40	90
Vault	0.06	0.10	0.15	50	60	110
Mine	0.06	0.27	0.33	50	120	170

[a] Values are rounded to two significant figures. All construction and operations workers at the disposal facilities were included in the physical hazard risk calculations.

[b] Fatality incidence and injury incidence were calculated as the number of full-time-equivalent employees times the annual fatality rate times the number of years. Only injuries involving lost workdays were included. Injury and fatality incidence rates used in the calculations were taken from National Safety Council (1995).

criteria pollutant concentrations are smaller fractions of their standards than is NO_x relative to its standard.

The NO_x concentrations for construction of the grouted U_3O_8 vault disposal option would be 0.35 times those for operation of the vaults and approximately the same as the estimated NO_x concentrations during operations for the disposal of grouted U_3O_8 in shallow earthen structures, shown in Table I.18. During operations for shallow earthen structure disposal of grouted U_3O_8, the CO, HC, SO_x, and PM_{10} impacts would be 0.22, 0.075, 0.066, and 0.070 times as large, respectively, as those for NO_x. The impacts of all of these other pollutants relative to their standards would be less than that of NO_x.

TABLE I.15 Pollutant Emissions from Construction Activities Associated with Disposal Facilities for Grouted U_3O_8[a]

Pollutant	Pollutant Emissions from Construction Activities (tons/yr)		
	Wasteform Facility	Shallow Earthen Structure	Vault
CO	2.11	1.55	2.62
HC	0.739	0.543	0.918
NO_x	9.79	7.18	12.2
SO_x	0.644	0.473	0.799
PM_{10}	0.688	0.505	0.854

[a] Represents emissions from construction of wasteform facility and from construction of either shallow earthen structures or vaults.

The NO_x concentrations from construction of the wasteform facility for grouted U_3O_8 disposal, shown in the upper half of Table I.17, would be slightly smaller than the NO_x concentrations for construction of vaults for grouted U_3O_8 disposal. However, construction of the wasteform facility would result in smaller ranges of impacts because the construction would take place only on a centrally located area; the ranges in this case reflect only the variability due to the different meteorological data sets used. For construction of the wasteform facility, the CO, HC, SO_x, and PM_{10} impacts relative to the NO_x impacts would be the same as those discussed for operation of the shallow earthen structure disposal of grouted U_3O_8.

Construction and operation would occur simultaneously for most of the operational phase. The combined construction and operations emissions might result in annual NO_x concentrations as large as 45 $\mu g/m^3$ at 2,460 ft (750 m) for the vault disposal of grouted U_3O_8, approaching 50% of the standard.

Operation of the wasteform facility would produce 0.6 lb/yr and 1.1 lb/yr of uranium emissions from the process stack for grouted U_3O_8 and grouted UO_2 suboptions, respectively, but no uranium emissions for the ungrouted suboptions. The impacts of uranium oxides emitted during operation of the wasteform facility for grouted disposal options are shown in Table I.19. Comparing the ranges of concentrations for the wet and dry settings indicates that the uranium emissions from the central point source would produce a slightly wider range of impacts for the dry setting than for the wet setting, in contrast to the wider wet setting impact ranges that would result for criteria pollutants from all the construction and operations area sources.

TABLE I.16 Scaling Factors for Criteria Pollutant Emissions from Construction and Operations for Disposal Options Relative to Emissions from Construction Activities Associated with Disposal Facilities for Grouted U_3O_8

	Scaling Factors	
Disposal Facility	Construction	Operations
Wasteform facility		
Grouted U_3O_8	1.00	0.62
Ungrouted U_3O_8	0.28	0.0041
Grouted UO_2	0.51	0.17
Ungrouted UO_2	0.17	0.0041
Shallow earthen structure		
Grouted U_3O_8	1.00	1.85
Ungrouted U_3O_8	0.51	0.87
Grouted UO_2	0.35	0.74
Ungrouted UO_2	0.26	0.56
Vault		
Grouted U_3O_8	1.00	2.87
Ungrouted U_3O_8	0.48	1.38
Grouted UO_2	0.21	1.12
Ungrouted UO_2	0.14	0.75

No quantitative estimate was made of the impacts on the ozone conditions. Ozone formation is a regional issue that would be affected by emissions for the entire area around a proposed disposal site. The pollutants most relevant to ozone formation that would result from the disposal of depleted uranium oxide are HC and NO_x. In later Phase II studies, when specific technologies and sites would be selected, the potential effects on ozone of releases of these pollutants at a proposed site could be evaluated by comparing those releases with the total emissions of HC and NO_x in the surrounding area. Small additional contributions to the regional totals would be unlikely to alter the ozone attainment status of the region.

I.3.4 Water and Soil

Tables I.20 through I.23 summarize the resource requirements for construction and operation of the wasteform facility, shallow earthen structure disposal facility, vault disposal facility, and mine disposal facility, respectively. Examination of these data indicates that the ranking of

TABLE I.17 Maximum NO_x Concentrations at Three Receptor Distances from Construction of the Wasteform Facility and Operation of Vaults for Disposal of Grouted U_3O_8

Site Environment/ Receptor Distance	Maximum NO_x Concentrations ($\mu g/m^3$) 1-Hour Average	3-Hour Average	8-Hour Average	24-Hour Average	Annual Average
Wasteform Facility: Construction					
Dry setting					
750 m	160 – 170	59 – 70	27 – 37	11 – 14	1.3 – 2.3
1,000 m	130 – 140	51 – 61	22 – 29	8.4 – 11	0.82 – 1.5
1,500 m	92 – 96	29 – 35	14 – 19	5.5 – 6.9	0.43 – 0.80
Wet setting					
750 m	150 – 250	57 – 110	25 – 57	10 – 25	1.1 – 2.7
1,000 m	120 – 220	49 – 96	20 – 45	7.8 – 20	0.67 – 1.7
1,500 m	84 – 150	27 – 57	13 – 29	5.1 – 13	0.35 – 0.92
Vault for Grouted U_3O_8: Operations					
Dry setting					
750 m	590 – 980	220 – 470	100 – 260	41 – 110	4.6 – 21
1,000 m	480 – 730	190 – 310	84 – 170	32 – 65	2.9 – 8.5
1,500 m	330 – 450	110 – 160	52 – 96	20 – 37	1.5 – 3.0
Wet setting					
750 m	540 – 1,500	210 – 790	95 – 410	38 – 200	3.8 – 37
1,000 m	440 – 1,100	180 – 530	77 – 270	29 – 120	2.4 – 15
1,500 m	310 – 690	110 – 280	48 – 160	19 – 67	1.3 – 5.2

facilities (largest to smallest) on the basis of resource requirements would be as follows: mine, vault, shallow earthen structure, and wasteform facility. For each facility, a secondary ranking indicates that the resource requirements would be consistently larger for disposal of U_3O_8, and grouted forms would require more resources than ungrouted.

Because the disposal option is based on a generic site without a specified location and detailed description, impacts could not be assessed on a site-specific basis; however, the impacts to surface water, groundwater, and soil would follow the same ranking as that for resource needs. For example, construction and operation of a mine disposal facility for U_3O_8 in a grouted form would produce the greatest impacts to the environment; the least impacts would result from construction and operation of the shallow earthen structure for disposal of ungrouted UO_2.

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TABLE I.18 Maximum NO_x Concentrations at Three Receptor Distances from Operation of the Shallow Earthen Structure for Disposal of Grouted U_3O_8

Site Environment/ Receptor Distance	Maximum NO_x Concentrations ($\mu g/m^3$)				
	1-Hour Average	3-Hour Average	8-Hour Average	24-Hour Average	Annual Average
Dry setting					
750 m	220 – 330	93 – 160	44 – 89	17 – 37	1.3 – 3.9
1,000 m	170 – 240	67 – 110	32 – 62	12 – 23	0.82 – 1.8
1,500 m	110 – 140	38 – 60	18 – 34	6.7 – 12	0.38 – 0.81
Wet setting					
750 m	200 – 510	90 – 260	41 – 140	16 – 67	1.1 – 6.8
1,000 m	160 – 370	64 – 180	30 – 100	11 – 40	0.68 – 3.2
1,500 m	97 – 220	37 – 100	17 – 55	6.6 – 22	0.35 – 1.3

If the disposal facility was located on a site having an area that was large compared with the size of the facility, and if it was near a river having a minimum flow that was large compared with annual water use and wastewater discharge, impacts to surface water, groundwater, and soil would be negligible. Negligible impacts would occur because a large site and large river could provide sufficient resource buffering to mitigate the effects produced by construction and operation of the facility.

On the other hand, if the site or the minimum flow in the river were small relative to the resource requirements, impacts would be larger. For example, if the minimum flow in the river was 500 gpm, the net annual water withdrawal for operation of the wasteform facility for disposing of grouted U_3O_8 would be about 10% of the flow. The impact of this relative withdrawal could produce moderate impacts to existing floodplains. Similarly, if the mine disposal facility were located on a 500-acre (200-ha) site, paving 94 acres (38 ha) for disposing of depleted uranium as grouted U_3O_8 would permanently alter the soil structure of almost 20% of the land available. This disruption could produce moderate to large impacts to runoff at the site and moderate to large impacts to soil permeability and erosion potential.

More detailed calculations would be performed in the next tier of analyses if a disposal facility option were selected. In general, impacts could be minimized by constructing and operating a facility that would have the smallest resource requirements.

TABLE I.19 Maximum Annual Average Uranium Concentrations in Air during Operation of the Wasteform Facility for Disposal of Grouted Uranium Oxide

Site Environment/ Receptor Distance	Maximum Annual Average Uranium Concentration ($\mu g/m^3$)
Disposal as Grouted UO_2	
Dry setting	
750 m	$1.7 \times 10^{-5} - 3.0 \times 10^{-5}$
1,000 m	$1.2 \times 10^{-5} - 2.1 \times 10^{-5}$
1,500 m	$0.71 \times 10^{-5} - 1.3 \times 10^{-5}$
Wet setting	
750 m	$1.8 \times 10^{-5} - 2.7 \times 10^{-5}$
1,000 m	$1.2 \times 10^{-5} - 2.0 \times 10^{-5}$
1,500 m	$0.76 \times 10^{-5} - 1.3 \times 10^{-5}$
Disposal as Grouted U_3O_8	
Dry setting	
750 m	$0.94 \times 10^{-5} - 1.6 \times 10^{-5}$
1,000 m	$0.66 \times 10^{-5} - 1.2 \times 10^{-5}$
1,500 m	$0.39 \times 10^{-5} - 0.72 \times 10^{-5}$
Wet setting	
750 m	$0.96 \times 10^{-5} - 1.5 \times 10^{-5}$
1,000 m	$0.68 \times 10^{-5} - 1.1 \times 10^{-5}$
1,500 m	$0.42 \times 10^{-5} - 0.70 \times 10^{-5}$

I.3.5 Socioeconomics

The socioeconomic impacts of each disposal option were assessed for a generic site because the location of a disposal facility has not yet been determined. Impacts for each facility are presented for the peak construction year and the first year of operations. Discussion of the assessment methodology is presented in Appendix C and Allison and Folga (1997). Table I.24 shows construction-related impacts (engineering, construction, project management, and site preparation and restoration activities), and operations-related impacts (operation, emplacement and closure, surveillance, and maintenance activities). Impacts for each facility are presented separately. Because the wasteform facility would be utilized to process waste at the disposal site for each disposal option,

TABLE I.20 Summary of Environmental Parameters for the Wasteform Facility

Parameter	Unit	Disposal as U_3O_8		Disposal as UO_2	
		Grouted	Ungrouted	Grouted	Ungrouted
Land area	acres	9.3	4	6.1	4
Disturbed area	acres	9.3	4	6.1	4
Paved area	acres	1.8	1	1.2	1
Water					
Construction	million gal/yr	1.1	0.3	0.7	0.2
Operations	million gal/yr	19.4	0.1	8.2	0.1
Wastewater					
Construction	million gal/yr	0.2	0.1	0.2	0.1
Operations	million gal/yr	1.1	0.1	0.6	0.1
Excavated material	yd^3	32,300	0	21,000	0

TABLE I.21 Summary of Environmental Parameters for the Shallow Earthen Structure Disposal Facility

Parameter	Unit	Disposal as U_3O_8		Disposal as UO_2	
		Grouted	Ungrouted	Grouted	Ungrouted
Land area	acres	76	42	33	24
Disturbed area	acres	70	38	29	20
Paved area	acres	2.7	2.0	1.7	1.5
Water					
Construction	million gal/yr	0.005	0.005	0.003	0.003
Operations	million gal/yr	0.02	0.01	0.01	0.01
Wastewater					
Construction	million gal/yr	0.005	0.005	0.003	0.003
Operations	million gal/yr	0.005	0.005	0.003	0.003
Excavated material	million yd^3	2.6	1.4	1.0	0.7

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TABLE I.22 Summary of Environmental Parameters for the Vault Disposal Facility

Parameter	Unit	Disposal as U_3O_8		Disposal as UO_2	
		Grouted	Ungrouted	Grouted	Ungrouted
Land area	acres	140	71	35	24
Disturbed area	acres	140	71	35	24
Paved area	acres	19	11	5	4
Water					
Construction	million gal/yr	1.7	0.8	0.4	0.2
Operations	million gal/yr	0.05	0.02	0.02	0.01
Wastewater					
Construction	million gal/yr	0.04	0.02	0.008	0.005
Operations	million gal/yr	0.05	0.02	0.02	0.01
Excavated material	million yd^3	1.7	0.8	0.4	0.3

TABLE I.23 Summary of Environmental Parameters for the Mine Disposal Facility

Parameter	Unit	Disposal as U_3O_8		Disposal as UO_2	
		Grouted	Ungrouted	Grouted	Ungrouted
Land area	acres	462	228	143	98
Disturbed area	acres	462	228	143	98
Paved area	acres	94	46	29	20
Water					
Construction	million gal/yr	0.7	0.5	0.4	0.3
Operations	million gal/yr	0.9	0.6	0.5	0.4
Wastewater					
Construction	million gal/yr	0.2	0.07	0.2	0.07
Operations	million gal/yr	0.2	0.1	0.08	0.07
Excavated material	million yd^3	2	1.2	0.9	0.4

the total impact of each option would be the summation of the impacts of the wasteform facility and the impact of each separate option.

I.3.5.1 Disposal as U_3O_8

The impacts of U_3O_8 disposal options in both grouted and ungrouted form on direct employment and income are shown in Table I.24. Construction of a wasteform facility for grouted U_3O_8 would create 360 direct jobs and $15 million in direct income during the peak year of construction in 2006. Operation of the grouted U_3O_8 wasteform facility would create 90 direct jobs and produce $13 million in direct income with the beginning of facility operations in 2009. Construction of a wasteform facility for ungrouted U_3O_8 would create 110 direct jobs and $4 million in direct income during the peak year of construction in 2006. Operation of the ungrouted U_3O_8 wasteform facility would create 40 direct jobs and produce $5 million in direct income annually with the beginning of facility operations in 2009.

Construction of a shallow earthen structure for grouted U_3O_8 would create 10 direct jobs and $1 million in direct income during the peak year of construction in 2008. Waste placement operations for a shallow earthen structure for grouted U_3O_8 would create 50 direct jobs and produce $3 million in direct income annually with the beginning of facility operations in 2009. Construction of a shallow earthen structure for ungrouted U_3O_8 would create less than 5 direct jobs and less than $500,000 in direct income during the peak year of construction in 2008. Operation of a shallow earthen structure for ungrouted U_3O_8 would create 30 direct jobs and produce $2 million in direct income annually with the beginning of facility operations in 2009.

Construction of a vault facility for grouted U_3O_8 would create 180 direct jobs and $8 million in direct income during the peak year of construction in 2008. Waste placement operations for a vault facility for grouted U_3O_8 would create 190 direct jobs and produce $5 million in direct income annually with the beginning of facility operations in 2009. Construction of a vault facility for ungrouted U_3O_8 would create 90 direct jobs and $4 million in direct income during the peak year of construction in 2008. Operation of a vault facility for ungrouted U_3O_8 would create 40 direct jobs and produce $3 million in direct income annually with the beginning of facility operations in 2009.

Construction of a mine facility for grouted U_3O_8 would create 410 direct jobs and $27 million in direct income during the peak year of construction in 2005. Waste placement operations for a mine facility for grouted U_3O_8 would create 190 direct jobs and produce $3 million in direct income annually with the beginning of facility operations in 2009. Construction of a mine facility for ungrouted U_3O_8 would create 300 direct jobs and $20 million in direct income during the peak year of construction in 2005. Operation of a mine facility for ungrouted U_3O_8 would create 30 direct jobs and produce $2 million in direct income with the beginning of facility operations in 2009.

TABLE I.24 Socioeconomic Impacts of U_3O_8 and UO_2 Disposal Facilities

Option/Location/Activity	Disposal of Grouted Form		Disposal of Ungrouted Form	
	Construction[a]	Operations[b]	Construction[a]	Operations[b]
U_3O_8 Disposal Facility				
Wasteform facility				
Direct employment	360	90	110	40
Direct income ($ million 1996)	15	13	4	5
Shallow earthen structure				
Direct employment	10	50	< 5	30
Direct income ($ million 1996)	1	3	< 0.5	2
Vault				
Direct employment	180	90	90	40
Direct income ($ million 1996)	8	5	4	3
Mine				
Direct employment	410	40	300	30
Direct income ($ million 1996)	27	3	20	2
UO_2 Disposal Facility				
Wasteform facility				
Direct employment	220	90	60	40
Direct income ($ million 1996)	9	12	3	5
Shallow earthen structure				
Direct employment	< 5	30	< 5	20
Direct income ($ million 1996)	< 0.5	1	< 0.5	1
Vault				
Direct employment	50	40	30	30
Direct income ($ million 1996)	2	2	1	2
Mine				
Direct employment	270	40	250	30
Direct income ($ million 1996)	18	2	16	2

[a] Impacts in the peak year of construction: 2007 for the wasteform facility; 2009 for the shallow earthen structure and the vault; and 2006 for the mine. Preoperations were assumed to occur from 1999 through 2008, with construction continuing concurrently with waste placement through 2028.

[b] Impacts are the annual average for operations for the period 2009–2028 (20 years).

I.3.5.2 Disposal as UO_2

The impacts of UO_2 disposal options in both grouted and ungrouted form on direct employment and income are shown in Table I.24. Construction of a wasteform facility for grouted UO_2 would create 220 direct jobs and $9 million in direct income during the peak year of construction in 2006. Operation of the grouted UO_2 wasteform facility would create 90 direct jobs and produce $12 million in direct income annually with the beginning of facility operations in 2009. Construction of a wasteform facility for ungrouted UO_2 would create 60 direct jobs and $3 million in direct income during the peak year of construction in 2006. Operation of the ungrouted UO_2 wasteform facility would create 40 direct jobs and produce $5 million in direct income annually with the beginning of facility operations in 2009.

Construction of a shallow earthen structure for grouted UO_2 would create less than 5 direct jobs and less than $500,000 in direct income during the peak year of construction in 2008. Waste placement operations for a shallow earthen structure for grouted UO_2 would create 30 direct jobs and produce $1 million in direct income annually with the beginning of facility operations in 2009. Construction of a shallow earthen structure for ungrouted UO_2 would create less than 5 direct jobs and less than $500,000 in direct income during the peak year of construction in 2008. Operation of a shallow earthen structure for ungrouted UO_2 would create 20 direct jobs and produce $1 million in direct income annually with the beginning of facility operations in 2009.

Construction of a vault facility for grouted UO_2 would create 50 direct jobs and $2 million in direct income during the peak year of construction in 2005. Waste placement operations for a vault facility for grouted UO_2 would create 40 direct jobs and produce $2 million in direct income annually with the beginning of facility operations in 2009. Construction of a vault facility for ungrouted UO_2 would create 30 direct jobs and $1 million in direct income during the peak year of construction in 2005. Operation of a vault facility for ungrouted UO_2 would create 30 direct jobs and produce $2 million in direct income with the beginning of facility operations in 2009.

Construction of a mine facility for grouted UO_2 would create 270 direct jobs and $18 million in direct income during the peak year of construction in 2005. Waste placement operations for a mine facility for grouted UO_2 would create 40 direct jobs and produce $2 million in direct income annually with the beginning of operations in 2009. Construction of a mine facility for ungrouted UO_2 would create 250 direct jobs and $16 million in direct income during the peak year of construction in 2005. Operation of a mine facility for ungrouted UO_2 would create 30 direct jobs and produce $2 million in direct income annually with the beginning of facility operations in 2009.

I.3.6 Ecology

Moderate to large impacts to ecological resources could result from construction of a facility for disposal of U_3O_8 or UO_2. Impacts could include mortality of individual organisms,

habitat loss, or changes in biotic communities. Discussion of the methodology used to assess ecological impacts is presented in Appendix C.

I.3.6.1 Disposal as U_3O_8

I.3.6.1.1 Shallow Earthen Structure

Site preparation for the construction of a facility for the disposal of U_3O_8 in shallow earthen structures would require the elimination of approximately 46 acres (18 ha) of habitat for ungrouted U_3O_8 and 85 acres (34 ha) for grouted U_3O_8, including 3 acres (1.1 ha) that would be paved — including the areas required for construction of the wasteform facility, primarily structures and paved areas. Existing vegetation would be destroyed during land clearing activities. The vegetative communities that would be eliminated by site preparation would depend on the actual location of the facility. Although herbaceous vegetation could be reestablished relatively rapidly in a wet setting (with at least 40 in./yr [100 cm/yr] precipitation), such as in the eastern United States, a considerable period of time might be required in a dry setting (less than 10 in./yr [25 cm/yr] precipitation), such as in the western United States. The loss of 46 to 85 acres (18 to 34 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table I.25.

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. Mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to recolonize replanted areas near the disposal facility following completion of construction. However, habitat use in the vicinity of the facility might be reduced for some species due to the construction of a perimeter fence. Therefore, the loss of 85 acres (34 ha) of habitat for the construction of a facility for U_3O_8 disposal in shallow earthen structures would be considered a moderate adverse impact to wildlife.

Wetlands could potentially be impacted by filling or draining during construction. In addition, impacts to wetlands and aquatic habitats due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the disposal facility was located adjacent to wetland or aquatic areas. However, impacts would be minimized by maintaining a buffer area around wetlands and aquatic habitats during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Water Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies. Depending on the facility location, water

TABLE I.25 Impacts to Ecological Resources from Disposal Facility Construction

Option/ Resource	Impacts from Disposal Facility Construction[a]		
	Shallow Earthen Structure	Vault	Mine
Disposal as U_3O_8			
Vegetation	Loss of 46 to 85 acres Moderate adverse impact	Loss of 75 to 149 acres Moderate to large adverse impact	Loss of 232 to 471 acres Large adverse impact
Wildlife	Loss of 46 to 85 acres Moderate adverse impact	Loss of 75 to 149 acres Moderate to large adverse impact	Loss of 232 to 471 acres Large adverse impact
Aquatic	Potential reduction in water quality, habitat	Potential reduction in water quality, habitat	Potential reduction in water quality, habitat
Wetlands	Potential loss, degradation	Potential loss, degradation	Potential loss, degradation
Protected species	Potential destruction, habitat loss	Potential destruction, habitat loss	Potential destruction, habitat loss
Disposal as UO_2			
Vegetation	Loss of 28 to 39 acres Moderate adverse impact	Loss of 28 to 41 acres Moderate adverse impact	Loss of 102 to 149 acres Large adverse impact
Wildlife	Loss of 28 to 39 acres Moderate adverse impact	Loss of 28 to 41 acres Moderate adverse impact	Loss of 102 to 149 acres Large adverse impact
Aquatic	Potential reduction in water quality, habitat	Potential reduction in water quality, habitat	Potential reduction in water quality, habitat
Wetlands	Potential loss, degradation	Potential loss, degradation	Potential loss, degradation
Protected species	Potential destruction, habitat loss	Potential destruction, habitat loss	Potential destruction, habitat loss

[a] All acreages include the wasteform facility.

withdrawal from surface waters or groundwater, as well as wastewater discharge, could potentially alter water levels (Section I.3.4), which could in turn affect aquatic ecosystems, including wetlands, especially those located along the periphery of these surface water bodies.

Prior to construction of a disposal facility, a survey for state and federally listed threatened, endangered, or candidate species, or species of special concern would be conducted so that, if possible, impacts to these species could be avoided. Where impacts were unavoidable, appropriate mitigation could be developed.

Ecological resources in the vicinity of the wasteform facility would be exposed to atmospheric emissions from facility operation; however, emission levels would be expected to be extremely low (Section I.3.3). At 230 ft (750 m) away, the highest annual average air concentration of U_3O_8 due to operation of the facility would be 1.6×10^{-5} µg/m^3. Resulting impacts to biota would be negligible.

Facility accidents, as discussed in Section I.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of the accident, season, and meteorological conditions.

I.3.6.1.2 Vault

The construction and operation of a facility for the disposal of U_3O_8 in vaults would generally result in impacts similar to those associated with shallow earthen structures. However, the size of the facility and area of disturbance for vault disposal would be larger. Disposal in vaults would require the disturbance of approximately 75 to 149 acres (30 to 60 ha) of habitat and 19 acres (8 ha) for paved areas, including the wasteform facility for grouted U_3O_8. This disposal option would also result in elevation of the soil surface by placement of excavated material and in reduction in soil permeability. The consequent decrease in soil moisture would make reestablishment of vegetation difficult and delay the establishment of native plant communities. This disposal option would result in a moderate to large adverse impact to existing vegetation and wildlife. Reestablishment of native vegetation over such a large area would be especially difficult in a dry environmental setting, and a considerable period of time might be required.

I.3.6.1.3 Mine

The construction and operation of a facility for the disposal of U_3O_8 in a mine would generally result in impacts similar to those associated with vaults. However, the mine option would require the disturbance of approximately 232 to 471 acres (93 to 188 ha), including 104 acres (42 ha) for buildings, paved areas, and the wasteform facility for grouted U_3O_8. This disposal option would result in elevation of the soil surface and in reduction in soil permeability. The excavated material would primarily consist of rock removed from the drifts and ramps. The consequent decrease in surface soil moisture would make reestablishment of vegetation difficult and delay the establishment of native plant communities. This disposal option would result in a large adverse impact to existing vegetation and wildlife. Reestablishment of native vegetation over such a large area would be especially difficult in a generic dry western environmental setting, and a considerable period of time might be required.

I.3.6.2 Disposal as UO_2

The construction and operation of a facility for the disposal of UO_2 would generally result in the types of impacts associated with the disposal of U_3O_8; however, the facility sizes would be smaller. A facility for disposal of UO_2 in shallow earthen structures would eliminate approximately 28 to 39 acres (11 to 16 ha) of habitat, including the wasteform facility for grouted UO_2. This habitat loss would result in a moderate adverse impact to vegetation and wildlife. A facility for the disposal of UO_2 in vaults would eliminate approximately 28 to 41 acres (11 to 16 ha) of habitat, including the wasteform facility for grouted UO_2. This loss would result in a moderate adverse impact to vegetation and wildlife. A mine disposal facility for UO_2 would result in disturbance of approximately 102 to 149 acres (41 to 60 ha) of habitat, including the wasteform facility for grouted UO_2. This habitat disturbance would constitute a large adverse impact to vegetation and wildlife.

Atmospheric emissions from wasteform facility operations would be expected to be slightly lower for grouted UO_2 disposal than for grouted U_3O_8 disposal (Section I.3.3). Emissions would be similar for ungrouted UO_2 and U_3O_8 disposal. The highest annual average air concentration of UO_2, due to operation of the facility, would be 0.00003 $\mu g/m^3$ at a distance of 230 ft (750 m) away from the facility. Resulting impacts to biota would be negligible.

I.3.7 Waste Management

Wastes would be generated during the construction of the wasteform facility. This facility would be used for the receipt of waste, grouting of the uranium oxide (if necessary), and storage of both the input and output from the facility. Waste generation would also occur during the construction of any of the three types of disposal facilities. No radioactive wastes would be generated during construction of the wasteform facility or any of the three possible disposal facilities because no radioactive materials would be used and the site would be uncontaminated. Table I.26 lists the various hazardous materials that would be generated in construction of the different types of disposal facilities. Only small differences are expected for the generation of waste for these different disposal options. The waste generated in the construction of any of these disposal facilities represents a negligible impact to DOE's waste management capabilities.

In grouting the converted uranium oxide, operation of the wasteform facility would generate two waste streams: the product (final form of uranium oxide grout) and minor amounts of secondary waste associated with making the final grout product of uranium. Table I.27 lists the volume throughputs of this facility as a function of the four different final form options for uranium. For the ungrouted wasteforms of U_3O_8 and UO_2, this facility would be used only as temporary storage between the conversion and disposal facilities. Consequently, no secondary waste streams would be generated at this facility for the ungrouted U_3O_8 and UO_2 final form options. Table I.28 lists the annual operational wastes from the wasteform facility for each of the four final waste form options (product waste) as well as the secondary waste streams expected from the two grouted waste options. The initial volumes of U_3O_8 and UO_2 listed under facility waste in Table I.28 are equivalent to the

TABLE I.26 Estimated Construction Wastes Generated under the Disposal Options

Facility/Waste Type	U_3O_8 (m^3)		UO_2 (m^3)	
	Grouted	Ungrouted	Grouted	Ungrouted
Wasteform Facility				
Hazardous liquids				
Paints	6.4	2.6	2.2	0.9
Phenol	1.6	0.6	0.6	0.2
Sulfuric acid	0.8	0.3	0.3	0.1
Total	8.8	3.5	3.1	1.2
Hazardous solids				
Mercury lamps	0.8	0.3	0.3	0.1
Lead batteries	0.2	0.1	0.1	0.05
Nonhazardous solids				
Conventional waste	600	240	210	90
Shallow Earthen Structure				
Hazardous liquids				
Paints	1.6	0.6	0.6	0.2
Phenol	0.4	0.2	0.1	0.05
Sulfuric acid	0.2	0.1	0.1	0.05
Total	2.2	0.9	0.8	0.3
Hazardous solids				
Mercury lamps	0.2	0.1	0.1	0.05
Lead batteries	0.05	0.03	0.02	0.01
Nonhazardous solids				
Conventional waste	150	60	60	30
Vault				
Hazardous liquids				
Paints	3.2	1.3	1.1	0.4
Phenol	0.8	0.3	0.3	0.1
Sulfuric acid	0.4	0.2	0.1	0.1
Total	4.4	1.8	1.5	0.6
Hazardous solids				
Mercury lamps	0.4	0.2	0.2	0.1
Lead batteries	0.1	0.04	0.03	0.01
Nonhazardous solids				
Conventional waste	300	120	110	50
Mine				
Hazardous liquids				
Paints	9.6	3.8	3.4	1.4
Phenol	2.4	1.0	0.8	0.3
Sulfuric acid	1.2	0.5	0.4	0.2
Total	13.2	5.3	4.6	1.9
Hazardous solids				
Mercury lamps	16.0	11.2	9.0	7.4
Lead batteries	0.4	0.3	0.2	0.15
Nonhazardous solids				
Conventional waste	900	640	500	420

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TABLE I.27 Variations in Wasteform Facility Operations for the Different Final Forms of Uranium

Uranium Type	Throughput Quantity (m^3)	Containers	
		Number	Type
Grouted U_3O_8	312,000	1,560,000	55-gal
Ungrouted U_3O_8	148,800	714,000	55-gal
Grouted UO_2	72,000	630,000	30-gal
Ungrouted UO_2	47,600	420,000	30-gal

final waste volumes expected for the two ungrouted wasteforms because no waste processing would take place in this facility for these two options.

Estimates of the amount of LLW to be disposed of at DOE waste management disposal facilities depend critically upon the time frame under consideration and the types of waste to be included. The *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) estimates that 1,060,000 m^3 of LLW will be disposed of during the time frame 1995-2014 (DOE 1997). This estimate does not include any LLW from environmental restoration activities or facility stabilization activities. A more appropriate value is reported in *The 1996 Baseline Environmental Management Report* (BEMR) (DOE 1996), which estimates the total amount of LLW for treatment at waste management facilities to be 3,400,000 m^3. This estimate is for the next 75 years and includes contributions from environmental restoration and facility stabilization programs.

The majority of environmental restoration wastes are expected to be generated between 2003 and 2033, approximately the correct time frame to compare with the depleted UF_6 program. For this reason, the BEMR estimate was used for comparison with the depleted UF_6 wastes. Adjustments must be made to the BEMR estimate to convert treatment volumes into disposal volumes. Both volume reductions and expansions would occur during waste treatment and grouting, depending on the relative amounts of the different types of waste. On the basis of the WM PEIS analysis (DOE 1997), the BEMR estimate was adjusted to 4,250,000 m^3 for the estimated disposal volume. The total LLW disposal volumes from disposal of depleted uranium, as either UO_2 or U_3O_8 (grouted or ungrouted), were compared with the total estimated disposal volume for LLW for all DOE waste management activities (including environmental restoration waste). Disposal volumes were compared as total volume (m^3) because disposal facilities would typically have no throughput limitations but rather would be limited by the total volume of waste that could be accepted.

For the case of grouted U_3O_8 with a waste volume of 15,600 m^3/yr, the total disposal volume would be [(15,600) x 20 years operation] = 312,000 m^3. This would add about 7.3% to the estimated total DOE LLW disposal volume of about 4,250,000 m^3. Using a similar approach for the other cases would add about 1.7% for grouted UO_2, 3.5% for ungrouted U_3O_8, and 1.1% for

TABLE I.28 Estimated Annual Radioactive Waste Streams from Wasteform Facility Operations

Waste Stream	Treatment	Initial Volume (m^3/yr)		Final Volume (m^3/yr)		Uranium Content (kg)	Treatability Category
		Ungrouted U_3O_8	Ungrouted UO_2	Grouted U_3O_8	Grouted UO_2		
Facility waste (product)	Cement solidification	7,440	2,380	15,600	3,600	18,900,000[a]	Not applicable
HEPA filters	Drumming	24	24	24	24	5.7[b]	Noncombustible compactible solid (LLW)
Dry active waste	Dewater/Drum	57	24	24	5.5	760[b]	Combustible solid (LLW)
Inorganic spray solution used to clean drums	Neutralize	0.31	0.2	0.18	0.10	< 1	Low-level mixed waste
Cotton waste wipes used to clean drums[c]	Neutralize	NA	NA	0.0078 m^3 (5 kg)	0.0078 m^3 (5 kg)	< 1	Low-level mixed waste

[a] Uranium content determined by stoichiometry, given in the form of U_3O_8.

[b] Determined by analogy to production facilities.

[c] Final volume based on bulk density of 40 lb/ft^3.

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ungrouted UO_2 to the total volume. The amount of low-level mixed waste (LLMW) from depleted UF_6 disposal added to total nationwide LLMW load would be negligible (less than 1%).

Although more secondary wastes would be generated in producing either of the grouted wasteforms of U_3O_8 and UO_2, compared with the ungrouted wasteforms, the differences are not significant. The choice of which wasteform would be used should be based on other factors such as long-term stability of the wasteform, leach rates of the radioactive contaminants, and cost.

Waste generation for the different disposal options is not expected to vary with wet or dry environments. The choice of which disposal option would be used in a wet or dry environment is based on considerations other than waste generation.

Overall, the disposal options would generate appreciable amounts of waste for disposal in DOE facilities. Within the context of the total amount of LLW undergoing disposal in DOE facilities, these wastes would have a low impact on DOE's total waste management disposal capabilities.

I.3.8 Resource Requirements

Resource requirements for the disposal options were estimated for construction and operations. The materials required for monitoring of the groundwater and disposal cell performance would be expected to be minor.

Materials and utilities required for construction and operation of the shallow earthen structure, vault, and mine options are presented in Table I.29. In general, the amount of resources is directly related to the volume of waste to be disposed, with the greatest resources required for the grouted U_3O_8 waste form and least with the ungrouted UO_2 waste form. A fixed facility for solidification is required for the two grouted waste forms, which results in greater construction requirements. During the operations phase, cement and sand are required for solidification of the uranium oxides. The total quantities of commonly used construction materials are not expected to be significant and would be comparable to construction of a multistory building. No specialty materials (e.g., Monel or Inconel) are projected to be needed for either construction or operations phases.

Significant quantities of electrical energy could be required during construction of the mine option because most of the construction equipment utilized in underground mines is powered by electricity to avoid polluting the air in the underground work area. Similarly, a relatively higher annual consumption of electricity is projected during underground operations, compared with the other disposal facility options.

TABLE I.29 Resource Requirements for Construction and Operation of Disposal Facilities

Facility/Activity	Resource	Unit	Resource Requirements for Disposal Facility: Grouted U_3O_8	Ungrouted U_3O_8	Grouted UO_2	Ungrouted UO_2
Shallow Earthen Structure						
Construction	Utilities					
	Electricity	MWh	7,700	4,000	3,100	2,300
	Solids					
	Concrete	yd^3	20,000	5,400	10,000	3,200
	Sand	yd^3	124,000	59,400	37,000	25,400
	Steel	tons	1,000	300	600	200
	Liquids					
	Diesel fuel	gal	530,000	260,000	200,000	130,000
Operations	Utilities					
	Electricity	MWh/yr	3,200	1,300	1,800	1,000
	Liquids					
	Diesel fuel	gal/yr	64,000	21,000	23,000	13,000
	Gases					
	Natural gas	million scf/yr	14	5.3	14	5.3
Vault						
Construction	Utilities					
	Electricity	MWh	3,100	1,400	1,000	590
	Solids					
	Concrete	yd^3	410,000	190,000	90,000	56,000
	Sand	yd^3	0	0	0	0
	Steel	tons	10,000	6,000	3,000	2,000
	Liquids					
	Diesel fuel	gal	860,000	400,000	200,000	120,000
Operations	Utilities					
	Electricity	MWh/yr	4,900	2,600	2,500	1,100
	Liquids					
	Diesel fuel	gal/yr	130,000	55,000	50,000	30,000
	Gases					
	Natural gas	million scf/yr	14	5.3	14	5.3

TABLE I.29 (Cont.)

Facility/Activity	Resource	Unit	Resource Requirements for Disposal Facility: Grouted U_3O_8	Ungrouted U_3O_8	Grouted UO_2	Ungrouted UO_2
Mine						
Construction	Utilities					
	Electricity	million MWh[a]	10	4.3	2.8	1.9
	Solids					
	Concrete	yd^3	180,000	102,000	83,000	62,000
	Sand	yd^3	0	0	0	0
	Steel	tons	42,000	17,000	18,000	8,900
	Liquids					
	Diesel fuel	gal	300,000	150,000	130,000	90,000
Operations	Utilities					
	Electricity	MWh/yr	110,900	6,600	5,900	4,300
	Liquids					
	Diesel fuel	gal/yr	23,000	2,000	8,000	2,000
	Gases					
	Natural gas	million scf/yr	14	5.3	14	5.3

[a] For the mine disposal facility, the unit of electricity is million MWh compared with MWh for the other disposal options.

I.3.9 Land Use

Land area requirements for each disposal option are presented in Table I.30. These data do not include acreage required for the construction phase for any of the disposal options because development of land would be incremental and space required for material excavation storage, equipment staging, and construction material laydown areas would be available on adjacent undeveloped parcels. Consequently, areal needs for construction would not be greater than those for operations.

Although no site has been chosen for facilities under each disposal option, selection of a site at or near a location that is already dedicated to similar use could result in reduced land-use impacts because immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use.

All disposal options would include a central wasteform facility where drums of uranium oxide would be received from the conversion facility and prepared for disposal. The facility would

TABLE I.30 Land Requirements and Excavated Material Volumes for Disposal Facilities

	Land Requirement[a] (acres)			
	Disposal as U_3O_8		Disposal as UO_2	
Facility	Grouted	Ungrouted	Grouted	Ungrouted
Shallow earthen structure	85	46	39	28
Vault	149	75	41	28
Mine	471	232	149	102

[a] Values include the wasteform facility areas, as follows: grouted U_3O_8 options, 9 acres, ungrouted U_3O_8 options, 4 acres; grouted UO_2 options, 6 acres; ungrouted UO_2 options, 4 acres.

Source: LLNL (1997).

include a grouting/cementing building, if necessary, which could affect the number of buildings erected for the wasteform facility. Impacts to land use from the wasteform facility would be very small and limited to clearing of required land, as well as potential minor and temporary disruptions to contiguous land parcels. No off-site impacts would be expected.

Land-use impacts resulting from the shallow earthen structure disposal option would be negligible to moderate and limited to clearing of required land and a potential slight increase in off-site vehicular traffic associated with construction activities. The shallow earthen structure option would require from 28 to 85 acres (11 to 34 ha) of land (including the wasteform facility) that would be cleared and developed incrementally. The rate of development would be determined by the selection of the wasteform. Up to 2.62 million yd^3 (2.0 million m^3) would be excavated. The large volume of excavated material that would remain on-site could, over time, result in topographical modifications of the site. Impacts of off-site disposal would be determined during the site-specific tier of NEPA documentation. Other than minor, temporary impacts associated with construction traffic, no other off-site impacts would be expected.

The vault option would require from 28 to 149 acres (11 to 60 ha) of land and would result in up to 1.62 million yd^3 (1.27 million m^3) of excavated material. Because the vault facility would be constructed incrementally (10 vault blocks per year), the amount of land disturbed during a given year would be limited. Impacts of off-site disposal would be determined during the site-specific tier of NEPA documentation.

Of all the disposal options, a mine would have the greatest potential for land-use impacts. A mine would require the largest amount of land, 102 to 471 acres (41 to 188 ha) (see Table I.30).

The construction associated with this option could result in potential land disturbance impacts for adjacent parcels. The large volume of excavated material (1.96 million yd^3 [1.5 million m^3]) would be disposed of on-site, probably resulting in topographical modifications of the site. The peak construction labor force could result in off-site land-use impacts, particularly if a remote site were chosen. Impacts could include pressure on existing commercial land and traffic congestion on local access roads and intersections.

I.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the disposal options considered in this PEIS were implemented include impacts to cultural resources and environmental justice, as well as impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of the disposal facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS.

I.4 IMPACTS OF OPTIONS — POST-CLOSURE PHASE

This section provides a summary of the potential environmental impacts associated with the post-closure phase of the disposal options. The post-closure phase considers the potential environmental impacts that could occur in the future, well beyond the time that any engineered disposal facility would be expected to function as designed. Post-closure impacts are evaluated because, no matter how well designed, all disposal facilities would be expected to release material to the environment eventually, a condition referred to as "failure."

Disposal facility failure would generally occur hundreds to thousands of years in the future (assuming no sustained effort to maintain the facility). This failure would be caused by natural degradation of the disposal structures over time, primarily from physical processes such as the intrusion of water. Following failure, the release of uranium from the facility would occur very slowly as water moved through the disposed material. This water would carry dissolved uranium through the soil under the facility, eventually contaminating the groundwater. This process could continue for thousands to millions of years because of the large amount of uranium in the disposal facility and low solubility of that uranium.

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In general, shallow earthen structures would be expected to contain the waste material for a period of at least several hundred years before failure. Vaults and a mine would be expected to last even longer, from many hundreds to thousands of years before failure. However, the exact time that a disposal facility would be expected to fail is extremely difficult to predict and would depend on the detailed facility design and site-specific conditions. Because of this difficulty, failure was assumed to occur at the end of a period of institutional control, 100 years after closure. The post-closure impacts were evaluated at 1,000 years after failure for all three disposal facility options.

Post-closure impacts were evaluated in three areas: (1) potential impacts to groundwater, (2) potential impacts to human health and safety, and (3) potential impacts to ecological resources. Impacts in other areas would be expected to be negligible. The following general assumptions apply to the assessment of post-closure impacts:

- All disposal facilities would fail at some time in the future. Failure is defined as the release of uranium material from the disposal facility to the surrounding soil. For consistency, failure was assumed to occur at the end of institutional control, 100 years after closure.

- The post-closure phase primarily considers impacts from the potential contamination of groundwater and surface water. Potential impacts from contamination of air and soil due to erosion of the disposal facility surface are also discussed.

- Impacts were evaluated at a time of 1,000 years after the facility failed and started to release uranium.

- Two generic environmental settings were assumed for the disposal facilities: a dry setting and a wet setting (see Section 3.4.4 for details).

- For analysis of groundwater impacts, assumptions were varied to assess a broad range of possibilities with respect to movement of the uranium through the soil to the groundwater aquifer.

The estimated impacts associated with the post-closure phase are subject to a great deal of uncertainty because the assessment considers an extremely long period of time and depends on predicting the behavior of the waste material as it interacts with soil and water in a complex and changing environment. Consequently, the estimated impacts are very dependent on the assessment assumptions. Key assumptions include such factors as soil characteristics, water infiltration rates, depth to the underlying groundwater table, chemistry of different uranium compounds, and the locations of future human receptors. These factors can vary widely depending on site-specific conditions. Because of these uncertainties, the assumptions were generally selected in a manner intended to produce conservative estimates of impact, that is, the assumptions tend to overestimate

the expected impact. Changes in key disposal assumptions could yield significantly different estimates of impact.

I.4.1 Human Health — Normal Operations

I.4.1.1 Radiological Impacts

Radiation doses and cancer risks for the post-closure phase were assessed for a hypothetical individual who would live at or near the disposal site after the institutional control period of the site ended. This individual was assumed to drill a well at the edge of the disposal site and use the well water for drinking, household purposes, irrigating plant foods and fodder, and watering livestock. Because of leaching of uranium from the disposal area to the groundwater table, the hypothetical resident could be exposed to radiation through use of contaminated well water. Detailed discussions of the methodologies used in radiological impact analyses are provided in Cheng et al. (1997). Additional information on the methodology and assumptions used in the groundwater analyses is provided in Section I.4.2.

The estimated groundwater concentrations involve large degrees of uncertainty because of the preliminary nature of facility design and the various soil properties that depend on the location of the facility. The radiological impacts estimated by using the groundwater concentrations are subject to a large degree of uncertainty as well. The groundwater contamination would persist for millions of years once it occurred because of the large inventory of U_3O_8 and UO_2 in the disposal area. Because of the long decay half-lives of uranium isotopes and the continuous generation of decay products, the maximum radiation dose, which could be greater than 1 rem/yr from using contaminated groundwater, would not be observed until sometime after 10,000 years, a time frame well beyond that considered in this analysis. Table I.31 lists the calculated radiation doses and cancer risks for the maximally exposed individual (MEI) 1,000 years after the failure of engineering barriers and waste containers. Although impacts from using the contaminated groundwater at that time could reach 110 mrem/yr, they could be either minimized by treating the groundwater or eliminated by switching to a clean water source.

In addition to the possible exposures resulting from use of contaminated groundwater, radiological impacts could be caused by external radiation and inhalation of contaminated dust particles if all the cover materials above the disposal site were removed and if containers of U_3O_8 or UO_2 disintegrated. This scenario could be caused by natural forces of erosion over long periods of time or by human intervention (i.e., digging) to bring the waste to the surface. The associated external radiation dose could be as high as 10 rem/yr for an individual living on the disposal site. However, the exposure would not occur until several thousand years after closure of the shallow earthen structure or vault disposal facility and would be quite unlikely for mine disposal because a mine would be located at a depth of several hundred feet below the ground surface. Detailed analyses for this exposure scenario were not conducted because it is beyond the time frame considered in this

TABLE I.31 Human Health Impacts for the MEI from Disposal Options: Post-Closure Phase

Option/ Location[a]	Radiological Impacts at 1,000 Years[b,c]				Chemical Impacts at 1,000 Years[b,c]	
	MEI Dose (mrem/yr)		MEI Risk (LCF/yr)		MEI Hazard Index[d]	
	Grouted Oxide	Ungrouted Oxide	Grouted Oxide	Ungrouted Oxide	Grouted Oxide	Ungrouted Oxide
Disposal as U_3O_8						
Shallow earthen structure						
Dry	0	0	0	0	0	0
Wet	49 – 72	41 – 60	2×10^{-5} – 4×10^{-5}	2×10^{-5} – 3×10^{-5}	5.9 – 8.7	5.0 – 7.3
Vault						
Dry	0	0	0	0	0	0
Wet	57 – 84	48 – 70	3×10^{-5} – 4×10^{-5}	2×10^{-5} – 4×10^{-5}	6.9 – 10	5.8 – 8.5
Mine						
Dry	0	0	0	0	0	0
Wet	0.88 – 110	0.72 – 93	4×10^{-7} – 6×10^{-5}	4×10^{-7} – 5×10^{-5}	0.1 – 14	0.1 – 11
Disposal as UO_2						
Shallow earthen structure						
Dry	0	0	0	0	0	0
Wet	37 – 54	34 – 50	2×10^{-5} – 3×10^{-5}	2×10^{-5} – 3×10^{-5}	4.5 – 6.6	4.1 – 6.0
Vault						
Dry	0	0	0	0	0	0
Wet	38 – 56	34 – 50	2×10^{-5} – 3×10^{-5}	2×10^{-5} – 3×10^{-5}	4.6 – 6.7	4.2 – 6.1
Mine						
Dry	0	0	0	0	0	0
Wet	0.64 – 84	0.59 – 77	3×10^{-7} – 4×10^{-5}	2×10^{-7} – 4×10^{-5}	0.1 – 10	0.1 – 9.3

[a] Two generic environmental settings were considered for each option, corresponding to dry and wet environments, respectively.

[b] Impacts are reported as ranges, which result from different transport speeds of radionuclides in the unsaturated and saturated zones. Retardation factors of 5 and 50 were used to represent relatively mobile and immobile transport situations, respectively. Values correspond to estimated impacts 1,000 years after failure of the engineering barriers and containers.

[c] The maximally exposed individual was assumed to live at the edge of the disposal site and use contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. The exposure pathways considered were ingestion of drinking water, plant foods, meat, and milk; and, for radiological exposures, inhalation of radon emanating from household water.

[d] The hazard index is an indicator for potential adverse health effects other than cancer; a hazard index of greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

analysis. If any exposure occurred, the radiation dose could be eliminated by adding new cover materials to the top of the waste area.

I.4.1.1.1 Disposal as U_3O_8

Radiological impacts are presented in Table I.31 for a scenario in which an individual uses contaminated groundwater. In a dry setting, it would take more than 10,000 years for uranium and its decay products to reach the groundwater because of the low water infiltration rate. Therefore, no radiation exposure would occur before 1,000 years in a dry environment, the time frame considered in this analysis.

In a wet setting, the required time for uranium and decay products to reach the groundwater table could be less than 1,000 years after the failure of the disposal facility. The groundwater concentrations would vary from site to site, depending on the specific soil properties (which determine whether the uranium and decay products travel rapidly or slowly in soil). As a result, at 1,000 years after failure of the disposal facility, the radiation dose from using groundwater could range from 41 to 72 mrem/yr for disposal in shallow earthen structures, 48 to 84 mrem/yr for disposal in vaults, and 0.72 to 110 mrem/yr for disposal in a mine. With no remediation effort, the radiation dose could exceed the dose limit of 25 mrem/yr set for low-level waste disposal (10 CFR Part 61). Variation of radiation doses among different disposal types is related to the size of the disposal facility. More discussions are provided in Section I.4.2 regarding the effect of facility dimensions on groundwater concentrations.

I.4.1.1.2 Disposal as UO_2

Variations in disposal settings and disposal types have the same effects on the groundwater concentrations for UO_2 disposal as they do on the groundwater concentrations for U_3O_8 disposal. The time required for uranium and decay products to reach the groundwater table would be greater than 10,000 years for a dry setting, so no impacts would be expected within 1,000 years. The radiation doses estimated for a wet setting for disposal of UO_2 tend to be smaller than those for disposal of U_3O_8 because the waste volume of UO_2 would be less than the volume of U_3O_8 and would require a smaller disposal facility. The doses estimated for use of groundwater range from 34 to 54 mrem/yr for disposal in shallow earthen structures, 34 to 56 mrem/yr for disposal in vaults, and 0.59 to 84 mrem/yr for disposal in a mine at 1,000 years after failure of the disposal facility. With no remediation effort, the exposure could exceed the dose limit of 25 mrem/yr set for low-level waste disposal.

I.4.1.2 Chemical Impacts

Chemical impacts during the post-closure phase are assessed for a hypothetical individual who lives at the border of the disposal site after the institutional control period is over. As for the radiological assessment, potential chemical impacts to human health were evaluated for a scenario involving a hypothetical individual who drills a well at the edge of the disposal site and uses the well water for drinking, irrigating plant foods and fodder, and watering livestock. Leaching of uranium from the disposal area to the groundwater table could potentially result in the hypothetical resident being exposed to uranium from ingestion of drinking water, plant foods, meat, and milk. Risks are estimated on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses used for uranium compounds, and calculational methods used in the chemical impact analysis are provided in Appendix C and Cheng et al. (1997).

I.4.1.2.1 Disposal as U_3O_8

Potential health impacts to the general public MEI from exposures to hazardous chemicals due to use of groundwater are presented in Table I.31. Two disposal options are evaluated: disposal as grouted U_3O_8 and ungrouted U_3O_8. The hazard indices for chemical impacts in a dry environment are always zero because the time required for the uranium to reach the groundwater would be greater than 10,000 years due to the low water infiltration rate. In a wet environmental setting, the time to reach groundwater would be less than 1,000 years, but would be dependent on the soil properties (i.e., retardation factor). A retardation factor of 5 results in the uranium reaching the groundwater more quickly and consequently producing greater chemical exposures at 1,000 years than would occur with a retardation factor of 50.

The range of hazard indices for all types of disposal facilities in a wet setting is about 0.1 to 14, exceeding the threshold of 1 for potential adverse health effects. The highest values are for mines, which would require the largest disposal area; and the lowest values are for shallow earthen structures, which would require the smallest disposal area. On the basis of maximum hazard indices, potential chemical impacts are greater for disposal as grouted waste than as ungrouted waste because of the larger waste volume that would be required. Among the groundwater-related exposure pathways that were analyzed, ingestion of drinking water is responsible for more than 80% of the total uranium exposure.

I.4.1.2.2 Disposal as UO_2

Potential human health impacts to the general public MEI from exposures to hazardous chemicals due to groundwater use are presented in Table I.31. Two disposal options were evaluated: disposal as grouted UO_2 and ungrouted UO_2. Differences in environmental settings and types of disposal facilities result in the same variations in groundwater concentrations for UO_2 disposal as they do in the groundwater concentrations for U_3O_8 disposal. Because the waste volume of UO_2

would be less than the volume of U_3O_8, the estimated maximum chemical exposures for UO_2 disposal are consistently less than those for U_3O_8 disposal.

The range of hazard indices for all types of UO_2 disposal facilities in a wet setting is about 0.1 to 10, exceeding the threshold of 1 for potential adverse health effects. The highest values are for mines, which would require the largest disposal area; and the lowest values are for shallow earthen structures, which would require the smallest disposal area. Based on maximum hazard indices, potential chemical impacts are greater for disposal as grouted waste because of the larger waste volume that would be required compared with disposal as ungrouted waste.

I.4.2 Groundwater

Potential impacts to groundwater for the three disposal options during the post-closure phase only include changes in groundwater quality. There would be no impacts to effective recharge, depth to groundwater, or the direction of groundwater flow.

I.4.2.1 Shallow Earthen Structure

During the post-closure period, the only potential impacts to groundwater would be to water quality. With time, the roof material would and allow water to infiltrate the disposal facility. This water could corrode the drums and permit leaching of their contents. Although both forms of the disposed material (U_3O_8 and UO_2) are essentially insoluble in water (LLNL 1997), a conservative estimate of dissolution was obtained by assuming that schoepite ($UO_3 \cdot H_2O$) would form under the aerobic conditions present in the structure.

With additional time (several hundred to thousands of years), the facility would fail completely, and dissolved schoepite would infiltrate the soil beneath the structure and interact with soil water present in the unsaturated zone. For the shallow earthen structure, this soil water would have a nearly neutral pH (about 7). For the ungrouted case, this interaction would have no impact, and the dissolved schoepite would move vertically downward toward the water table. Transport of the schoepite would be influenced by advection, dispersion, adsorption, and decay (Tomasko 1997).

For the grouted wastes, schoepite was again assumed to form at a concentration equal to its equilibrium value, although carbonates might also form, depending on the type of grout used and site-specific conditions. Because schoepite is about two million times more soluble under the high pH conditions that would occur for the grouted forms of the waste (pH between 10 and 12), the disposed material would dissolve at greatly different rates. However, once the schoepite reached the groundwater, its concentration would be oversaturated relative to the soil water, and it would precipitate and then slowly redissolve. After redissolving, it would be transported vertically downward through the unsaturated zone in the same way that transport would occur for the ungrouted case (Tomasko 1997).

At the water table, schoepite would mix with initially clean water in the uppermost groundwater aquifer and be diluted. After mixing and dilution, the contaminants would be transported in a direction consistent with natural flow. Advection, dispersion, adsorption, and decay would again influence the transport process (Tomasko 1997).

Uranium concentrations and activities at the water table for a wet environmental setting are summarized in Table I.32 for 1,000 years after failure. Values are shown for lateral distances of 0 and 1,000 ft (300 m) downgradient of the facility. For a dry setting, the concentrations would be very small (nearly zero) and are not shown. Additional details on the calculations for the dry location are presented in Tomasko (1997).

The highest uranium groundwater concentrations (270 pCi/L; 1,100 µg/L) would result from a grouted U_3O_8 wasteform; the lowest concentrations (188 pCi/L; 760 µg/L) would result from ungrouted UO_2 (see Table I.32). All of the predicted concentrations would exceed the U.S. Environmental Protection Agency (EPA) proposed maximum contaminant level (MCL) of 20 µg/L (EPA 1996) used for comparison. In all cases, concentrations from grouted wasteforms would be higher than those from ungrouted forms over the long term. This result occurs because a larger facility would be required for the grouted wastes, which would, in turn, reduce the amount of subsequent dilution when the leachate mixes with water in the underlying aquifer. Impacts to groundwater quality could be reduced by decreasing the size of the facility in a direction parallel to the direction of groundwater flow, thereby increasing dilution. The relative concentrations for the decay products formed during transport are reported in Tomasko (1997).

Varying the distance to the receptor from 0 to 1,000 ft (300 m) would have no effect on concentrations if the uranium was relatively mobile in the soil (a retardation of 5 [Table I.32]). This result occurs because of hydrological conditions present in the soil beneath the facility in the wet environment (Tomasko 1997). If the uranium was less mobile and had a retardation coefficient of 50, the concentration at 1,000 years at a lateral distance of 1,000 ft (300 m) would be about 100 times less than the concentration directly below the edge of the facility (0 ft) (Table I.32).

I.4.2.2 Vault

The disposal vault would be located in a dry or wet environment. Because of the design of the facility with a concrete slab roof and other engineered barriers (LLNL 1997), the vault would be expected to have an effective life ranging from several hundred years to tens of thousands of years. Failure of this facility would parallel the failure process described for the shallow earthen structure, and the only impacts to groundwater would be changes in quality once the facility failed completely.

Uranium concentrations in groundwater at 1,000 years for distances of 0 and 1,000 ft (300 m) from the edge of the vault are given in Table I.32. As for the shallow earthen structure, concentrations in the dry environment would be nearly zero, and are not presented here. At 1,000 years, uranium concentrations for a relatively mobile uranium species (retardation coefficient

TABLE I.32 Uranium Activity and Schoepite Concentration in Groundwater for the Disposal Options at 1,000 Years in a Wet Environmental Setting: Retardation Factor = 5 or 50[a]

	Uranium Activity (pCi/L) at Two Distances from Edge of Disposal Facility			
	X = 0 ft		X = 1,000 ft	
Option/Uranium Oxide	Rf = 5	Rf = 50	Rf = 5	Rf = 50
Shallow earthen structure				
Grouted U_3O_8	270	184	270	2.4
Ungrouted U_3O_8	226	154	226	2.0
Grouted UO_2	204	139	204	1.8
Ungrouted UO_2	188	128	188	1.7
Vault				
Grouted U_3O_8	315	214	315	2.8
Ungrouted U_3O_8	264	180	264	2.4
Grouted UO_2	209	142	209	1.9
Ungrouted UO_2	189	129	189	1.7
Mine				
Grouted U_3O_8	425	3.3	425	0
Ungrouted U_3O_8	350	2.7	350	0
Grouted UO_2	316	2.4	316	0
Ungrouted UO_2	289	2.2	289	0

	Schoepite ($UO_3 \cdot 2H_2O$) Concentration (µg/L) at Two Distances from Edge of Disposal Facility			
	X = 0 ft		X = 1,000 ft	
Option/Uranium Oxide	Rf = 5	Rf = 50	Rf = 5	Rf = 50
Shallow earthen structure				
Grouted U_3O_8	1,100	740	1,100	9.7
Ungrouted U_3O_8	910	620	910	8.1
Grouted UO_2	820	560	820	7.3
Ungrouted UO_2	760	520	760	6.9
Vault				
Grouted U_3O_8	1,300	860	1,300	11
Ungrouted U_3O_8	1,100	730	1,100	9.7
Grouted UO_2	840	570	840	7.7
Ungrouted UO_2	760	520	760	6.9
Mine				
Grouted U_3O_8	1,700	13	1,700	0
Ungrouted U_3O_8	1,400	11	1,400	0
Grouted UO_2	1,300	9.7	1,300	0
Ungrouted UO_2	1,200	8.9	1,200	0

[a] The retardation factor (Rf) describes how readily a contaminant such as uranium moves through the soil to the groundwater. An Rf of 5 represents a case in which the uranium moves relatively rapidly through the soil, whereas an Rf of 50 represents a case in which the uranium moves very slowly through the soil.

of 5) would be the same at 0 and 1,000 ft (300 m) downstream of the facility because of the hydrological characteristics of the saturated zone (Tomasko 1997). The maximum concentration of uranium would be 315 pCi/L (1,300 µg/L) for grouted U_3O_8, and the minimum concentration (189 pCi/L; 760 µg/L) would occur for ungrouted UO_2 (Table I.32). These values would exceed the proposed EPA MCL of 20 µg/L (EPA 1996) used for comparison. The differences in concentrations between the different wasteforms primarily results from differences in the size of the facility. That is, the larger the facility, the greater the concentration because of decreased dilution. Impacts to groundwater quality could be reduced by decreasing the size of the facility in a direction parallel to the direction of groundwater flow, thereby increasing dilution (Tomasko 1997).

If the uranium were less mobile in the saturated zone and had a retardation coefficient of 50, uranium concentrations at 1,000 ft (300 m) would be about 100 times less than the concentration directly below the edge of the facility. Because of design considerations (size of the facility), the concentrations from the vault would be greater than those from the shallow earthen structure by about a factor of 1.2 (Tomasko 1997).

I.4.2.3 Mine

For disposal in a mine, waste would be placed in a mine hundreds of feet below the ground surface to minimize intrusion and potential erosion of a surface cap. The effective life of the mine would be expected to be thousands of years. As with the shallow earthen structure and vault, the only impacts to groundwater would be to quality once the facility failed completely.

If the disposal site were located in a dry environment, all of the resulting uranium concentrations at 1,000 years would be nearly zero (Tomasko 1997). In a wet climate, the uranium concentrations would all greatly exceed the proposed EPA MCL if the uranium was mobile (retardation coefficient of 5) (Table I.32) because the distance from the bottom of the mine to the top of the next lower aquifer was assumed to be small (100 ft). If the schoepite was less mobile (retardation coefficient of 50), uranium concentrations in groundwater after 1,000 years would be much less than the EPA proposed MCL and would be the smallest of all the disposal options considered (Table I.32) because the mine was assumed to be located at a distance of 100 ft (30 m) from the water table, whereas the shallow earthen structure and vault were assumed to be 30 ft (9.1 m) from the underlying aquifer. Impacts to groundwater quality could be reduced by decreasing the size of the facility in a direction parallel to the direction of groundwater flow, thereby increasing dilution (Tomasko 1997).

I.4.3 Ecology

Predicted concentrations of contaminants in groundwater were compared to benchmark values of toxic and radiological effects to assess impacts to biota. Discussion of assessment methodology is presented in Appendix C.

I.4.3.1 Disposal as U_3O_8

The disposal facilities considered would be expected to adequately prevent the release of their contents for considerable periods of time. Impacts to ecological resources due to the presence of the facility would not be expected to occur prior to facility failure. Failure of facility integrity would result in contamination of groundwater if the facility was located in a wet environmental setting (typical of the eastern United States, with at least 40 in./yr [100 cm/yr] precipitation). Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of schoepite ($UO_3 \cdot 2H_2O$) were calculated for 1,000 years after facility failure (Section I.4.2). Schoepite concentrations would be nearly zero throughout the time period analyzed for a disposal facility located in a dry environmental setting (typical of the western United States, with less than 10 in./yr [25 cm/yr] precipitation). Ecological impacts are summarized in Table I.33.

Failure of a shallow earthen structure disposal facility would result in groundwater concentrations of schoepite near the facility ranging from 3.1×10^{-6} to 1.1×10^{-3} g/L (0.003 to 1.5 ppm). Soluble uranium compounds can produce toxic effects in aquatic biota at concentrations as low as 1.5×10^{-4} g/L (0.15 ppm). An organism continuously exposed to the undiluted groundwater could therefore be adversely impacted by the toxic effects of uranium. Uranium activity would range from 2.0 to 270 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d for aquatic organisms specified in DOE Order 5400.5.

Failure of a facility for disposal in vaults would result in groundwater concentrations of schoepite ranging from 9.7×10^{-6} to 1.3×10^{-3} g/L (0.01 to 1.3 ppm). Therefore an organism continuously exposed to this undiluted groundwater could be adversely impacted by the toxic effects of uranium. Uranium activity would range from 2.4 to 315 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d.

Failure of a mine disposal facility would result in groundwater concentrations ranging from 0 to 1.7×10^{-3} g/L (1.7 ppm). Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range. Uranium activity would range from 0 to 425 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d.

I.4.3.2 Disposal as UO_2

Groundwater schoepite concentrations resulting from the failure of a facility for disposal of UO_2 would also be nearly zero at 1,000 years for a facility in a dry environmental setting. Groundwater concentrations for disposal of UO_2 in a wet environmental setting would be similar to those for disposal of U_3O_8.

TABLE I.33 Potential Radiological and Chemical Impacts to Aquatic Biota due to Failure of a Disposal Facility

Option/Contaminant	Maximum Exposure	Effect
Disposal as U_3O_8		
Shallow earthen structure		
Uranium in groundwater	2.0 to 270 pCi/L	Negligible
Uranium in groundwater	3.1×10^{-6} to 1.1×10^{-3} g/L	Moderate
Vault		
Uranium in groundwater	2.4 to 315 pCi/L	Negligible
Uranium in groundwater	9.7×10^{-6} to 1.3×10^{-3} g/L	Moderate
Mine		
Uranium in groundwater	0 to 425 pCi/L	Negligible
Uranium in groundwater	0 to 1.7×10^{-3} g/L	Negligible to moderate
Disposal as UO_2		
Shallow earthen structure		
Uranium in groundwater	1.7 to 204 pCi/L	Negligible
Uranium in groundwater	6.9×10^{-6} to 8.2×10^{-4} g/L	Moderate
Vault		
Uranium in groundwater	1.7 to 209 pCi/L	Negligible
Uranium in groundwater	6.9×10^{-6} to 8.4×10^{-4} g/L	Moderate
Mine		
Uranium in groundwater	0 to 316 pCi/L	Negligible
Uranium in groundwater	0 to 1.3×10^{-3} g/L	Negligible to moderate

Failure of a shallow earthen structure facility would result in groundwater concentrations of schoepite near the facility ranging from 6.9×10^{-6} to 8.2×10^{-4} g/L (0.007 to 0.82 ppm). Soluble uranium compounds can produce toxic effects in aquatic biota at concentrations as low as 1.5×10^{-4} g/L (0.15 ppm). An organism continuously exposed to the undiluted groundwater could be adversely impacted by the toxic effects of uranium. Uranium activity would range from 1.7 to 204 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d.

Failure of a facility for disposal in vaults would result in groundwater concentrations of schoepite ranging from 6.9×10^{-6} to 8.4×10^{-4} g/L (0.007 to 0.84 ppm). Therefore, an organism

continuously exposed to this undiluted groundwater could be adversely impacted by the toxic effects of uranium. Uranium activity would range from 1.7 to 209 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d.

Failure of a mined cavity disposal facility would result in groundwater schoepite concentrations ranging from 0 to 1.3×10^{-3} g/L (1.3 ppm). Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range. Uranium activity would range from 0 to 316 pCi/L (Section I.4.2). Resulting dose rates to maximally exposed organisms would be considerably lower than the dose limit of 1 rad/d.

I.5 REFERENCES FOR APPENDIX I

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APPENDIX J:

ENVIRONMENTAL IMPACTS OF TRANSPORTATION OF UF_6 CYLINDERS, URANIUM OXIDE, URANIUM METAL, AND ASSOCIATED MATERIALS

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NOTATION (APPENDIX J)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ICRP	International Commission on Radiological Protection
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
PEIS	programmatic environmental impact statement

Chemicals

CaF_2	calcium fluoride
HF	hydrogen fluoride; hydrofluoric acid
MgF_2	magnesium fluoride
NH_3	ammonia
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

ft	foot (feet)
h	hour(s)
kg	kilogram(s)
km	kilometer(s)
lb	pound(s)
m	meter(s)
mrem	millirem(s)

APPENDIX J:

ENVIRONMENTAL IMPACTS OF TRANSPORTATION OF UF_6 CYLINDERS, URANIUM OXIDE, URANIUM METAL, AND ASSOCIATED MATERIALS

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period from 1999 through 2039. This appendix provides detailed information describing the transportation of radioactive and other hazardous materials associated with the options considered in the PEIS. The discussion provides background information, as well as a summary of the estimated environmental impacts associated with transportation.

Transportation

The transportation of hazardous and radioactive materials was assessed for all alternative strategies considered in the PEIS for management of the depleted UF_6 inventory currently stored at three DOE sites. For purposes of analysis, it was assumed that all long-term storage, conversion, disposal, and manufacture and use facilities would be located at different sites, thus requiring the transportation of materials between sites. The PEIS transportation assessment considered the impacts from all shipments associated with each category of the options that make up the alternatives. The materials considered include depleted UF_6 cylinders, uranium conversion products, chemicals required for or produced during processing (such as hydrogen fluoride and hydrochloric acid), as well as any low-level radioactive, low-level mixed radioactive, and hazardous waste generated during operations. The analysis considered both truck and rail shipment options.

All of the PEIS alternatives would involve some transportation of radioactive and hazardous materials. For purposes of the PEIS analysis, it was assumed that all long-term storage, conversion, disposal, and manufacture and use facilities would be located at different locations. Thus, transportation would form the links between the options that make up each of the PEIS alternatives, as shown graphically in Chapter 2, Figures 2.2 through 2.6. In reality, the transportation activities actually required by an alternative would depend on the locations of the facilities involved — if facilities were colocated, the transportation of materials, and any associated impacts, would be minimized or eliminated.

The transportation assessment considered all shipments associated with the categories of options that make up each of the PEIS alternatives. The primary uranium materials transported under these alternatives include depleted UF_6 cylinders, uranium oxide (uranium dioxide [UO_2] or triuranium octaoxide [U_3O_8]), uranium metal, and uranium oxide and uranium metal storage casks (see Table J.1). Also, each alternative would involve transportation of chemicals required for or

TABLE J.1 Primary Uranium Materials Transported under Each Management Alternative

PEIS Alternative	Primary Material Transported[a]				
	Depleted UF_6 Cylinders	Oxide (UO_2 or U_3O_8)	Uranium Metal	Uranium Oxide Casks	Uranium Metal Casks
No action	–	–	–	–	–
Long-term storage as UF_6	X[b]	–	–	–	–
Long-term storage as oxide	X	X	–	–	–
Use as uranium oxide	X	X	–	X	–
Use as uranium metal	X	–	X	–	X
Disposal	X	X	–	–	–

[a] In addition to the uranium materials listed, each alternative would also involve the transportation of chemicals required for or produced during processing, as well as LLW and LLMW.

[b] X indicates that the material was assumed to be transported under that PEIS alternative.

produced during processing (such as hydrogen fluoride [HF]), as well as any low-level radioactive waste (LLW), low-level mixed waste (LLMW), and hazardous chemical waste generated during operations.

Impacts from the on-site transportation of the various materials at the different facilities (conversion, storage, manufacture, and disposal) were not computed. On-site transportation impacts are expected to be negligible when compared with the impacts associated with the off-site transportation between facilities. On-site shipments of over 19 miles (30 km) were assessed for the Hanford site for comparison with off-site shipments analyzed in the *Waste Management Programmatic Environmental Impact Statement* (DOE 1997). The on-site impacts were found to be more than 100 times smaller than the off-site impacts, primarily because of the much shorter shipment distances involved (Biwer et al. 1996). For the depleted UF_6 PEIS, shorter on-site distances are likely; therefore, the on-site transportation impacts are also expected to be more than 100 times smaller than the off-site impacts. The decisions to be made based on this PEIS would not be affected by on-site transportation impacts. In addition, transportation impacts would be much smaller for on-site shipments than off-site shipments and would also be smaller than the impacts associated with loading and unloading shipments for off-site shipments, which were included in the involved worker doses estimated for facility operations.

Additional details regarding the methodology used to assess transportation impacts are provided in Biwer et al. (1997).

J.1 SUMMARY OF TRANSPORTATION OPTION IMPACTS

The potential environmental impacts associated with transportation activities for the PEIS alternatives are summarized in Table J.2. For purposes of comparison in Table J.2, the analysis was based on the assumption that all shipments would be transported a distance of 620 miles (1,000 km), regardless of the type of material. (Transportation impacts were evaluated for distances ranging from 155 to 3,100 mi [250 to 5,000 km] in Section J.3.) The assessment considered impacts on human health that would result from the radioactive and hazardous chemical characteristics of the materials shipped, as well as the impacts that would result from operation of the transportation vehicles. Additional discussion and details related to the results for individual areas of impact are provided in Section J.3.

Various options were considered for each alternative, including the following transportation-related steps:

- ***No Action Alternative.*** No off-site transportation is expected under the no action alternative, except for a few LLW and LLMW shipments. Minor amounts of LLW and LLMW may be generated during monitoring and maintenance activities associated with the storage of the depleted UF_6 cylinders at their current locations. Fewer than one shipment per year to a disposal site would be expected for the waste generated, and no fatalities would be anticipated from waste shipments. Shipment impacts are expected to be negligible, similar to LLW and LLMW shipments from the cylinder treatment facility or the cylinder transfer facility as considered under other alternatives.

- ***Long-Term Storage as UF_6.*** Long-term storage as UF_6 would involve transportation of the depleted UF_6 cylinders from the three existing storage sites to a long-term storage facility. The cylinders might be shipped in overcontainers. If a transfer facility were used to alleviate the problem of substandard cylinders before shipment of the UF_6, shipment of LLW and LLMW from the transfer facility would be required.

- ***Long-Term Storage as Oxide.*** Long-term storage as oxide (UO_2 or U_3O_8) would involve transportation of the depleted UF_6 cylinders to an oxide conversion plant. The conversion facility would also require inbound shipments of ammonia and outbound shipments of HF and waste. Cleaning of the empty cylinders at a cylinder treatment facility colocated with the conversion facility would require outbound shipments of U_3O_8 and waste. The final transportation step would be shipment of the oxide to the long-term storage facility.

TABLE J.2 Summary of Transportation Impacts by Alternative[a]

Impacts from Long-Term Storage as UF_6	Impacts from Long-Term Storage as Oxide	Impacts from Use as Uranium Oxide Cask	Impacts from Use as Uranium Metal Cask	Impacts from Disposal
Total Shipments: LLW (cylinder transfer): 460 – 580 LLMW (cylinder transfer): 60 Cylinders: 11,606 – 46,666	**Total Shipments:** LLW (cylinder transfer): 460 – 580 LLMW (cylinder transfer): 60 Cylinders: 11,606 – 46,666 HF: 0 – 4,860 NH_3: 0 – 1,120 LLW (oxide conversion): 320 – 1,680 LLMW (oxide conversion): 20 – 40 CaF_2: 180 – 19,760 Oxide: 8,480 – 26,800	**Total Shipments:** LLW (cylinder transfer): 460 – 580 LLMW (cylinder transfer): 60 Cylinders: 11,606 – 46,666 HF: 0 – 4,860 NH_3: 0 – 1,120 LLW (UO_2 conversion): 360 – 1,680 LLMW (UO_2 conversion): 20 – 40 CaF_2: 180 – 19,760 Oxide: 8,480 – 26,800 LLW (cask manufacture): 300 LLMW (cask manufacture): 20 Uranium oxide casks: 9,600	**Total Shipments:** LLW (cylinder transfer): 460 – 580 LLMW (cylinder transfer): 60 Cylinders: 11,606 – 46,666 HF: 1,640 NH_3: 920 LLW (metal conversion): 360 – 3,840 LLMW (metal conversion): 20 MgF_2: 3,800 – 10,780 Metal: 7,360 – 21,500 LLW (cask manufacture): 1,540 LLMW (cask manufacture): 20 Uranium metal casks: 9,060	**Total Shipments:** LLW (cylinder transfer): 460 – 580 LLMW (cylinder transfer): 60 Cylinders: 11,606 – 46,666 HF: 0 – 4,860 NH_3: 0 – 1,120 LLW (oxide conversion): 320 – 1,680 LLMW (oxide conversion): 20 – 40 CaF_2: 180 – 19,760 Oxide: 8,480 – 26,800
Human Health – Normal Operations: Radiological[b]				
Workers and Public: Total number of LCFs: 0.1 Maximum risk of LCF to MEI member of general public (resident along route): $9 \times 10^{-15} - 8 \times 10^{-12}$	**Workers and Public:** Total number of LCFs: 0.1 – 0.3 Maximum risk of LCF to MEI member of general public (resident along route): $9 \times 10^{-15} - 8 \times 10^{-12}$	**Workers and Public:** Total number of LCFs: 0.1 – 0.3 Maximum risk of LCF to MEI member of general public (resident along route): $9 \times 10^{-15} - 8 \times 10^{-12}$	**Workers and Public:** Total number of LCFs: 0.1 – 0.2 Maximum risk of LCF to MEI member of general public (resident along route): $9 \times 10^{-15} - 8 \times 10^{-12}$	**Workers and Public:** Total number of LCFs: 0.1 – 0.3 Maximum risk of LCF to MEI member of general public (resident along route): $9 \times 10^{-15} - 8 \times 10^{-12}$
Human Health – Normal Operations: Chemical				
Workers and Public: Fatalities from vehicle exhaust emissions: 0.04 – 0.2	**Workers and Public:** Fatalities from vehicle exhaust emissions: 0.08 – 0.4	**Workers and Public:** Fatalities from vehicle exhaust emissions: 0.1 – 0.5	**Workers and Public:** Fatalities from vehicle exhaust emissions: 0.08 – 0.4	**Workers and Public:** Fatalities from vehicle exhaust emissions: 0.08 – 0.4

TABLE J.2 (Cont.)

Impacts from Long-Term Storage as UF_6	Impacts from Long-Term Storage as Oxide	Impacts from Use as Uranium Oxide Cask	Impacts from Use as Uranium Metal Cask	Impacts from Disposal
		Human Health – Accidents: Radiological[b]		
Overall accident risk (LCFs): 0.00007 – 0.0005	Overall accident risk (LCFs): 0.001 – 0.007	Overall accident risk (LCFs): 0.001 – 0.007	Overall accident risk (LCFs): 0.00007 – 0.0005	Overall accident risk (LCFs): 0.001 – 0.007
Bounding accident: UF_6 cylinder rail accident in urban area	Bounding accident: UF_6 cylinder rail accident in urban area	Bounding accident: UF_6 cylinder rail accident in urban area	Bounding accident: UF_6 cylinder rail accident in urban area	Bounding accident: UF_6 cylinder rail accident in urban area
Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km
Bounding accident consequences to population within 50 miles (per occurrence): 60 LCFs	Bounding accident consequences to population within 50 miles (per occurrence): 60 LCFs	Bounding accident consequences to population within 50 miles (per occurrence): 60 LCFs	Bounding accident consequences to population within 50 miles (per occurrence): 60 LCFs	Bounding accident consequences to population within 50 miles (per occurrence): 60 LCFs
Bounding accident consequences to MEI (per occurrence): Risk of LCF: 0.002	Bounding accident consequences to MEI (per occurrence): Risk of LCF: 0.002	Bounding accident consequences to MEI (per occurrence): Risk of LCF: 0.002	Bounding accident consequences to MEI (per occurrence): Risk of LCF: 0.002	Bounding accident consequences to MEI (per occurrence): Risk of LCF: 0.002

TABLE J.2 (Cont.)

Impacts from Long-Term Storage as UF_6	Impacts from Long-Term Storage as Oxide	Impacts from Use as Uranium Oxide Cask	Impacts from Use as Uranium Metal Cask	Impacts from Disposal
		Human Health – Accidents: Chemical		
Overall accident risk (irreversible adverse effects): 1×10^{-6} – 0.00003	Overall accident risk (irreversible adverse effects): 0.5 – 20	Overall accident risk (irreversible adverse effects): 0.5 – 20	Overall accident risk (irreversible adverse effects): 7	Overall accident risk (irreversible adverse effects): 0.5 – 20
Bounding accident: UF_6 cylinder rail accident in urban area	Bounding accident: HF rail accident in urban area	Bounding accident: HF rail accident in urban area	Bounding accident: HF rail accident in urban area	Bounding accident: HF rail accident in urban area
Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-9} per railcar-km	Bounding accident frequency: 1×10^{-90} per railcar-km
Bounding accident consequences to population within 50 miles (per occurrence): up to 4 irreversible adverse effects	Bounding accident consequences to population within 50 miles (per occurrence): up to 30,000 irreversible adverse effects	Bounding accident consequences to population within 50 miles (per occurrence): up to 30,000 irreversible adverse effects	Bounding accident consequences to population within 50 miles (per occurrence): up to 30,000 irreversible adverse effects	Bounding accident consequences to population within 50 miles (per occurrence): up to 30,000 irreversible adverse effects
Bounding accident consequences to MEI (per occurrence): expected irreversible adverse effects	Bounding accident consequences to MEI (per occurrence): expected irreversible adverse effects	Bounding accident consequences to MEI (per occurrence): expected irreversible adverse effects	Bounding accident consequences to MEI (per occurrence): expected irreversible adverse effects	Bounding accident consequences to MEI (per occurrence): expected irreversible adverse effects
		Human Health — Accidents: Physical Hazards		
Total traffic fatalities: 0.6 – 2	Total traffic fatalities: 1 – 4	Total traffic fatalities: 2 – 4	Total traffic fatalities: 1 – 3	Total traffic fatalities: 1 – 4

[a] Shipping distance of 621 miles (1,000 km) for all materials; vehicle-related impacts were based on round-trip distance. The no action alternative is not included in this table (see Table J.1). Fewer than one off-site shipment per year to a disposal site would be expected for the minor amounts of LLW and LLMW generated during monitoring and maintenance activities under this alternative.

[b] Radiological LCFs were estimated from the calculated dose using dose-to-risk conversion factors of 0.0005 and 0.0004 fatalities per person-rem for members of the general public and occupational workers, respectively, as recommended in Publication 60 of the International Commission on Radiological Protection (ICRP 1991). The approximate corresponding dose for each of the radiological fatality risks listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide.

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- ***Use as Uranium Oxide Casks.*** Use as uranium oxide casks would involve transportation of the depleted UF_6 cylinders to a UO_2 conversion plant. The conversion facility would also require inbound shipments of ammonia and outbound shipments of HF and waste. Cleaning of the empty cylinders at a cylinder treatment facility colocated with the conversion facility would require outbound shipments of U_3O_8 and waste. The UO_2 would be transported to a cask manufacturing facility, which would also generate some waste for shipment to disposal. Finally, the casks would be shipped to an end user.

- ***Use as Uranium Metal Casks.*** Use as uranium metal casks would involve transportation of the depleted UF_6 cylinders to a metal conversion plant. The conversion facility would also require inbound shipments of ammonia and outbound shipments of HF and waste. Cleaning of the empty cylinders at a cylinder treatment facility colocated with the conversion facility would require outbound shipments of U_3O_8 and waste. The metal would be transported to a cask manufacturing facility, which would also generate some waste for shipment to disposal. Finally, the casks would be shipped to an end user.

- ***Disposal.*** The disposal option would involve the same transportation steps required for long-term storage as oxide, except that the final shipments of oxide would be sent to a disposal facility rather than a storage facility.

The transportation impacts in Table J.2 are presented as ranges of values. The ranges reflect differences in risk between truck and rail modes and differences in the types and quantities of materials required within a given option. The following is a general summary of potential impacts from transportation activities (based on information in Table J.2 and additional detailed information in Section J.3):

- The analysis of transportation risks presented in Table J.2 was based on the assumption that all shipments would travel a distance of 620 miles (1,000 km) and that essentially the entire inventory of DOE-generated depleted uranium would be shipped between long-term storage, conversion, manufacture and use, and disposal facilities. Transportation risks would be reduced or eliminated by colocating facilities or minimizing shipment distances between facilities.

- In general, the greatest risk from transportation would result from vehicle-related physical hazards, that is, potential fatalities caused by the physical trauma received during transportation accidents, independent of the material transported. This risk would increase directly with the number of shipments and shipment distance.

- The overall transportation risk resulting from the radioactive characteristics of the transported material would be small, generally less than one-tenth of the risk from vehicle-related causes for a given shipment.

- The overall transportation risk resulting from the hazardous chemical characteristics of the transported material would also be small, generally less than one-tenth of the risk from vehicle-related causes for most shipments.

- There is potential for low-probability, severe transportation accidents that could have large consequences. The accidents with the largest potential consequences would be rail accidents involving a tank car containing HF. Under unfavorable weather conditions, the HF released from these accidents could result in approximately 10 irreversible adverse effects in a rural environment or approximately 30,000 irreversible adverse effects in an urban environment. These impacts are discussed in Section J.3.4.2.

- Within each material category, the total transportation risk would be dominated by shipments of depleted UF_6 cylinders, U_3O_8, UO_2, uranium metal, and uranium oxide and uranium metal casks because of the large number of shipments required for these materials. Shipments of waste and process chemicals would not contribute significantly to the overall risk, except for potential shipments of the ammonia required for some conversion options and the HF by-product associated with some conversion options.

- In general, rail transportation would result in a slightly lower overall risk than truck transportation for the same amount of material, due primarily to higher rail shipment capacities and therefore fewer shipments.

J.2 TRANSPORTATION MODES

This assessment of transportation impacts was based on data provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL 1997]). For each category of option assessed in the PEIS, the engineering analysis report provides estimates of the types, characteristics, and quantities of each material that would require transportation.

J.2.1 Truck Transportation

Truck transportation was considered for all materials shipped, except for some bulk shipments of HF, ammonia, and spent nuclear fuel casks (which are too large for road transport). Truck shipments would generally be in legal-weight semitrailer trucks, consistent with current practices. The maximum gross vehicle weight for truck shipments is limited by the U.S. Department of

Transportation (DOT) to 80,000 lb (36,400 kg). Truck shipments of depleted UF_6 were assumed to consist of a single cylinder per trailer. Shipments of conversion products and waste materials would generally be near the maximum allowed by weight limitations.

J.2.2 Rail Transportation

Rail transportation was considered as an option to truck transportation for the shipment of bulk materials where the amount of material shipped would justify the use of full railcars. These materials would include depleted UF_6 cylinders and conversion products. For rail transportation, the average payload weights for boxcars range from 100,000 to 150,000 lb (45,000 to 68,000 kg). Rail shipments of depleted UF_6 were assumed to consist of four cylinders per railcar, with transport by regular freight train service. In general, rail transportation was not considered for shipments of waste materials and most chemicals generated or used during processing because the annual volumes of these materials would be much less than typical railcar capacities.

J.2.3 Transportation Options Considered But Not Analyzed in Detail

Air and barge transportation options were considered but not analyzed in detail. Air transportation would be prohibitively expensive and is not practical for shipping waste and large amounts of material. The use of barge transportation for the depleted UF_6 cylinders, conversion products, or manufactured products was considered but not examined in detail because sites for the proposed facilities under consideration in the PEIS have not yet been determined. Generic input parameters to estimate the risks associated with barge transport are not as readily applicable as they are for truck or rail transport because of the fixed and limited nature of the inland and coastal waterways.

The use of barge transport for bulk shipments of depleted uranium materials would be a viable alternative if both the shipping and receiving sites were located near the U.S. inland or coastal waterway systems. In general, the risk per shipment would be approximately the same as for a truck or rail (one railcar) shipment, but fewer shipments would be necessary and the costs per ton-mile much lower. The primary risks to workers would occur during loading and unloading operations. Risks to the public could occur in the vicinity of locks when the barges were stopped during their passage through the locks and from accidents that might result in potential releases to the environment. Barge transport of the depleted UF_6 cylinders from the existing storage sites would first require truck or rail transport to the nearest river port, approximately 20 to 25 miles (32 to 40 km) for the Portsmouth and Paducah sites and approximately 1 mile (1.6 km) for the K-25 site.

J.3 IMPACTS OF OPTIONS

The potential environmental impacts associated with transportation activities are summarized in this section. Additional information related to the assessment methodologies for each area of impact is provided in Appendix C.

J.3.1 General Assumptions

The environmental impacts from transportation were evaluated for each category of option (i.e., cylinder preparation, conversion, long-term storage, manufacture and use, and disposal) on the basis of information described in the engineering analysis report (LLNL 1997). The materials transported for each option category are summarized in Table J.3, along with the origin and destination sites for each material and an indication of whether the material poses a radiological, chemical, or vehicle-related risk. The following general assumptions apply to the assessment of impacts:

- Because sites for long-term storage, conversion, disposal, and manufacture and use will not be selected or known until some time in the future, transportation impacts for each material were estimated as the risk per kilometer traveled, using representative national average route statistics. For comparison, total transportation impacts are presented for shipment distances of 155, 620, and 3,100 miles (250, 1,000, and 5,000 km).

- The assessment of total transportation impacts was based on the assumption that the entire inventory of depleted uranium would be shipped between long-term storage, conversion, manufacture and use, and disposal facilities.

- National average accident occurrence rates (accidents per million miles) and fatality rates (accident fatalities per million miles) were used for accident calculations for truck and rail shipments.

- Transportation impacts were estimated for all shipments of depleted UF_6 cylinders, uranium conversion products, chemicals required for or produced during processing (such as HF and ammonia), as well as any LLW and LLMW generated during operations. Some conversion options would produce large quantities of calcium fluoride (CaF_2) or magnesium fluoride (MgF_2). CaF_2 can be used or disposed of as either sanitary waste or LLW, depending on the residual uranium concentration and applicable regulatory release limits at the time of disposal. Similarly, MgF_2 can be disposed of as sanitary waste or LLW.

TABLE J.3 Summary of Materials Transported for Each Transportation Option

Option Category	Material Transported	Risk			Origin Site	Destination Site
		Radiological	Chemical	Vehicular		
Cylinder preparation	LLW	X	X	X	UF_6 current locations	LLW disposal site
	LLMW	X	X	X	UF_6 current locations	LLMW treatment/disposal site
	Hazardous waste	X	X	X	UF_6 current locations	Hazardous waste disposal site
Conversion	Depleted UF_6	X	X	X	Current locations	Conversion site
	LLW	X	X	X	Conversion site	LLW disposal site
	LLMW	X	X	X	Conversion site	LLMW treatment/disposal site
	Hazardous waste	–	X	X	Conversion site	Hazardous waste disposal site
	U_3O_8	X	X	X	Cylinder treatment facility	Storage or disposal site
	LLW	X	X	X	Cylinder treatment facility	LLW disposal site
	LLMW	X	X	X	Cylinder treatment facility	LLMW treatment/disposal
	Hazardous waste	–	X	X	Cylinder treatment facility	Hazardous waste disposal
	HF and NH_3 (various combinations, depending on conversion option)	–	X	X	Chemical manufacturer or conversion site	Conversion or disposal site
	CaF_2	–	–	X	Conversion site	LLW disposal site
	MgF_2	–	–	X	Conversion site	LLW disposal site
Long-term storage	Depleted UF_6	X	X	X	Current locations	Long-term storage site
	UO_2 or U_3O_8	X	X	X	Conversion site	Long-term storage site
Manufacture and use	Uranium metal or UO_2	X	X	X	Conversion site	Manufacturing site
	LLW	X	X	X	Manufacturing site	LLW disposal site
	LLMW	X	X	X	Manufacturing site	LLMW treatment/disposal site
	Uranium oxide or uranium metal casks	X	–	X	Manufacturing site	End user
Disposal	UO_2 or U_3O_8	X	X	X	Conversion or storage site	Disposal site (shallow earthen structure, vault, or mine)

- For the various options, the transportation risk for a number of shipments listed in the engineering analysis report (LLNL 1997) are not included in this PEIS because they would not pose a radiological risk or a chemical fatality risk. Such shipments include chemicals used for processing (hydrochloric acid, sodium hydroxide, and nitric acid) and output hazardous waste for most facilities. The acids would not be in concentrated form, and sodium hydroxide is not an inhalation hazard. Relatively few drums of hazardous waste would be generated with minor amounts per drum, typically less than 1 or 2 kg of hazardous material, some of which would not be an inhalation hazard.

- In general, transportation activities were assumed to take place over a 20-year period, consistent with the operational period of the facilities considered.

J.3.2 Impacts Considered

The transportation of depleted uranium and associated materials would pose potential risks to human health and the environment. These risks would result from both the radioactive and chemical nature of the materials transported, as well as from operation of the transportation vehicles. The potential risks are discussed in this section. Additional details are given in Appendix C. The collective risks are presented in terms of the expected number of fatalities (or potentially life-threatening effects for chemical impacts) among the general public from all shipments for per-shipment distances ranging from 155 to 3,100 miles (250 to 5,000 km). The risks are presented for both truck and rail options, where appropriate.

J.3.2.1 Human Health — Normal Operations

J.3.2.1.1 Radiological Impacts

Radiological risk associated with routine transportation would result from the potential exposure of people to low levels of external radiation near a radioactive shipment. External exposures could occur as shipments moved past members of the public along routes or while the shipment was stopped along the route. No radioactive materials would be released during routine operations. Collective risks were estimated for the transportation crew members and for members of the public living and working along the transportation routes, sharing the routes, and present at stops along the routes.

In addition to assessing the routine collective population risk, risks to the maximally exposed individual (MEI) were estimated for a number of hypothetical exposure scenarios; these risks are listed in Table J.4. The scenarios include exposure of persons living next to a shipment route or being next to a shipment while stopped in traffic. The scenarios were chosen to provide a

TABLE J.4 Definition of Maximally Exposed Individuals for Assessment of Routine Transportation Risk

Maximally Exposed Individual	Assumptions	Distance (m)	Exposure Duration
Inspector (truck and rail)	Federal or state vehicle inspector, not covered by a dosimetry program	3	30 minutes
Resident (truck and rail)	Person living near a site shipment entrance, not protected by shielding	30	Shipments pass at average speed of 24 km/h
Person at traffic obstruction (truck and rail)	Person stopped next to a radioactive material shipment due to traffic or other causes, not protected by shielding	1	30 minutes
Person at truck service station	Worker at a truck stop	20	2 hours
Resident near a rail stop	Resident living near a rail classification yard, not protected by shielding	200	20 hours

range of exposure conditions; they were not intended to be all inclusive. For the transportation-related radiological impacts assessed in this PEIS, all those resulting from external radiation during routine transport would be very small because the highest level of radiation from any one shipment would be less than 1 mrem/h at a distance of 3.3 ft (1 m) from the transport vehicle. This dose rate is more than 10 times less than the regulatory limit of 10 mrem/h at 6.6 ft (2 m) from the transport vehicle, as directed by the DOT (49 *Code of Federal Regulations* [CFR] Part 173) and the U.S. Nuclear Regulatory Commission (10 CFR Part 71).

J.3.2.1.2 Chemical Impacts

The analysis assumed that no leaks would occur in the shipping packages during normal transport. Therefore, no impacts on human health would be related directly to the hazardous nature of chemical shipments during routine operations.

J.3.2.1.3 Vehicle-Related Impacts (Chemical Hazards)

Vehicle-related health risks are independent of the nature of the cargo and would be incurred for similar shipments of any commodity. The routine risks assessed might be caused by potential exposure to increased levels of airborne particulates from vehicular exhaust emissions and

from fugitive dust raised from the roadbed by the transport vehicle. The health endpoint assessed was the excess (additional) latent mortality caused by inhalation of these particulates in urban areas where ambient particulate air concentrations already exceed threshold values thought to be necessary before adverse effects are observed. It was assumed that a latent mortality is equivalent to a latent cancer fatality.

J.3.2.2 Human Health — Accident Conditions

J.3.2.2.1 Radiological Impacts

Radiological impacts from transportation-related accidents could result from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple pathways, such as exposure to contaminated soil, inhalation, or ingestion of contaminated food. The radiological impacts are expressed in terms of latent cancer fatalities (LCFs). No acute effects would be expected for the materials relevant to the action under consideration in this PEIS.

The collective accident risks from radiological causes over the life of the project have been estimated for all radioactive material shipments for each option category (see Table J.3 for a list of shipments). The accident risk estimates were based not only on the consequences of potential accidents but also on the probabilities that accidents would occur.

Although the overall radiological accident risk would be small for all shipments, there would be potential for low-probability, severe transportation accidents that could have relatively large consequences. Population and MEI impacts were estimated for such accidents.

J.3.2.2.2 Chemical Impacts

Chemical impacts from transportation-related accidents could result from the potential release and dispersal of hazardous chemicals into the environment during an accident and the subsequent exposure of people through the inhalation pathway. None of the hazardous chemicals involved in the action under consideration are suspected carcinogens, and any acute effects from ingestion or dermal absorption of the contaminants would be expected to be dominated by inhalation effects. The collective accident risks from chemical causes were estimated in the same manner as the radiological risks, taking into account accident probability, the spectrum of accident severities, and accident consequences. The health endpoints presented are potential irreversible adverse effects and expected fatalities, which are discussed in detail in Appendix C and Policastro et al. (1997). Population and MEI consequences from potentially severe accidents are presented.

J.3.2.2.3 Vehicle-Related Impacts (Physical Hazards)

Accident risks from physical hazards are vehicle-related risks that result from the physical trauma created by accidents; such risks are not related to the shipment's cargo. Physical hazard risks represent fatalities from mechanical causes and were determined from fatality rates based on national average statistics maintained by the DOT for truck and rail transportation (Saricks and Kvitek 1994).

J.3.3 Cylinder Preparation Options

Two options were evaluated for preparing nonconforming cylinders for off-site transportation to either a conversion facility or a long-term storage site (see Appendix E). These problem cylinders were classified into three types: (1) overfilled cylinders, (2) overpressurized cylinders, and (3) substandard cylinders. Each of the two cylinder preparation options would prepare all three types of cylinders to meet all DOT requirements for off-site shipment.

J.3.3.1 Cylinder Overcontainers

An overcontainer would be suitable to contain, transport, and store the cylinder contents, regardless of cylinder condition, and could be designed as a pressure vessel enabling liquefaction of the depleted UF_6 for transfer out of the cylinder. Because only minimal cylinder handling operations would be required to load substandard cylinders into an overcontainer, no chemical transportation risks would be associated with this option. Potential risks associated with the transportation of depleted UF_6 cylinders in protective overcontainers are presented in Sections J.3.4.1 and J.3.5.1 for the conversion options and long-term storage options, respectively.

J.3.3.2 Cylinder Transfer Facility

The alternative to placing nonconforming cylinders into overcontainers would be to transfer the depleted UF_6 to new cylinders. A facility necessary to effect such a transfer was assumed to be colocated at each of the three existing sites where the cylinders are currently stored. Therefore, the only transportation risks would be from minor amounts of chemicals used at the facility and small amounts of LLW and LLMW generated at the facility.

The total collective radiological risks (i.e., the total risk to all workers and members of the general public potentially exposed) for shipments associated with the cylinder transfer option are summarized in Tables J.5 and J.6 for routine and accident risks, respectively. Routine risks to MEIs are summarized in Table J.7, whereas potential severe accident consequences to local populations from radiological and chemical hazards are summarized in Tables J.8 and J.9, respectively. Accident consequences to MEIs are summarized in Table J.10.

TABLE J.5 Total Routine Shipment Risks for the Transportation of Materials for the Cylinder Preparation and Conversion Options

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF
Cylinder transfer facility											
LLW	Truck	460 – 580	0.00004 – 0.00005	0	0.0005 – 0.0007	0.0001 – 0.0002	0	0.002 – 0.003	0.0007 – 0.0009	0	0.01
LLMW	Truck	20	2×10^{-8}	0	0.00002	1×10^{-7}	0	0.00009	5×10^{-7}	0	0.0005
Depleted UF_6 cylinders[d]											
Paducah	Truck	28,513	0.02	0	0.03	0.08	0	0.1	0.4	0	0.7
	Rail	7,129	0.01	0	0.005	0.02	0	0.02	0.06	0	0.1
Portsmouth	Truck	13,421	0.009	0	0.02	0.04	0	0.06	0.2	0	0.3
	Rail	3,356	0.005	0	0.003	0.008	0	0.01	0.03	0	0.05
Oak Ridge	Truck	4,732	0.003	0	0.006	0.01	0	0.02	0.06	0	0.1
	Rail	1,183	0.002	0	0.0009	0.003	0	0.004	0.01	0	0.02
UF_6 with overcontainers											
Paducah	Truck	28,351	0.01	0	0.03	0.04	0	0.1	0.2	0	0.7
	Rail	7,088	0.009	0	0.005	0.01	0	0.02	0.03	0	0.1
Portsmouth	Truck	13,388	0.005	0	0.02	0.02	0	0.06	0.09	0	0.3
	Rail	3,347	0.004	0	0.003	0.006	0	0.01	0.01	0	0.05
Oak Ridge	Truck	4,683	0.002	0	0.005	0.006	0	0.02	0.03	0	0.1
	Rail	1,171	0.001	0	0.0009	0.002	0	0.004	0.005	0	0.02

TABLE J.5 (Cont.)

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF
U_3O_8 conversion facility											
Ammonia	Truck	0 – 520	NA	0	0 – 0.0006	NA	0	0 – 0.002	NA	0	0 – 0.01
LLW	Truck	320 – 1,420	0.00002 – 0.0001	0	0.0004 – 0.002	0.00009 – 0.0005	0	0.001 – 0.007	0.0005 – 0.003	0	0.007 – 0.03
LLMW	Truck	20	2×10^{-8}	0	0.00002	1×10^{-7}	0	0.00009	5×10^{-7}	0	0.0005
HF	Rail	0 – 4,860	NA	0	0 – 0.004	NA	0	0 – 0.01	NA	0	0 – 0.07
CaF_2	Truck	460 – 19,760	NA	0	0.0005 – 0.02	NA	0	0.002 – 0.09	NA	0	0.01 – 0.5
	Rail	180 –7,300	NA	0	0.0001 – 0.005	NA	0	0.0005 – 0.02	NA	0	0.003 – 0.01
UO_2 conversion facility											
Ammonia	Rail	960 – 1,120	NA	0	0.0007 – 0.0008	NA	0	0.003	NA	0	0.01 – 0.02
LLW	Truck	360 – 1,680	0.00007 – 0.0003	0	0.0004 – 0.002	0.0003 – 0.001	0	0.002 – 0.008	0.001 – 0.006	0	0.008 – 0.04
LLMW	Truck	20 – 40	2×10^{-8} – 5×10^{-8}	0	0.00002 – 0.00005	1×10^{-7} – 2×10^{-7}	0	0.00009 – 0.0002	5×10^{-7} – 1×10^{-6}	0	0.0005 – 0.0009
HF	Rail	0 – 4,860	NA	0	0 – 0.004	NA	0	0 – 0.01	NA	0	0 – 0.07
CaF_2	Truck	460 – 19,760	NA	0	0.0005 – 0.02	NA	0	0.002 – 0.09	NA	0	0.01 – 0.5
	Rail	180 –7,300	NA	0	0.0001 – 0.005	NA	0	0.0005 – 0.02	NA	0	0.003 – 0.01

TABLE J.5 (Cont.)

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF
Uranium metal conversion facility											
Ammonia	Rail	920	NA	0	0.0007	NA	0	0.003	NA	0	0.01
LLW	Truck	360 – 3,840	0.00003 – 0.004	0	0.0004 – 0.004	0.0001 – 0.02	0	0.002 – 0.02	0.0006 – 0.08	0	0.008 – 0.09
LLMW	Truck	20	2×10^{-8} – 7×10^{-8}	0	0.00002	1×10^{-7} – 3×10^{-7}	0	0.00009	5×10^{-7} – 1×10^{-6}	0	0.0005
HF	Rail	1,640	NA	0	0.001	NA	0	0.005	NA	0	0.02
MgF_2	Truck	10,320 – 10,780	NA	0	0.01	NA	0	0.05	NA	0	0.2 – 0.3
	Rail	3,800 – 3,980	NA	0	0.003	NA	0	0.01	NA	0	0.06
Cylinder treatment facility											
U_3O_8	Truck	22	0.00004	0	0.00003	0.0002	0	0.0001	0.0008	0	0.0005
LLW	Truck	88	3×10^{-7}	0	0.0001	1×10^{-6}	0	0.0004	5×10^{-6}	0	0.002
LLMW	Truck	20	4×10^{-9}	0	0.00002	2×10^{-8}	0	0.00009	8×10^{-8}	0	0.0005

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., 1 ÷ 0.0004).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997). Exposure to ammonia was estimated to result in fatality for approximately 2% or less of those persons experiencing irreversible adverse effects.

[d] Includes the estimate for additional cylinders required to handle the depleted uranium in overfilled containers.

TABLE J.6 Total Accident Shipment Risks for the Transportation of Materials for the Cylinder Preparation and Conversion Options

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities
Cylinder transfer facility											
LLW	Truck	460 – 580	1×10^{-9} – 2×10^{-9}	0	0.004 – 0.006	5×10^{-9} – 6×10^{-9}	0	0.02	3×10^{-8}	0	0.1
LLMW	Truck	20	1×10^{-12}	0	0.0002	5×10^{-12}	0	0.0009	2×10^{-11}	0	0.004
Depleted UF_6 cylinders[d]											
Paducah	Truck	28,513	0.00008	5×10^{-6}	0.3	0.0003	0.00002	1	0.002	0.0001	6
	Rail	7,129	0.00001	2×10^{-7}	0.08	0.00004	7×10^{-7}	0.3	0.0002	4×10^{-6}	2
Portsmouth	Truck	13,421	0.00004	2×10^{-6}	0.1	0.0002	0.00001	0.5	0.0008	0.00005	3
	Rail	3,356	5×10^{-6}	8×10^{-8}	0.04	0.00002	3×10^{-7}	0.2	0.0001	2×10^{-6}	0.8
Oak Ridge	Truck	4,732	0.00001	8×10^{-7}	0.05	0.00005	3×10^{-6}	0.2	0.0003	0.00002	0.9
	Rail	1,183	2×10^{-6}	3×10^{-8}	0.01	7×10^{-6}	1×10^{-7}	0.06	0.00003	6×10^{-7}	0.3
UF_6 with overcontainers											
Paducah	Truck	28,351	0.00008	5×10^{-6}	0.3	0.0003	0.00002	1	0.002	0.0001	6
	Rail	7,088	0.00001	2×10^{-7}	0.08	0.00004	7×10^{-7}	0.3	0.0002	4×10^{-6}	2
Portsmouth	Truck	13,388	0.00004	2×10^{-6}	0.1	0.0002	0.00001	0.5	0.0008	0.00005	3
	Rail	3,347	5×10^{-6}	8×10^{-8}	0.04	0.00002	3×10^{-7}	0.2	0.0001	2×10^{-6}	0.8
Oak Ridge	Truck	4,683	0.00001	8×10^{-7}	0.05	0.00005	3×10^{-6}	0.2	0.0003	0.00002	0.9
	Rail	1,171	2×10^{-6}	3×10^{-8}	0.01	7×10^{-6}	1×10^{-7}	0.06	0.00003	6×10^{-7}	0.3

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TABLE J.6 (Cont.)

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities
U_3O_8 conversion facility											
Ammonia	Truck	0 – 520	NA	0 – 0.1	0 – 0.005	NA	0 – 0.6	0 – 0.02	NA	0 – 3	0 – 0.1
LLW	Truck	320 – 1,420	2×10^{-7} – 7×10^{-7}	0	0.003 – 0.01	7×10^{-7} – 3×10^{-6}	0	0.01 – 0.06	3×10^{-6} – 0.00001	0	0.06 – 0.3
LLMW	Truck	20	7×10^{-11}	0	0.0002	3×10^{-10}	0	0.0008	1×10^{-9}	0	0.004
HF	Rail	0 – 4,860	NA	0 – 5	0 – 0.06	NA	0 – 20	0 – 0.2	NA	0 – 100	0 – 1
CaF_2	Truck	460 – 19,760	NA	0	0.005 – 0.2	NA	0	0.02 – 0.8	NA	0	0.09 – 4
	Rail	180 – 7,300	NA	0	0.002 – 0.09	NA	0	0.008 – 0.3	NA	0	0.04 – 2.0
UO_2 conversion facility											
Ammonia	Rail	960 – 1,120	NA	0.1	0.01	NA	0.5	0.05	NA	2 – 3	0.2 – 0.3
LLW	Truck	360 – 1,680	5×10^{-7} – 2×10^{-6}	0	0.004 – 0.02	2×10^{-6} – 8×10^{-6}	0	0.01 – 0.07	0.00001 – 0.00004	0	0.07 – 0.3
LLMW	Truck	20 – 40	7×10^{-11} – 3×10^{-10}	0	0.0002 – 0.0004	3×10^{-10} – 1×10^{-9}	0	0.0008 – 0.002	1×10^{-9} – 7×10^{-9}	0	0.004 – 0.008
HF	Rail	0 – 4,860	NA	0 – 5	0 – 0.06	NA	0 – 20	0 – 0.2	NA	0 – 100	0 – 1
CaF_2	Truck	460 – 19,760	NA	0	0.005 – 0.2	NA	0	0.02 – 0.8	NA	0	0.09 – 4
	Rail	180 – 7,300	NA	0	0.002 – 0.09	NA	0	0.008 – 0.3	NA	0	0.04 – 2.0

TABLE J.6 (Cont.)

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities
Uranium metal conversion facility											
Ammonia	Rail	920	NA	0.1	0.01	NA	0.4	0.04	NA	2	0.2
LLW	Truck	360 – 3,840	4×10^{-8} – 3×10^{-6}	0	0.004 – 0.04	1×10^{-7} – 0.00001	0	0.01 – 0.2	7×10^{-7} – 0.00006	0	0.07 – 0.8
LLMW	Truck	20	7×10^{-11}	0	0.0002	3×10^{-10}	0	0.0008	1×10^{-9}	0	0.004
HF	Rail	1,640	NA	2	0.02	NA	7	0.08	NA	30	0.4
MgF_2	Truck	10,320 – 10,780	NA	0	0.1	NA	0	0.4	NA	0	2
	Rail	3,800 – 3,980	NA	0	0.04 – 0.05	NA	0	0.2	NA	0	0.9
Cylinder treatment facility											
U_3O_8	Truck	22	1×10^{-6}	2×10^{-8}	0.0002	6×10^{-6}	7×10^{-8}	0.0009	0.00003	4×10^{-7}	0.004
LLW	Truck	88	7×10^{-10}	0	0.0009	3×10^{-9}	0	0.003	1×10^{-8}	0	0.02
LLMW	Truck	20	3×10^{-11}	0	0.0002	1×10^{-10}	0	0.0008	7×10^{-10}	0	0.004

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997). Exposure to ammonia was estimated to result in fatality for approximately 2% or less of those persons experiencing irreversible adverse effects.

[d] Includes the estimate for additional cylinders required to handle the depleted uranium in overfilled containers.

TABLE J.7 Consequences to the MEI from Routine Shipment of Depleted Uranium Materials

Facility/Material	Mode	Routine Radiological Risk from Single Shipment (Lifetime Risk of LCF[a]) Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Cylinder transfer facility						
LLW	Truck	2×10^{-9}	2×10^{-13}	6×10^{-9}	3×10^{-10}	NA
LLMW	Truck	9×10^{-11}	9×10^{-15}	3×10^{-10}	1×10^{-11}	NA
Depleted UF_6	Truck	3×10^{-8}	3×10^{-12}	1×10^{-7}	4×10^{-9}	NA
	Rail	6×10^{-8}	8×10^{-12}	1×10^{-7}	NA	5×10^{-10}
UF_6 with overcontainer	Truck	2×10^{-8}	1×10^{-12}	6×10^{-8}	2×10^{-9}	NA
	Rail	3×10^{-8}	3×10^{-12}	6×10^{-8}	NA	2×10^{-10}
U_3O_8 conversion facility						
LLW	Truck	2×10^{-9}	2×10^{-13}	6×10^{-9} – 8×10^{-9}	3×10^{-10}	NA
LLMW	Truck	9×10^{-11}	9×10^{-15}	3×10^{-10}	1×10^{-11}	NA
UO_2 conversion facility						
LLW	Truck	2×10^{-9} – 5×10^{-9}	2×10^{-13} – 5×10^{-13}	6×10^{-9} – 2×10^{-8}	3×10^{-10} – 7×10^{-10}	NA
LLMW	Truck	9×10^{-11}	9×10^{-15}	3×10^{-10}	1×10^{-11}	NA
Uranium metal conversion facility						
LLW	Truck	2×10^{-9} – 3×10^{-8}	2×10^{-13} – 3×10^{-12}	7×10^{-9} – 8×10^{-8}	3×10^{-10} – 4×10^{-9}	NA
LLMW	Truck	9×10^{-11}	9×10^{-15}	3×10^{-10}	1×10^{-11}	NA
Cylinder treatment facility						
U_3O_8	Truck	6×10^{-8}	5×10^{-12}	2×10^{-7}	7×10^{-9}	NA
LLW	Truck	8×10^{-11}	8×10^{-15}	2×10^{-10}	1×10^{-11}	NA
LLMW	Truck	1×10^{-11}	1×10^{-15}	5×10^{-11}	2×10^{-12}	NA
U_3O_8	Truck	6×10^{-8}	5×10^{-12}	2×10^{-7}	7×10^{-9}	NA
	Rail	7×10^{-8}	8×10^{-12}	2×10^{-7}	NA	5×10^{-10}
UO_2	Truck	5×10^{-8}	4×10^{-12}	2×10^{-7}	6×10^{-9}	NA
	Rail	6×10^{-8}	5×10^{-12}	2×10^{-7}	NA	3×10^{-10}
Uranium metal	Truck	1×10^{-8}	8×10^{-13} – 9×10^{-13}	3×10^{-8} – 4×10^{-8}	1×10^{-9}	NA
	Rail	1×10^{-8}	1×10^{-12}	3×10^{-8} – 4×10^{-8}	NA	7×10^{-11} – 8×10^{-11}
Uranium oxide casks						
LLW	Truck	1×10^{-8}	1×10^{-12}	3×10^{-8}	1×10^{-9}	NA
LLMW	Truck	1×10^{-9}	1×10^{-13}	4×10^{-9}	2×10^{-10}	NA
Cask	Rail	2×10^{-8}	2×10^{-12}	8×10^{-8}	NA	1×10^{-10}
Uranium metal casks						
LLW	Truck	2×10^{-9}	2×10^{-13}	5×10^{-9}	2×10^{-10}	NA
LLMW	Truck	5×10^{-9}	5×10^{-13}	1×10^{-8}	7×10^{-10}	NA
Cask	Rail	1×10^{-8}	1×10^{-12}	4×10^{-8}	NA	6×10^{-11}

[a] Lifetime risk of LCF for an individual was estimated from the calculated dose using the dose-to-risk conversion factor of 0.0005 fatalities per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the risk of LCF by 2,000 (i.e., $1 \div 0.0005$).

TABLE J.8 Potential Radiological Consequences to the Population from Severe Accidents Involving Shipment of Materials for the Cylinder Preparation and Conversion Options

		Radiological Risk (LCF[a])					
		Neutral Weather Conditions			Stable Weather Conditions		
Facility/Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Cylinder transfer facility							
LLW	Truck	0.0002	0.0002	0.0004	0.0004	0.0004	0.0009
LLMW	Truck	4×10^{-6}	4×10^{-6}	8×10^{-6}	9×10^{-6}	9×10^{-6}	0.00002
Depleted UF_6	Truck	0.3	0.3	0.6	7	7	20
	Rail	1	1	3	30	30	60
U_3O_8 conversion facility							
LLW	Truck	0.0008 – 0.0009	0.0008 – 0.0009	0.002	0.002	0.002	0.004 – 0.005
LLMW	Truck	6×10^{-6}	5×10^{-6}	0.00001	0.00001	0.00001	0.00003
UO_2 conversion facility							
LLW	Truck	0.001 – 0.002	0.001 – 0.002	0.003 – 0.005	0.003 – 0.006	0.003 – 0.006	0.007 – 0.01
LLMW	Truck	0.00001 – 6×10^{-6}	0.00001 – 6×10^{-6}	0.00001 – 0.00003	0.00001 – 0.00003	0.00001 – 0.00003	0.00003 – 0.00007
Uranium metal conversion facility							
LLW	Truck	0.0005 – 0.002	0.0005 – 0.002	0.001 – 0.004	0.001 – 0.004	0.001 – 0.004	0.003 – 0.009
LLMW	Truck	6×10^{-6}	5×10^{-6}	0.00001	0.00001	0.00001	0.00003
Cylinder treatment facility							
U_3O_8	Truck	0.1	0.1	0.2	0.3	0.2	0.5
LLW	Truck	0.00001	0.00001	0.00003	0.00003	0.00003	0.00007
LLMW	Truck	3×10^{-6}	3×10^{-6}	6×10^{-6}	7×10^{-6}	6×10^{-6}	0.00001

[a] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

TABLE J.9 Potential Chemical Consequences to the Population from Severe Accidents Involving Shipment of Materials for the Cylinder Preparation and Conversion Options

		Number of Persons with Potential for Irreversible Adverse Effects[a]					
		Neutral Weather Conditions			Stable Weather Conditions		
Facility/Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Cylinder transfer facility							
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
Depleted UF_6	Truck	0	1	2	0	1	3
	Rail	0	1	3	0	2	4
U_3O_8 conversion facility							
Ammonia	Truck	0 – 1	0 – 100	0 – 200	0 – 10	0 – 1,000	0 – 3,000
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
HF	Rail	0 – 10	0 – 1,000	0 – 3,000	0 – 100	0 – 10,000	0 – 30,000
UO_2 conversion facility							
Ammonia	Rail	1	200	400	20	2,000	5,000
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
HF	Rail	0 – 10	0 – 1,000	0 – 3,000	0 – 100	0 – 10,000	0 – 30,000
Uranium metal conversion facility							
Ammonia	Rail	1	200	400	20	2,000	5,000
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
HF	Rail	10	1,000	3,000	100	10,000	30,000
Cylinder treatment facility							
U_3O_8	Truck	0	0	0	0	4	8
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0

[a] Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997). Exposure to ammonia was estimated to result in fatality for approximately 2% or less of those persons experiencing irreversible adverse effects.

TABLE J.10 Potential Consequences to the MEI from Severe Accidents Involving Shipment of Materials for the Cylinder Preparation and Conversion Options

		Accident Risk			
		Neutral Weather Conditions		Stable Weather Conditions	
Facility/Material	Mode	Radiological Risk of LCF[a]	Chemical Effects[b]	Radiological Risk of LCF[a]	Chemical Effects[b]
Cylinder transfer facility					
LLW	Truck	7×10^{-6}	No	0.0001	No
LLMW	Truck	2×10^{-7}	No	2×10^{-6}	No
Depleted UF_6	Truck	0.0002	Yes	0.0005	Yes
	Rail	0.0009	Yes	0.002	Yes
U_3O_8 conversion facility					
Ammonia	Truck	NA	Yes	NA	Yes
LLW	Truck	0.00003 – 0.00004	No	0.0006	No
LLMW	Truck	2×10^{-7}	No	4×10^{-6}	No
HF	Rail	NA	Yes	NA	Yes
UO_2 conversion facility					
Ammonia	Rail	NA	Yes	NA	Yes
LLW	Truck	0.00006 – 0.0001	No	0.0009 – 0.002	No
LLMW	Truck	$2 \times 10^{-7} - 6 \times 10^{-7}$	No	$4 \times 10^{-6} - 9 \times 10^{-6}$	No
HF	Rail	NA	Yes	NA	Yes
Uranium metal conversion facility					
Ammonia	Rail	NA	Yes	NA	Yes
LLW	Truck	0.00002 – 0.00007	No	0.0004 – 0.001	No
LLMW	Truck	2×10^{-7}	No	4×10^{-6}	No
HF	Rail	NA	Yes	NA	Yes
Cylinder treatment facility					
U_3O_8	Truck	0.004	Yes	0.07	Yes
LLW	Truck	6×10^{-7}	No	9×10^{-6}	No
LLMW	Truck	1×10^{-7}	No	2×10^{-6}	No

[a] Lifetime risk of LCF for an individual was estimated from the calculated doses using a dose-to-risk conversion factor of 5×10^{-4} fatality per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,000 (i.e., $1 \div 0.0005$).

[b] Yes or No applies to the effect of chemical exposure on the MEI. There is no probability estimate; either there would or would not be an irreversible adverse effect. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997). Exposure to ammonia was estimated to result in fatality for approximately 2% or less of those persons experiencing irreversible adverse effects.

Transportation impacts associated with the cylinder transfer facility would be very small. No vehicle-related fatalities would be expected (< 1), and the vehicle-related risks would be about 10 times higher than the radiological risks. No radiological fatalities or irreversible adverse chemical effects would be expected as a result of a potential severe accident. The highest potential routine radiological exposure to an MEI, with a latent cancer fatality risk of 6×10^{-9}, would occur for a person stopped in traffic near a shipment for 30 minutes at a distance of 3.3 ft (1 m). Such an exposure would be about 100 times less than the exposure a person receives from natural sources in the course of 1 day.

J.3.4 Conversion Options

The conversion options would involve transportation of the depleted UF_6 cylinders from their current locations at the three storage sites to a conversion facility, transportation of any chemicals required by the conversion process, and transportation of the waste materials to a disposal site. Transportation of the conversion products is included in the discussion of the long-term storage, manufacture and use, and disposal options in Appendices G, H, and I of this PEIS.

The total collective radiological risks (i.e., the total risks to all workers and members of the public potentially exposed) associated with transportation of the depleted UF_6 cylinders; conversion to U_3O_8, UO_2, and metal; and the cylinder treatment facility are summarized in Tables J.5 and J.6 for routine and accident risks, respectively. Table J.7 summarizes the routine risks to MEIs, and Tables J.8 and J.9 summarize the potential severe accident consequences to local populations from radiological and chemical hazards, respectively. Table J.10 summarizes the accident consequences to MEIs.

J.3.4.1 Transportation of Depleted UF_6

The initial step in the conversion process would be to deliver the depleted UF_6 from the three storage sites to the conversion facility. The cylinders would be prepared for transport at each site, as discussed in Section J.3.3, and shipped to the conversion facility location. Shipment of all cylinders by both truck or rail has been assessed. Rail shipments would consist of four cylinders per railcar, whereas truck shipments would involve only one cylinder per truck. Because the number of cylinders that might require overcontainers is uncertain at this time, impacts were assessed for two bounding cases: under the first case, the depleted UF_6 would be transferred from nonconforming cylinders to new cylinders before transport; under the second case, all cylinders would be shipped in protective overcontainers. Risks for a given combination of cylinder shipments with and without overcontainers can be obtained by a linear interpolation between the two cases.

Protective overcontainers would reduce the external radiation emanating from the shipments by a factor of almost two. Because the radiological risk would be dominated by exposure during routine transport, the radiological risk from shipments with overcontainers would also be

about half the value for shipments without overcontainers. On the other hand, shipment of the depleted UF_6 cylinders in overcontainers is not expected to provide additional protection under severe accident conditions. Therefore, the risks from shipment of cylinders with and without overcontainers would be expected to be the same for severe accidents.

The chemical risk associated with cylinder transport would be much less than the radiological risk; however, the total risks would be dominated by vehicle-related risks, which would be about 10 times larger than the radiological and chemical risks combined. Thus, risks from transport by rail appear to be slightly less than the truck risks because of higher shipment capacities and therefore fewer shipments.

Impacts from a potential severe accident could lead to fatalities from both radiological and chemical effects. Up to 60 potential latent cancer fatalities from radiological hazards are estimated for a rail accident occurring in an urban population zone under stable weather conditions. On the basis of chemical toxicity effects for the same conditions, up to 4 persons could be affected by irreversible adverse effects.

The highest potential routine radiological exposure to an MEI, with a latent cancer fatality risk of 1×10^{-7}, would be for a person stopped in traffic near a shipment for 30 minutes at a distance of 3.3 ft (1 m). Such an exposure would be approximately 5 times less than the exposure a person receives from natural sources in the course of 1 day.

J.3.4.2 Conversion to U_3O_8, UO_2, or Metal

Conversion of the depleted UF_6 to the U_3O_8 or UO_2 oxide forms was assessed for both long-term storage (Appendix G) and disposal (Appendix I); conversion to UO_2 or metal was also assessed for use in cask manufacture (Appendix H). Transportation of other materials related to the conversion process would include the ammonia used in the conversion processes and the LLW, LLMW, and HF by-products of the conversion processes.

The total transportation risks associated with the conversion process would be low for all three conversion processes. The LLW and LLMW shipments to disposal would pose no irreversible adverse chemical effects, and the radiological risks would be about 100 times less than the vehicle-related risks. The largest risks would be associated with the chemical hazards associated with transportation of the HF by-product. These risks would be about 100 times the vehicle-related risks.

No radiological fatalities would be expected as a result of a potential severe accident. A severe accident involving ammonia or HF could result in fatalities, with a potential for approximately 30,000 persons to experience irreversible adverse effects from an accident involving HF under stable conditions in an urban area. However, the overall probability of an anhydrous HF accident occurring would depend on the total number of shipments and the actual locations of the

origin and destination sites. The probability of an accident would increase with the number of shipments and distance between sites. Approximately 5,000 railcars of anhydrous HF would be produced if the entire UF_6 inventory were converted to oxide. Assuming the distance traveled per shipment is 620 miles (1,000 km) and based on national average accident statistics for railcars, the overall probability for such an accident in an urban area would be about 3×10^{-5} (about 1 chance in 30,000) over the duration of the program. The resulting overall risk to the public (defined as the product of the accident consequence and the probability) would be 1 irreversible adverse effect (i.e, about 1 person would be expected to experience irreversible adverse effects) due to HF-related transportation accidents. This calculation assumes that the accident would occur in an urban area under weather conditions that result in maximum consequences. Further discussion on potential severe anhydrous HF accidents is presented in Chapter 5, Section 5.2.2.2.

The risk of latent cancer fatality to an MEI from a single routine radiological exposure to a given shipment would be negligible. The highest potential exposure, with an LCF risk of 6×10^{-9}, would occur for a person stopped in traffic near a shipment for 30 minutes at a distance of 3.3 ft (1 m). Such an exposure would be approximately 100 times less than the exposure a person receives from natural sources in the course of 1 day.

J.3.4.3 Cylinder Treatment Facility

After the depleted UF_6 cylinders were "emptied" at the conversion facility, they would still retain approximately 22 lb (10 kg) of UF_6, which corresponds to the amount remaining in the cylinder in the vapor phase at autoclave pressure and temperature (Charles et al. 1991). A cylinder treatment facility was assumed to be colocated with the conversion facility to clean and decontaminate the cylinders once they had been emptied. Therefore, the only chemical or radioactive material transportation risks would be from small amounts of U_3O_8, LLW, and LLMW generated at the facility. It was assumed that the cleaned cylinders would be placed in the scrap metal pile at the conversion site.

No fatalities would be expected due to transportation of materials from the cylinder treatment facility. The highest potential routine radiological exposure, with a latent cancer fatality risk of 2×10^{-7}, would occur for a person stopped in traffic near a shipment of U_3O_8 for 30 minutes at a distance of 3.3 ft (1 m) if it were shipped to a disposal site. Such an exposure would be less than half the radiological exposure that a person receives from natural sources in the course of 1 day.

Less than one radiological latent cancer fatality might be expected as a result of a potential severe accident involving shipment of U_3O_8 under stable weather conditions. Because of the chemical toxicity of the uranium oxide, approximately 8 persons could experience irreversible adverse effects in an urban area under stable weather conditions.

J.3.5 Long-Term Storage Options

Three options were assessed for long-term storage of depleted uranium compounds at a single location. The depleted uranium could be stored in its current form as depleted UF_6 or converted to an oxide form (UO_2 or U_3O_8) and then stored. Transportation impacts related to conversion of the depleted UF_6 to the oxide forms are discussed in Section J.3.4.2. Potential impacts from transportation of the depleted uranium material in its final form to a long-term storage site are discussed in this section.

Small amounts of waste could be generated due to container failure during the surveillance phase of the long-term storage options. The impacts of transporting this waste to a disposal site was not considered because the number of associated shipments would be less than one per year (LLNL 1997).

The estimated impacts associated with transportation for the long-term storage options are presented in Tables J.11 through J.14. The total collective radiological risks (i.e., the total risk to all workers and members of the public potentially exposed) are summarized in Tables J.11 and J.12 for routine and accident risks, respectively. Table J.7 summarizes the routine risks to MEIs, and Tables J.13 and J.14 summarize the potential severe accident consequences to local populations and MEIs, respectively.

J.3.5.1 Storage as Depleted UF_6

Long-term storage of depleted UF_6 at a single storage site would involve shipping the depleted UF_6 cylinders from their current locations at the three existing storage sites. The potential transportation impacts from shipping these depleted UF_6 cylinders to a storage facility would be the same as for shipping to a conversion facility (Section J.3.4.1).

J.3.5.2 Storage as U_3O_8 or UO_2

Long-term storage of depleted uranium as U_3O_8 or UO_2 would involve shipping the oxide from a single conversion facility to the storage site. The same impacts would also be incurred from shipping the oxide from a conversion facility or storage site to a disposal site (Section J.3.7) or to a cask manufacturing facility (Section J.3.6).

The radiological risk associated with shipping all of the U_3O_8 or UO_2 to a storage site from a conversion facility would be larger than the chemical risk, but the total risks would still be dominated by vehicle-related risks, which would be about 10 times larger than the radiological risks. Therefore, risks from rail transport would be less than risks from truck transport because of higher shipment capacities and therefore fewer shipments.

TABLE J.11 Total Routine Shipment Risks for the Transportation of Materials for Long-Term Storage

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF
Depleted UF_6 cylinders[d]											
Paducah	Truck	28,513	0.02	0	0.03	0.08	0	0.1	0.4	0	0.7
	Rail	7,129	0.01	0	0.005	0.02	0	0.02	0.06	0	0.1
Portsmouth	Truck	13,421	0.009	0	0.02	0.04	0	0.06	0.2	0	0.3
	Rail	3,356	0.005	0	0.003	0.008	0	0.01	0.03	0	0.05
Oak Ridge	Truck	4,732	0.003	0	0.006	0.01	0	0.02	0.06	0	0.1
	Rail	1,183	0.002	0	0.0009	0.003	0	0.004	0.01	0	0.02
UF_6 with overcontainers											
Paducah	Truck	28,351	0.01	0	0.03	0.04	0	0.1	0.2	0	0.7
	Rail	7,088	0.009	0	0.005	0.01	0	0.02	0.03	0	0.1
Portsmouth	Truck	13,388	0.005	0	0.02	0.02	0	0.06	0.09	0	0.3
	Rail	3,347	0.004	0	0.003	0.006	0	0.01	0.01	0	0.05
Oak Ridge	Truck	4,683	0.002	0	0.005	0.006	0	0.02	0.03	0	0.1
	Rail	1,171	0.001	0	0.0009	0.002	0	0.004	0.005	0	0.02
U_3O_8	Truck	25,500	0.05	0	0.03	0.2	0	0.1	0.9	0	0.6
	Rail	8,960	0.02	0	0.007	0.03	0	0.03	0.09	0	0.1
UO_2	Truck	26,260 – 26,800	0.04	0	0.03	0.2	0	0.1	0.8	0	0.6
	Rail	8,480 – 8,800	0.01	0	0.006 – 0.007	0.02	0	0.03	0.06	0	0.1

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., 1 ÷ 0.0004).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

[d] Includes the estimate for additional cylinders required to handle the depleted uranium in overfilled containers.

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TABLE J.12 Total Accident Shipment Risks for the Transportation of Materials for Long-Term Storage

Facility/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities
Depleted UF_6 cylinders[d]											
Paducah	Truck	28,513	0.00008	5×10^{-6}	0.3	0.0003	0.00002	1	0.002	0.0001	6
	Rail	7,129	0.00001	2×10^{-7}	0.08	0.00004	7×10^{-7}	0.3	0.0002	4×10^{-6}	2
Portsmouth	Truck	13,421	0.00004	2×10^{-6}	0.1	0.0002	0.00001	0.5	0.0008	0.00005	3
	Rail	3,356	5×10^{-6}	8×10^{-8}	0.04	0.00002	3×10^{-7}	0.2	0.0001	2×10^{-6}	0.8
Oak Ridge	Truck	4,732	0.00001	8×10^{-7}	0.05	0.00005	3×10^{-6}	0.2	0.0003	0.00002	0.9
	Rail	1,183	2×10^{-6}	3×10^{-8}	0.01	7×10^{-6}	1×10^{-7}	0.06	0.00003	6×10^{-7}	0.3
UF_6 with overcontainers											
Paducah	Truck	28,351	0.00008	5×10^{-6}	0.3	0.0003	0.00002	1	0.002	0.0001	6
	Rail	7,088	0.00001	2×10^{-7}	0.08	0.00004	7×10^{-7}	0.3	0.0002	4×10^{-6}	2
Portsmouth	Truck	13,388	0.00004	2×10^{-6}	0.1	0.0002	0.00001	0.5	0.0008	0.00005	3
	Rail	3,347	5×10^{-6}	8×10^{-8}	0.04	0.00002	3×10^{-7}	0.2	0.0001	2×10^{-6}	0.8
Oak Ridge	Truck	4,683	0.00001	8×10^{-7}	0.05	0.00005	3×10^{-6}	0.2	0.0003	0.00002	0.9
	Rail	1,171	2×10^{-6}	3×10^{-8}	0.01	7×10^{-6}	1×10^{-7}	0.06	0.00003	6×10^{-7}	0.3
U_3O_8	Truck	25,500	0.002	0.00002	0.3	0.006	0.00009	1	0.03	0.0004	5
	Rail	8,960	0.0004	0.00002	0.1	0.001	0.00007	0.4	0.007	0.0004	2
UO_2	Truck	26,260 – 26,800	0.002	0 – 5×10^{-6}	0.3	0.006	0 – 0.00002	1	0.03	0 – 0.0001	5
	Rail	8,480 – 8,800	0.0004	3×10^{-6} – 6×10^{-6}	0.1	0.001	0.00001 – 0.00003	0.4	0.007	0.00005 – 0.0001	2

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

[d] Includes the estimate for additional cylinders required to handle the depleted uranium in overfilled containers.

TABLE J.13 Potential Consequences to the Population from Severe Accidents Involving Shipment of Materials for Long-Term Storage

		Radiological Risk[a] (LCF)					
		Neutral Weather Conditions			Stable Weather Conditions		
Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Depleted UF_6	Truck	0.3	0.3	0.6	7	7	20
	Rail	1	1	3	30	30	60
U_3O_8	Truck	0.1	0.1	0.2	0.3	0.2	0.5
	Rail	0.3	0.3	0.6	0.7	0.7	2
UO_2	Truck	0.1	0.1	0.2	0.2	0.2	0.5
	Rail	0.3	0.3	0.6 – 0.7	0.7 – 0.8	0.7	2
		Chemical Risk[b] (no. of persons with potential for irreversible adverse effects)					
		Neutral Weather Conditions			Stable Weather Conditions		
Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Depleted UF_6	Truck	0	1	2	0	1	3
	Rail	0	1	3	0	2	4
U_3O_8	Truck	0	0	0	0	4	8
	Rail	0	1	1	0	10	20
UO_2	Truck	0	0	0	0	1	2
	Rail	0	0	0	0	3	8

[a] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

[b] Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

TABLE J.14 Potential Consequences to the MEI from Severe Accidents Involving Shipment of Materials for Long-Term Storage

		Accident Risk			
		Neutral Weather Conditions		Stable Weather Conditions	
Material	Mode	Radiological Risk of LCF[a]	Chemical Effects[b]	Radiological Risk of LCF[a]	Chemical Effects[b]
Depleted UF_6	Truck	0.0002	Yes	0.0005	Yes
	Rail	0.0009	Yes	0.002	Yes
UF_6 with overcontainer	Truck	0.0002	Yes	0.0005	Yes
	Rail	0.0009	Yes	0.002	Yes
U_3O_8	Truck	0.004	No	0.07	Yes
	Rail	0.01	Yes	0.2	Yes
UO_2	Truck	0.004	No	0.06	Yes
	Rail	0.01	No	0.2	Yes

[a] Lifetime risk of LCF for an individual was estimated from the calculated doses using a dose-to-risk conversion factor of 5×10^{-4} fatality per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,000 (i.e., $1 \div 0.0005$).

[b] Yes or No applies to the effect of chemical exposure on the MEI. There is no probability estimate; either there would or would not be an irreversible adverse effect. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

The risk of latent cancer fatality to an MEI for a single exposure to a given shipment would be small. The highest potential exposure, with a latent cancer fatality risk of 2×10^{-7}, would occur for a person stopped in traffic near a shipment for 30 minutes at a distance of 3.3 ft (1 m). Such an exposure would be less than half the radiological exposure that a person receives from natural sources in the course of 1 day.

Impacts from a potential severe accident could lead to fatalities from both radiological and chemical effects. Approximately 2 potential latent cancer fatalities from radiological hazards are estimated for a rail accident occurring in an urban population zone under stable weather conditions. Because of the chemical hazard of uranium, an estimated 20 people could experience irreversible adverse effects from chemical toxicity under the same conditions.

J.3.6 Manufacture and Use Options

Two alternative uses of depleted uranium were assessed: manufacture of casks using concrete made with cement and UO_2 and manufacture of casks using uranium metal. Potential impacts would be incurred from transport of the feed material (UO_2 or uranium metal) from a conversion facility to the manufacturing plant, transport of the manufactured cask to an end user, and transport of the small amount of LLW and LLMW expected to be generated at the manufacturing facility to a disposal site. Because of the size of the manufactured casks, cask shipment was assumed to occur by rail only. The shipment risks would be approximately the same for both cask options.

The collective population risks associated with the two manufacture and use options are summarized in Tables J.15 and J.16 for routine and accident risks, respectively. The routine risks to MEIs are summarized in Table J.7, and the accident consequences to MEIs and the population are summarized in Tables J.17 and J.18, respectively.

J.3.6.1 Uranium Oxide Casks

The uranium oxide cask option would involve the use of depleted uranium in the form of high-density UO_2 for the manufacture of depleted uranium concrete for shielding in spent nuclear fuel storage casks. The transportation risks associated with transport of the UO_2 to the cask manufacturing facility would be the same as the risks associated with transport of the UO_2 to a storage site (see Section J.3.5.2). Shipment of the uranium oxide casks to an end user would result in approximately the same overall risks as the UO_2 shipments. No chemical risks would be anticipated for transportation of the fabricated casks, and no radiological fatalities would be expected under severe accident conditions.

J.3.6.2 Uranium Metal Casks

The uranium metal cask option would involve the conversion of depleted UF_6 to uranium metal that would then be fabricated into a cask. Transportation impacts were analyzed for shipment of the uranium metal from a conversion facility to a cask manufacturing facility and shipment of the fabricated cask to an end user. No chemical transportation risks would be expected for this option.

The total radiological risk associated with uranium metal transport would be about a factor of 30 or more less than the vehicle-related risks. Shipment risks for the cask would be about the same as for rail transport of the uranium metal feed material. Risks for the generated waste shipments would be negligible compared with the shipment of uranium metal and casks.

The risk of latent cancer fatality to an MEI for a single exposure to a given shipment would be small. The highest potential routine radiological exposure, with a latent cancer fatality risk of 4×10^{-8}, would occur for a person stopped in traffic near a uranium metal or cask shipment for

TABLE J.15 Total Routine Shipment Risks for the Transportation of Materials for Manufacture and Use

Use/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF	Radiological LCF[b]	Chemical Effects[c]	Vehicular LCF
Uranium oxide casks											
UO_2	Truck	26,260 – 26,800	0.04	0	0.03	0.2	0	0.1	0.8	0	0.6
	Rail	8,480 – 8,800	0.01	0	0.006 – 0.007	0.02	0	0.03	0.06	0	0.1
LLW	Truck	300	0.0001	0	0.0003	0.0004	0	0.001	0.002	0	0.006
LLMW	Truck	20	1×10^{-6}	0	0.00002	4×10^{-6}	0	0.00009	0.00002	0	0.0005
Cask	Rail	9,600	0.003	0	0.007	0.005	0	0.03	0.02	0	0.1
Uranium metal casks											
Uranium metal	Truck	20,840 – 21,500	0.006 – 0.007	0	0.02 – 0.03	0.03	0	0.1	0.1	0	0.5
	Rail	7,360 – 7,520	0.002	0	0.006	0.004	0	0.02	0.01	0	0.1
LLW	Truck	1,540	0.0001	0	0.002	0.0004	0	0.007	0.02	0	0.04
LLMW	Truck	20	4×10^{-6}	0	0.00002	0.00001	0	0.00009	0.00007	0	0.0005
Cask	Rail	9,060	0.0002	0	0.007	0.0004	0	0.03	0.001	0	0.1

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., 1 ÷ 0.0004).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

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TABLE J.16 Total Accident Shipment Risks for the Transportation of Materials for Manufacture and Use

Use/Material	Mode	Total Shipments[a]	Risks over 250 km			Risks over 1,000 km			Risks over 5,000 km		
			Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities	Radiological LCF[b]	Chemical Effects[c]	Vehicular Fatalities
Uranium oxide casks											
UO_2	Truck	26,260 – 26,800	0.002	0 – 5×10^{-6}	0.3	0.006	0 – 0.00002	1	0.03	0 – 0.0001	5
	Rail	8,480 – 8,800	0.0004	3×10^{-6} – 6×10^{-6}	0.1	0.001	0.00001 – 0.00003	0.4	0.007	0.00005 – 0.0001	2
LLW	Truck	300	2×10^{-12}	0	0.003	8×10^{-12}	0	0.1	4×10^{-11}	0	0.06
LLMW	Truck	20	8×10^{-11}	0	0.0002	3×10^{-10}	0	0.0008	2×10^{-9}	0	0.004
Cask	Rail	9,600	4×10^{-9}	0	0.1	1×10^{-8}	0	0.5	7×10^{-8}	0	2
Uranium metal casks											
Uranium metal	Truck	20,840 – 21,500	4×10^{-10}	0	0.2	2×10^{-9}	0	0.8	8×10^{-9}	0	4
	Rail	7,360 – 7,520	9×10^{-11}	0	0.09	4×10^{-10}	0	0.3 – 0.4	2×10^{-9}	0	2
LLW	Truck	1,540	2×10^{-6}	0	0.02	8×10^{-6}	0	0.06	0.00004	0	0.3
LLMW	Truck	20	7×10^{-11}	0	0.0002	3×10^{-10}	0	0.0008	1×10^{-9}	0	0.004
Cask	Rail	9,060	1×10^{-10}	0	0.1	4×10^{-10}	0	0.4	2×10^{-9}	0	2

[a] Risks for rail transport were estimated on a railcar basis; therefore, the number of railcars was used for the total number of rail shipments.

[b] Radiological LCFs were estimated from the calculated doses using dose-to-risk conversion factors of 0.0005 and 0.0004 fatality per person-rem for members of the general public and occupational workers, respectively, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,500 (i.e., $1 \div 0.0004$).

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

TABLE J.17 Potential Consequences to the MEI from Severe Accidents Involving Shipment of Materials for Manufacture and Use

		Accident Risk			
		Neutral Weather Conditions		Stable Weather Conditions	
Use/Material	Mode	Radiological Risk of LCF[a]	Chemical Effects[b]	Radiological Risk of LCF[a]	Chemical Effects[b]
Uranium oxide casks					
UO_2	Truck	0.004	No	0.06	Yes
	Rail	0.01	No	0.2	Yes
LLW	Truck	2×10^{-6}	No	0.00003	No
LLMW	Truck	2×10^{-7}	No	4×10^{-6}	No
Cask	Rail	0.0004	No	0.006	No
Uranium metal casks					
Uranium metal	Truck	0.0001 – 0.0002	No	0.002	No
	Rail	0.0004	No	0.007	No
LLW	Truck	0.00008	No	0.001	No
LLMW	Truck	2×10^{-7}	No	4×10^{-6}	No
Cask	Rail	0.0004	No	0.006	No

[a] Lifetime risk of LCF for an individual was estimated from the calculated doses using a dose-to-risk conversion factor of 0.0005 fatality per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,000 (i.e., $1 \div 0.0005$).

[b] Yes or No applies to the effect of chemical exposure on the MEI. There is no probability estimate; either there would or would not be an irreversible adverse effect. Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

30 minutes at a distance of 3.3 ft (1 m). Such an exposure would be approximately 10 times less than the exposure a person receives from natural sources in the course of 1 day.

No fatalities from severe accidents would be expected. The transportation risks associated with the transport of the uranium metal cask would be approximately the same as those for the uranium oxide cask.

J.3.7 Disposal Options

Two options were identified for potential disposal of the depleted uranium: disposal as U_3O_8 or disposal as UO_2. In each case, the uranium oxide form would be transported from a single site, either a conversion facility or a storage site, to a disposal site. The impacts associated with

TABLE J.18 Potential Consequences to the Population from Severe Accidents Involving Shipment of Materials for Manufacture and Use

		Radiological Risk[a] (LCF)					
		Neutral Weather Conditions			Stable Weather Conditions		
Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Uranium oxide casks							
UO_2	Truck	0.1	0.1	0.2	0.2	0.2	0.5
	Rail	0.3	0.3	0.6 – 0.7	0.7 – 0.8	0.7	2
LLW	Truck	1×10^{-8}	1×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	5×10^{-8}
LLMW	Truck	6×10^{-6}	6×10^{-6}	0.00001	0.00001	0.00001	0.00003
Cask	Rail	3×10^{-6}	3×10^{-6}	6×10^{-6}	7×10^{-6}	5×10^{-6}	0.00001
Uranium metal casks							
Uranium metal	Truck	1×10^{-6}	8×10^{-7} – 9×10^{-7}	2×10^{-6}	3×10^{-6}	2×10^{-6}	4×10^{-6} – 5×10^{-6}
	Rail	3×10^{-6} – 4×10^{-6}	2×10^{-6}	5×10^{-6}	8×10^{-6} – 9×10^{-6}	6×10^{-6}	0.00001
LLW	Truck	0.002	0.002	0.004	0.005	0.005	0.01
LLMW	Truck	6×10^{-6}	6×10^{-6}	0.00001	0.00001	0.00001	0.00003
Cask	Rail	3×10^{-6}	2×10^{-6}	5×10^{-6}	8×10^{-6}	5×10^{-6}	0.00001

		Chemical Risk[b] (no. of persons with potential for irreversible adverse effects)					
		Neutral Weather Conditions			Stable Weather Conditions		
Material	Mode	Rural	Suburban	Urban	Rural	Suburban	Urban
Uranium oxide casks							
UO_2	Truck	0	0	0	0	1	2
	Rail	0	0	0	0	3	8
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
Cask	Rail	0	0	0	0	0	0
Uranium metal casks							
Uranium metal	Truck	0	0	0	0	0	0
	Rail	0	0	0	0	0	0
LLW	Truck	0	0	0	0	0	0
LLMW	Truck	0	0	0	0	0	0
Cask	Rail	0	0	0	0	0	0

[a] Radiological LCFs were estimated from the calculated doses using a dose-to-risk conversion factor of 0.0005 fatality per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,000 (i.e., $1 \div 0.0005$).

[b] Exposure to HF or uranium compounds was estimated to result in fatality for approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

transport to a disposal site would be the same as those for transport to a storage site (see Section J.3.5.2). Comparison of the transportation impacts associated with the two disposal options shows no significant difference between the two.

J.3.8 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the transportation options considered in this PEIS were implemented, including impacts to air quality, water quality, ecology, socioeconomics, cultural resources, visual environment (e.g., aesthetics), recreational resources, wetlands, noise levels, and environmental justice issues. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- Consideration of the impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the Record of Decision that will be issued following this PEIS.

- The impacts could not be determined at the programmatic level without consideration of specific routes between specific sites. Potential impacts would be more appropriately addressed in the second-tier *National Environmental Policy Act* (NEPA) documentation when specific sites are considered.

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APPENDIX K:

PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF_6 INVENTORY

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NOTATION (APPENDIX K)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
PEIS	programmatic environmental impact statement
ROI	region of influence

Chemicals

HF	hydrogen fluoride
MgF_2	magnesium fluoride
NO_x	nitrogen oxides
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

d	day(s)	mrem	millirem(s)
ft	foot (feet)	MWh	megawatt-hour(s)
ha	hectare(s)	pCi	picocurie(s)
km	kilometer(s)	rad	radiation absorbed dose(s)
L	liter(s)	rem	roentgen equivalent man
µg	microgram(s)	yd^3	cubic yard(s)
m	meter(s)	yr	year(s)
m^3	cubic meter(s)		

APPENDIX K:

PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF_6 INVENTORY

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period from 1999 through 2039. This appendix provides detailed information describing the parametric analysis used to assess potential environmental impacts of conversion, long-term storage, manufacture and use, and disposal options considered in the PEIS for processing less than the total depleted UF_6 inventory.

The environmental impacts presented in Chapter 5 of the PEIS are based on the assumption that all facilities would be designed to either convert, store, manufacture and use, or dispose of all of the depleted UF_6 in the DOE inventory. This approach provided a conservative estimate of the impacts that could result from each of the alternatives considered. Detailed discussions of the estimated environmental impacts from processing the entire depleted UF_6 inventory are presented for cylinder preparation, conversion, long-term storage, manufacture and use, disposal, and transportation options in Appendices E through J, respectively. The results of these evaluations are referred to as "100%" cases because they are based on the assumption that all of the depleted UF_6 would be processed (i.e., converted, stored, manufactured and used, disposed of, or transported).

In contrast to the 100% cases, the parametric analysis cases presented in this appendix considered the environmental impacts of each option category if the facilities were designed to process or accommodate only a fraction of the depleted UF_6 inventory (in the event that DOE would select a combination of alternatives to manage the entire inventory; see below). The intent of the parametric analysis was to show how the environmental impacts calculated for the 100% cases would be affected by reductions in facility size and throughput. "Throughput" is a general term that refers to the amount of material handled or processed by a facility in a year. Sections K.2-K.6 of this parametric appendix present the environmental impacts for the conversion, long-term storage, manufacture and use, disposal, and transportation options for facilities designed to process between 25% and 100% of the depleted UF_6 inventory. (The impacts of the cylinder preparation options for various throughputs are addressed in Appendix E.)

The results of the parametric analyses for the individual management components presented in Sections K.2-K.6 can be compiled to estimate the environmental impacts of combinations of alternatives; for example, use of 50% of the inventory as metal and use of 50% of the inventory as oxide. An example calculation of impacts for such a combination of alternatives is provided in

Section K.7. Any combination of alternatives selected would result in management of 100% of the depleted UF_6 inventory. The results of the parametric analyses can also be used to estimate the impacts for situations in which more than one site would be used (e.g., conversion to oxide at two locations).

For assessment purposes, the parametric analysis assumed that all facilities would be designed to operate over a 20-year time period (i.e., the period required to process the DOE-generated cylinders, similar to the 100% cases presented in Appendices E through J). Thus, it was assumed that the processing of only a fraction of the DOE depleted UF_6 inventory would be accomplished by building and operating smaller facilities than those required for the 100% cases. In practice, it would be possible to process a fraction of the inventory by operating facilities designed to process 100% of the inventory over 20 years for a reduced time period, such as 10 years, or by operating the facility at a reduced level. In addition, changes in operating schedule could be used to accommodate small changes in the DOE inventory. For example, a 10% increase in the total DOE inventory could be accommodated by operating a full-scale facility for 22 years instead of 20.

For a given option, the environmental impacts resulting from the parametric analysis cases would tend to be less than or equal to those presented for the 100% cases. Thus, if the impacts were negligible for the 100% case, the impacts for the parametric cases would also be negligible. For most areas considered — such as human health and safety during normal operations, water, ecology, resource requirements, waste management, land use, and socioeconomics — the impacts would decrease as the facility size or throughput decreased. However, the reduction in impacts would not always be proportional to the reduction in throughput. For example, a facility designed to process 500 cylinders per year would generally have smaller impacts than a facility designed to process 1,000 cylinders per year, although the impacts would not necessarily be half of those of the larger facility. For accidents producing the greatest consequences, impacts would tend to be the same for the parametric analysis cases and the 100% case, primarily because these types of accidents would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput.

The following sections summarize the approach and results of the parametric analysis. Section K.1 presents a short summary of the assessment approach. The results are presented for the conversion options in Section K.2, for long-term storage options in Section K.3, for manufacture and use options in Section K.4, for disposal options in Section K.5, and for transportation options in Section K.6; parametric assessment results for the cylinder preparation options are provided in Appendix E. Section K.7 presents an example of the calculation of impacts for a specific combination alternative and the summary of impacts for several example combination alternatives.

The discussion in this appendix (Appendix K) does not include details of the assessment methodologies or definitions of the options considered in the PEIS. A detailed description of methodologies is presented in Appendix C, and definitions and descriptions of the option categories are provided in Appendices F through J. Finally, in cases where the impacts from the parametric analysis do not differ significantly from the 100% case, readers are referred to Appendices F through J for additional discussion.

K.1 PARAMETRIC ANALYSIS ASSESSMENT APPROACH

Two parametric cases were analyzed for conversion, long-term storage as oxide, manufacture and use, and disposal options: (1) facilities designed to process or accommodate 50% of the depleted UF_6 inventory; and (2) facilities designed to process or accommodate 25% of the inventory. To simplify the analysis, the parametric cases were analyzed in detail for a subset of options within each option category, as summarized in Table K.1. A subset of options was selected because the relationships among the options within each category could be determined from the detailed analyses conducted for the 100% cases. Therefore, the results for the options analyzed in detail were used to estimate the impacts for all options within each category by comparison with the 100% cases.

The basic assessment approach, areas of impact, and methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases. The environmental impacts for the 100% cases were evaluated using information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL 1997a]), including descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios. To support the parametric assessment, similar design information was used for facilities sized to process or accommodate 25% and 50% of the depleted UF_6 inventory (LLNL 1997a).

The results of the parametric analysis are presented, where appropriate, as curves that show the environmental impacts as a function of facility throughput. The curves were constructed using the results for the 25%, 50%, and 100% cases. These curves can be used to estimate the environmental impacts for throughputs ranging between 25% and 100% of the depleted UF_6 inventory. In addition, the curves can also be used to provide rough estimates of the impacts for throughputs slightly below 25% and slightly above 100%. In cases where the impacts for the 100% case were negligible, the parametric analysis was conducted to confirm that the impacts were also negligible, and only a brief discussion is provided. (The terms used in this PEIS to describe impacts, such as "negligible," are defined in Chapter 4, Table 4.2.)

K.2 CONVERSION OPTIONS

The parametric analysis of the conversion options considered the environmental impacts of converting 25% and 50% of the depleted UF_6 inventory to triuranium octaoxide (U_3O_8), uranium dioxide (UO_2), or uranium metal over a 20-year period. The assessment considered the environmental impacts that would occur during (1) construction of a conversion facility, (2) routine conversion facility operations, and (3) potential conversion facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases, the results of which are discussed in Appendix F. The supporting data for the 25% and 50% parametric conversion cases are provided in the engineering analysis report (LLNL 1997a).

TABLE K.1 Specific Options and Parametric Cases Analyzed in Detail

Option Category/ Options Analyzed in Detail	Parametric Cases Analyzed for Each Option
Conversion	Conversion to U_3O_8, UO_2, and metal:
	100% case: Conversion of 100% of the inventory over 20 years
	50% case: Conversion of 50% of the inventory over 20 years
	25% case: Conversion of 25% of the inventory over 20 years
Long-term storage	
Storage as UF_6 in buildings	Storage as UF_6:
	100% case: Storage of 46,422 cylinders
	50% case: Storage of 23,211 cylinders
	25% case: Storage of 11,606 cylinders
Storage as UO_2 in buildings	Storage as UO_2:
	100% case: Storage of 420,000 drums
	50% case: Storage of 210,000 drums
	25% case: Storage of 105,000 drums
Manufacture and use	
Use as uranium oxide	Use as UO_2:
	100% case: Use of 100% of the inventory as oxide shielding
	50% case: Use of 50% of the inventory as oxide shielding
	25% case: Use of 25% of the inventory as oxide shielding
Use as uranium metal	Use as metal:
	100% case: Use of 100% of the inventory as metal shielding
	50% case: Use of 50% of the inventory as metal shielding
	25% case: Use of 25% of the inventory as metal shielding
Disposal	
Disposal as ungrouted U_3O_8 in a mine	100% case: Disposal of 100% of the inventory over 20 years
	50% case: Disposal of 50% of the inventory over 20 years
	25% case: Disposal of 25% of the inventory over 20 years

In general, the impacts for the 100% cases are presented in Appendix F as ranges, resulting from differences in technologies within each option and site differences. For the purposes of the parametric analysis, one technology from each option was considered and evaluated in detail at a representative site. A single technology and a representative site were evaluated for each option to simplify the parametric analysis. This simplification was possible because all technologies were evaluated at all representative sites for the 100% base case. The specific technologies considered were defluorination with anhydrous hydrogen fluoride (HF) production for conversion to U_3O_8; dry defluorination with anhydrous HF production for conversion to UO_2; and continuous metallothermic reduction for conversion to uranium metal. The resulting relationships between the technologies and sites that were identified for the 100% case were used to infer ranges of impacts for the parametric cases examined in detail.

K.2.1 Human Health — Normal Operations

K.2.1.1 Radiological Impacts

The estimated radiological impacts — radiation doses and latent cancer fatalities (LCFs) — from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to U_3O_8 are described in Appendix F, Section F.3.1.1. Similar impacts were calculated for the 50% and 25% conversion facilities for the parametric analysis. The radiological impacts estimated for the 100%, 50%, and 25% case are shown in Figures K.1 through K.6 as the radiation doses for the six receptor scenarios considered in the PEIS:

- Members of the general public
  - Annual collective dose
  - Annual dose to the maximally exposed individual (MEI)

- Noninvolved workers
  - Annual collective dose
  - Annual dose to the MEI

- Involved workers
  - Annual collective dose
  - Annual average individual dose

The ranges of impacts resulting from site and technology differences for each option are represented by dashed lines in the figures. The results for the technology selected for detailed analysis are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds for impacts for the 25% and 50% cases were estimated on the basis of the range determined for the 100% case. The

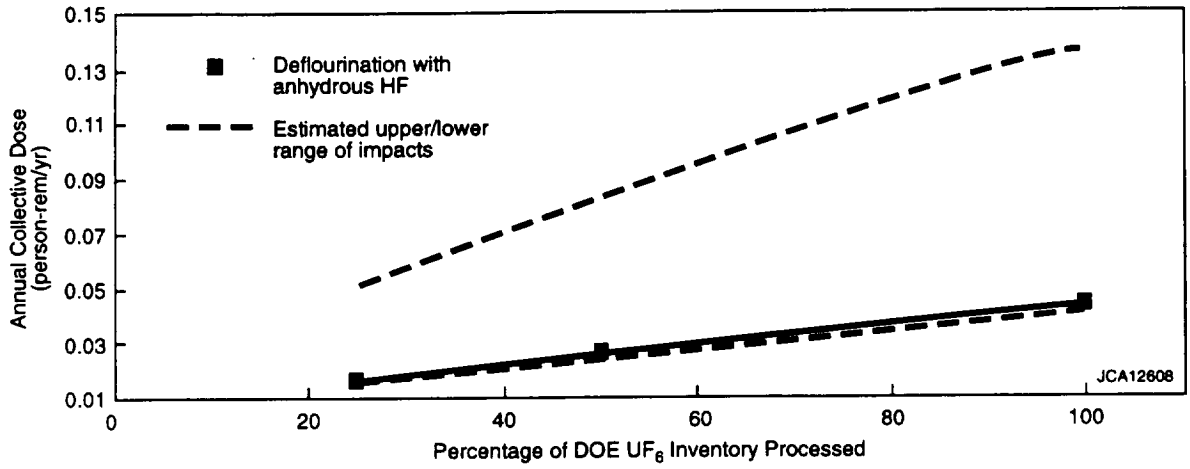

FIGURE K.1 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

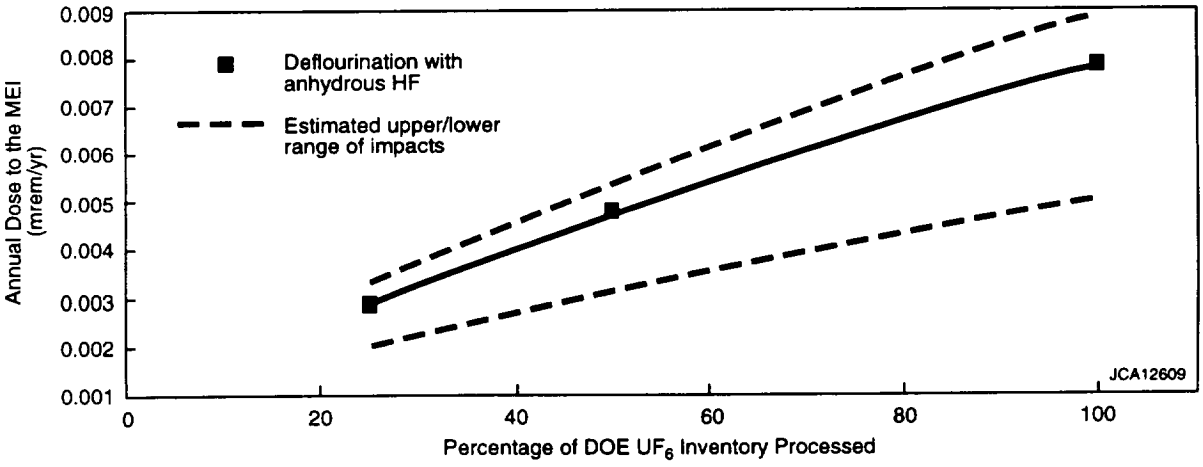

FIGURE K.2 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

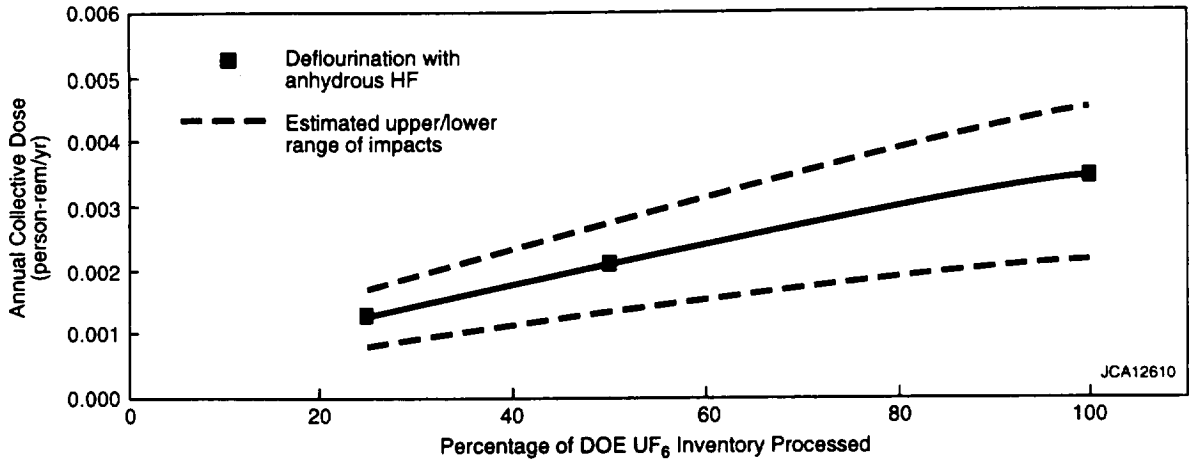

FIGURE K.3 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

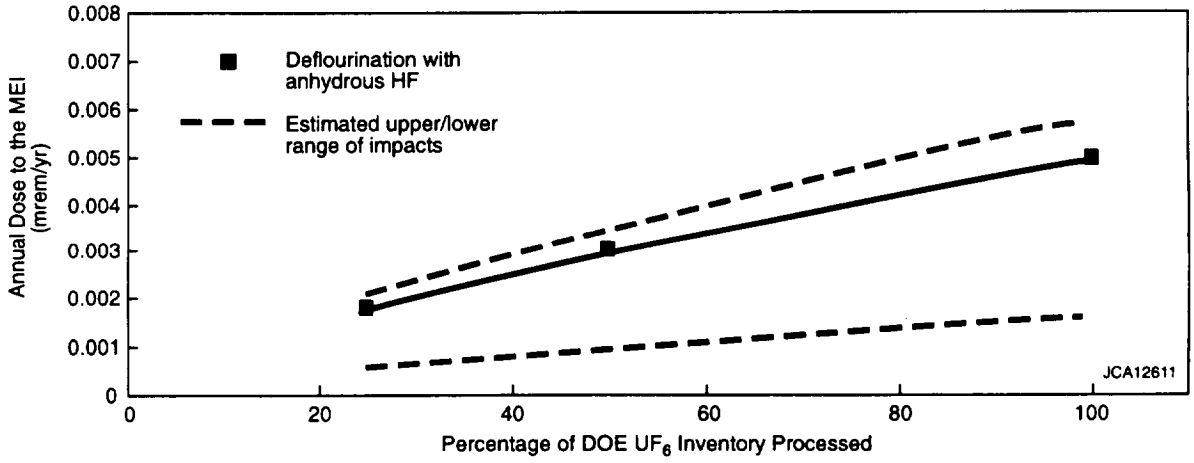

FIGURE K.4 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

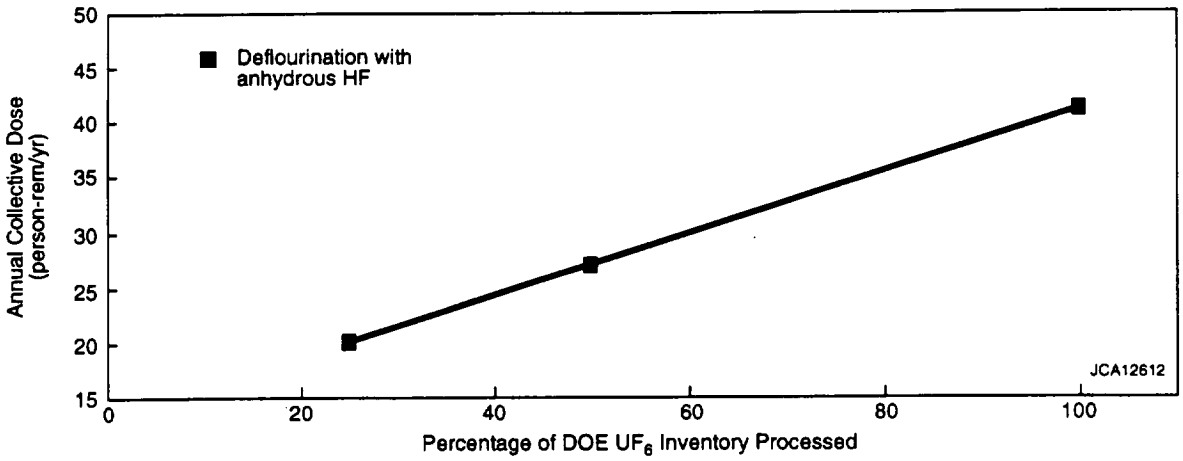

FIGURE K.5 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (No range is presented because the estimated collective doses to involved workers were almost identical between conversion technologies.)

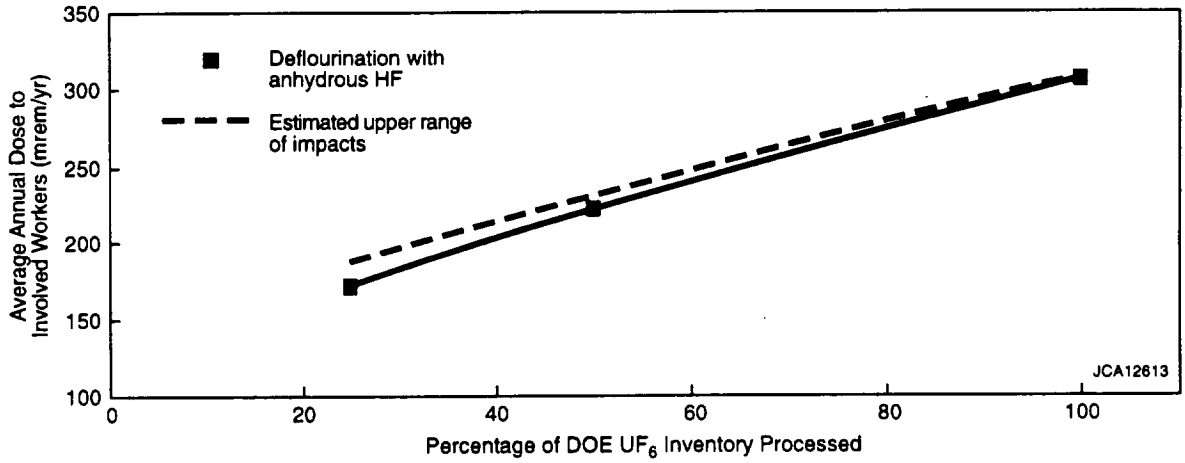

FIGURE K.6 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in conversion technologies.)

area enclosed by the lines in each figure indicates the range of impacts expected for throughputs between 25% and 100%, taking into account both technology and site differences.

The results of the parametric analysis for conversion to U_3O_8 (as shown in Figures K.1 through K.6) indicate that the radiological impacts would scale relatively linearly with the quantity of depleted UF_6 processed annually. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The radiation doses to the general public would be greater than those to noninvolved workers because of longer exposure times and, for the collective dose, larger population size. The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix F.

For conversion to UO_2, the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.7 through K.12 for each of the six receptor scenarios considered in the PEIS. The results are presented in a manner similar to the results discussed previously for conversion to U_3O_8. The general relationship between radiological impacts and throughput for conversion to UO_2 is similar to that for conversion to U_3O_8; that is, the radiological impacts would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from normal operation of a full-scale (100%) facility for converting depleted UF_6 to UO_2 are described in Appendix F, Section F.3.1.1.

For conversion to metal, the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.13 through K.18 for each of the six receptor scenarios considered in the PEIS. Similar to conversion to U_3O_8 and UO_2, the radiological impacts from conversion to metal would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to uranium metal are described in Appendix F, Section F.3.1.1.

The estimated radiological impacts from operation of the cylinder treatment facility are less than the impacts from the operations of the conversion facilities. Low-level exposures would be expected for involved workers and negligible exposures for noninvolved workers and the general public. The estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.19 through K.24 for each of the six receptor scenarios considered in the PEIS.

K.2.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) facilities for converting depleted UF_6 to U_3O_8, UO_2, and uranium metal are described in Appendix F, Section F.3.1.2. The results of the 100% case analyses indicated that noninvolved

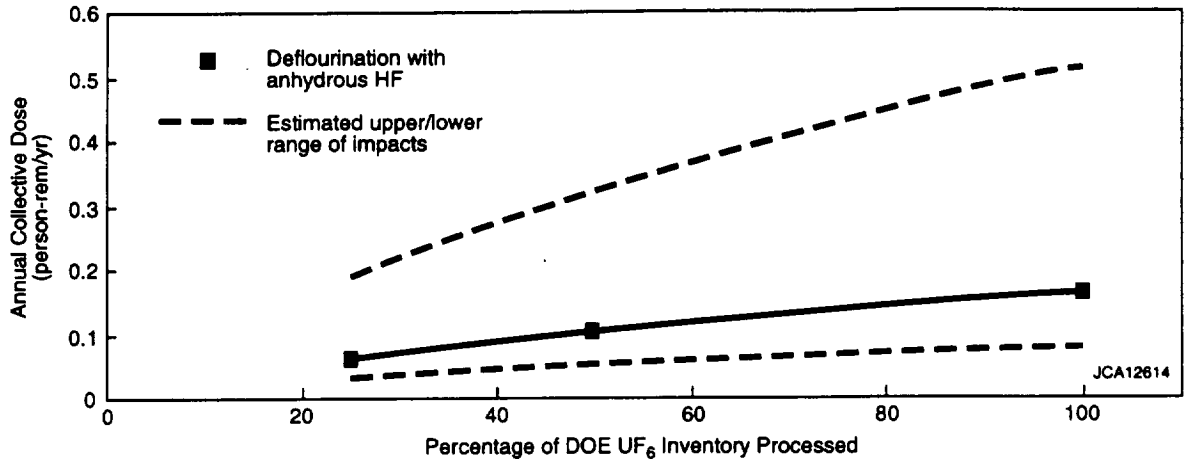

FIGURE K.7 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

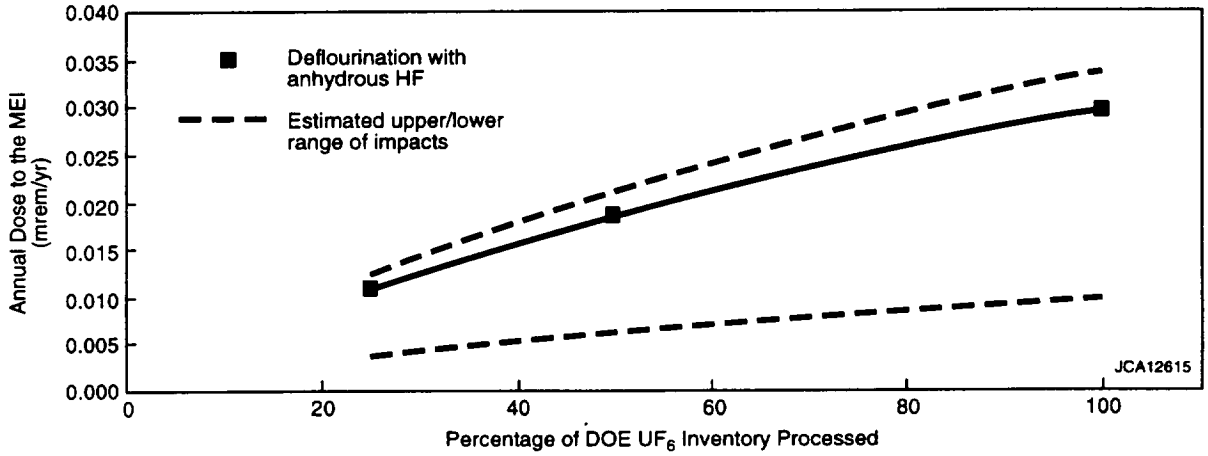

FIGURE K.8 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

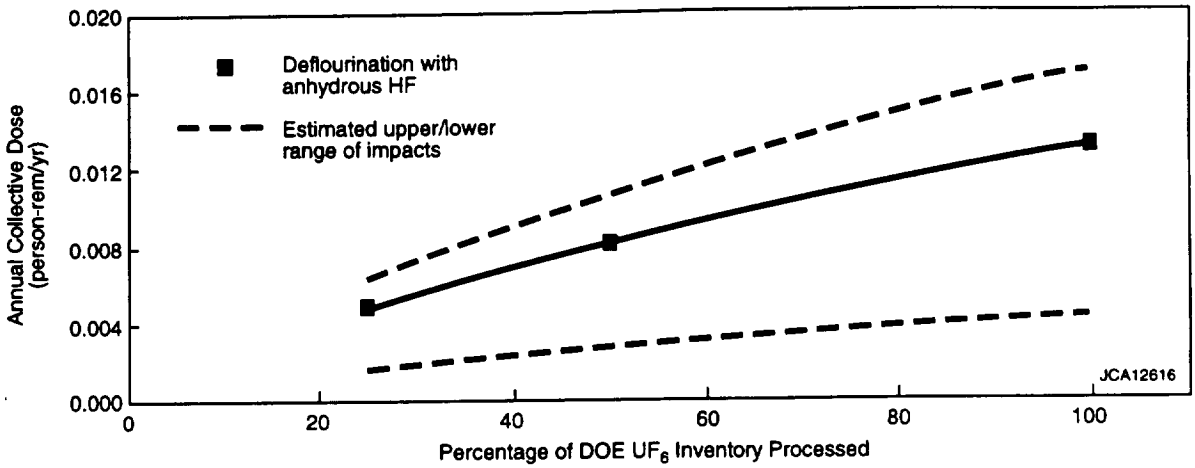

FIGURE K.9 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

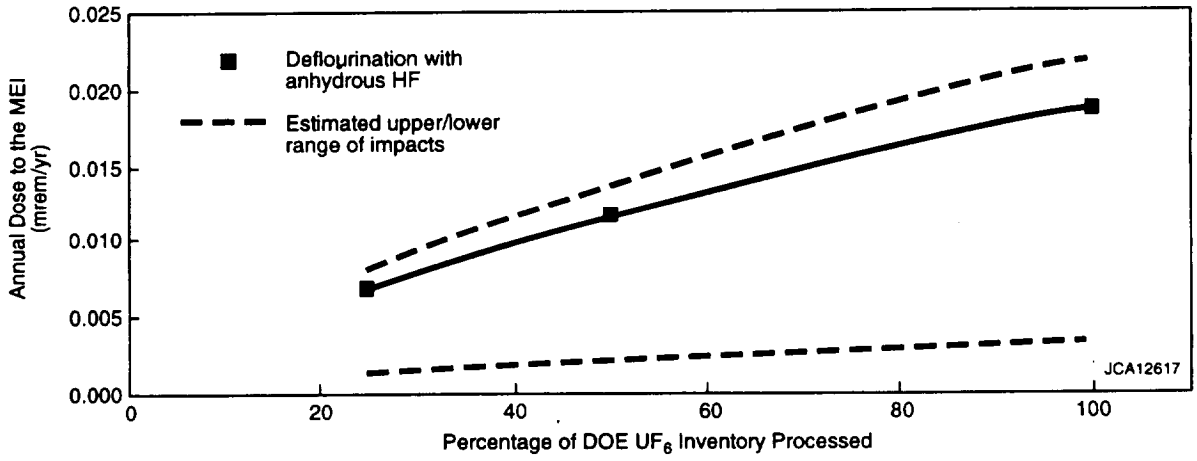

FIGURE K.10 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

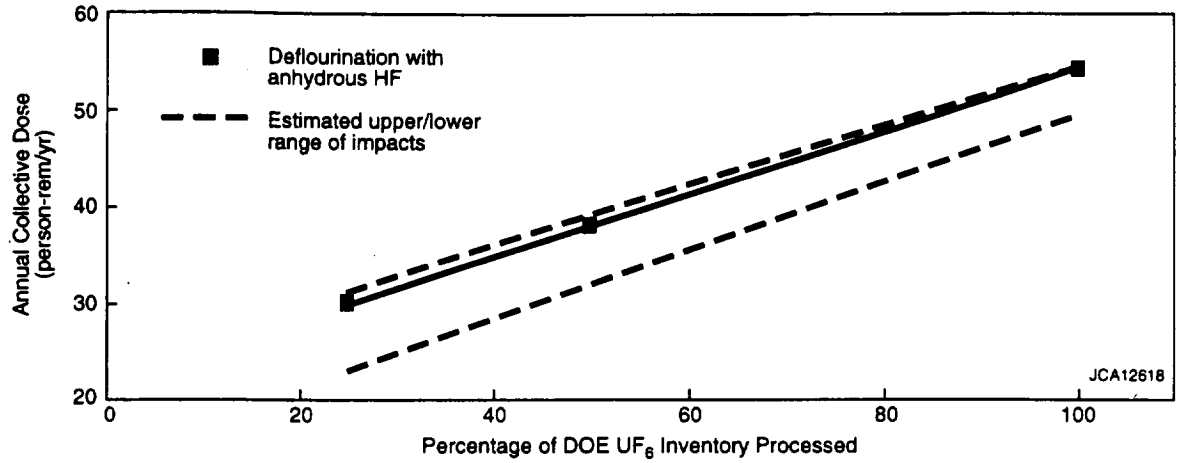

FIGURE K.11 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

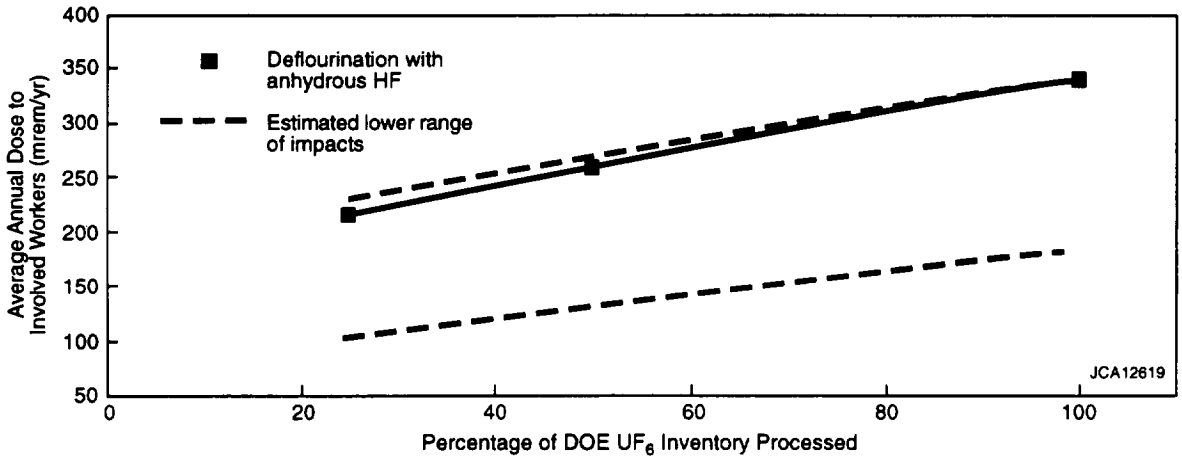

FIGURE K.12 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

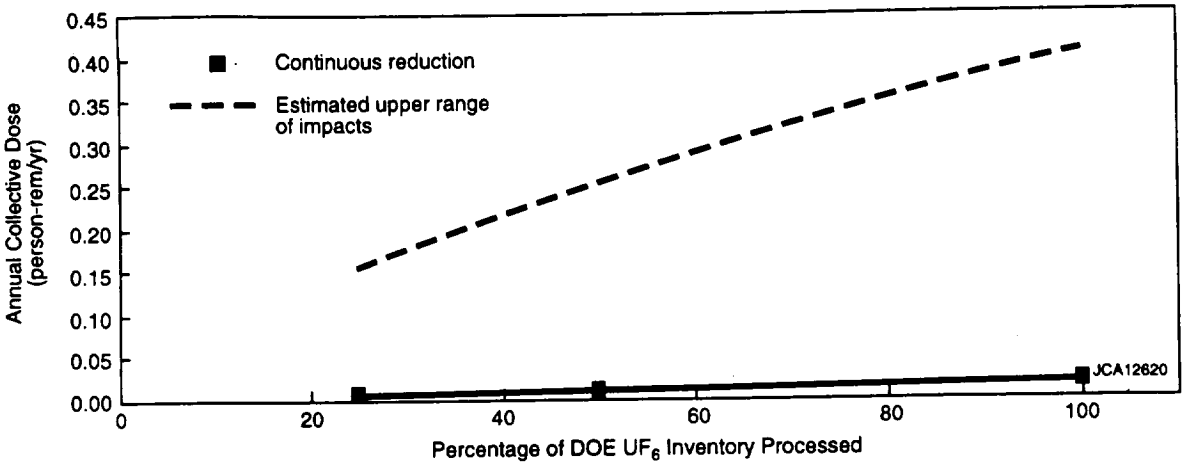

FIGURE K.13 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

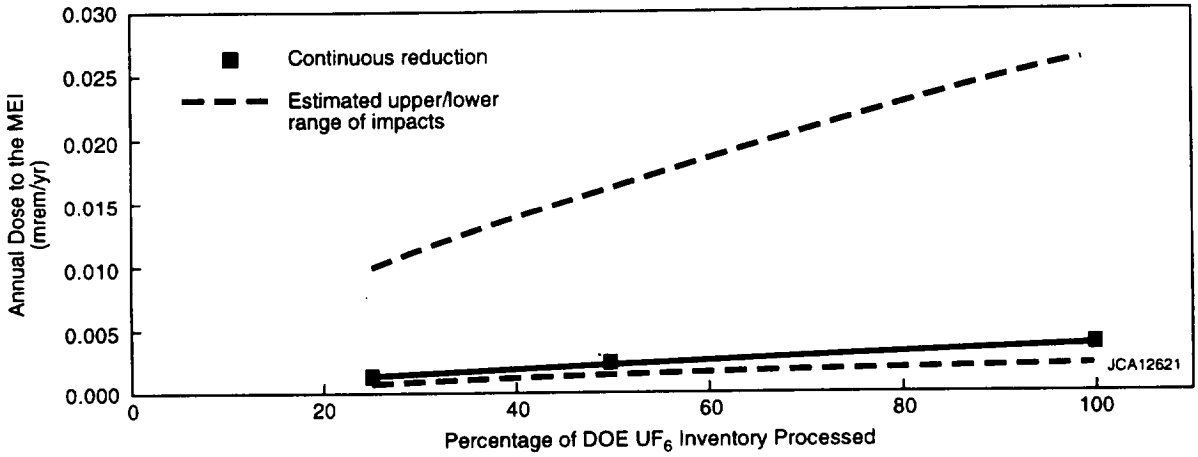

FIGURE K.14 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

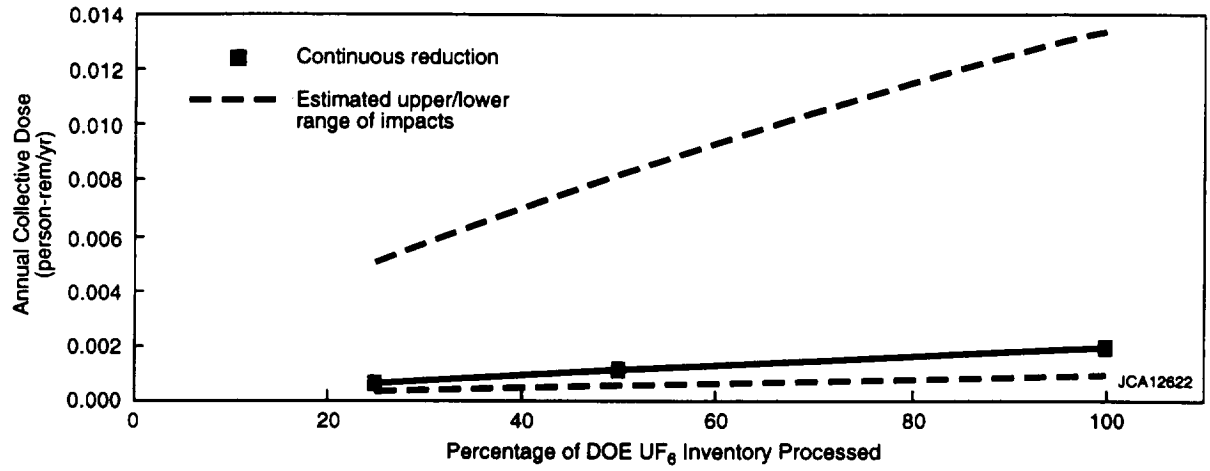

FIGURE K.15 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

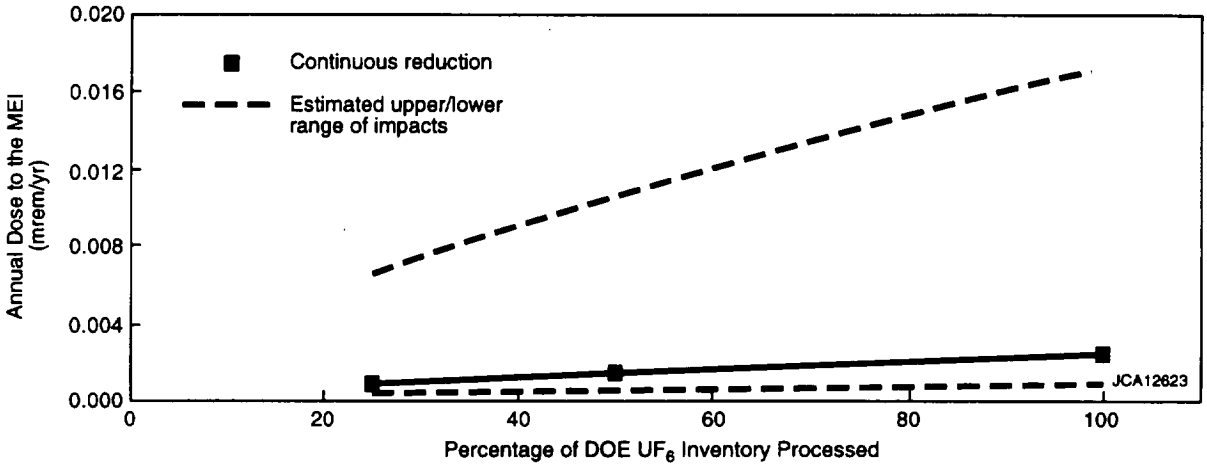

FIGURE K.16 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

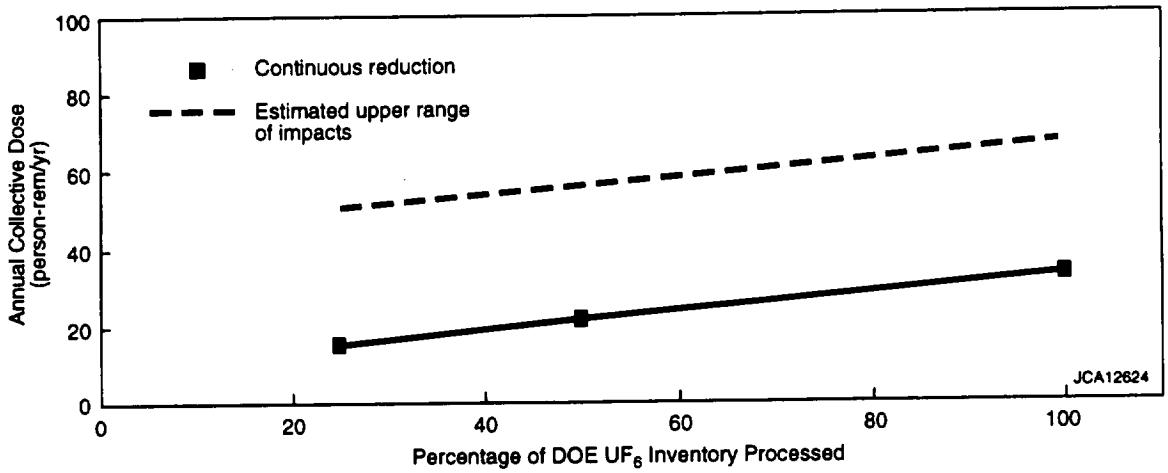

FIGURE K.17 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

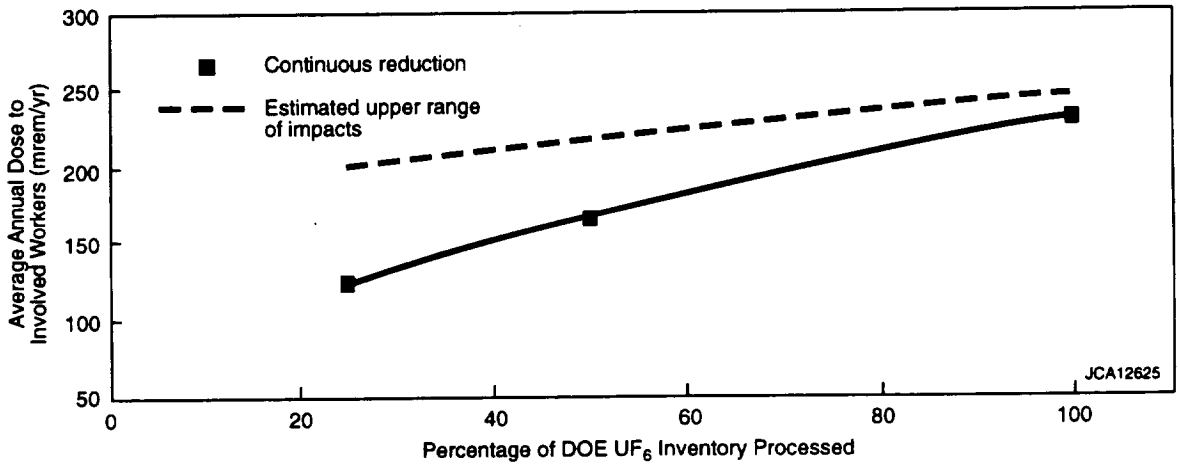

FIGURE K.18 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

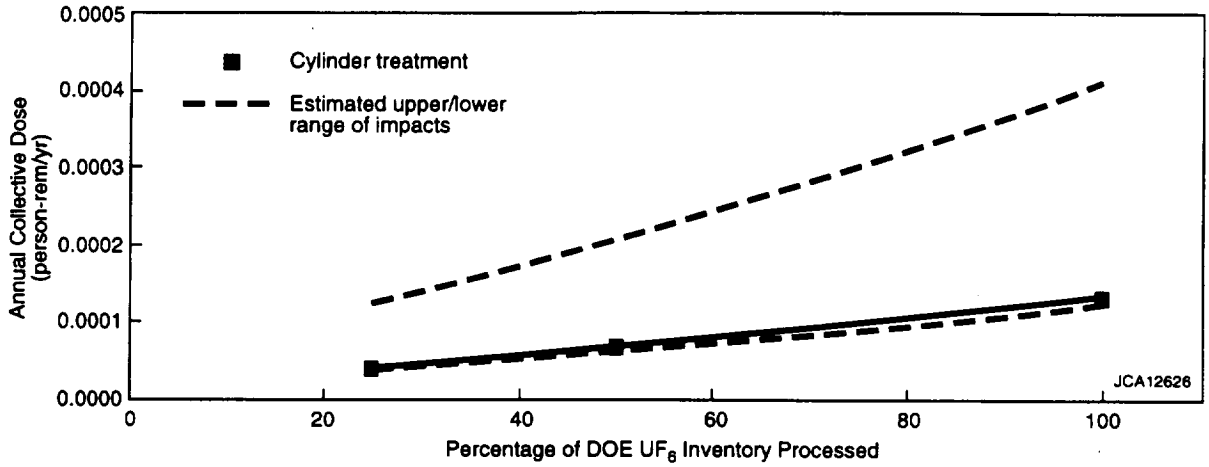

FIGURE K.19 Estimated Annual Collective Dose to Members of the Public from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

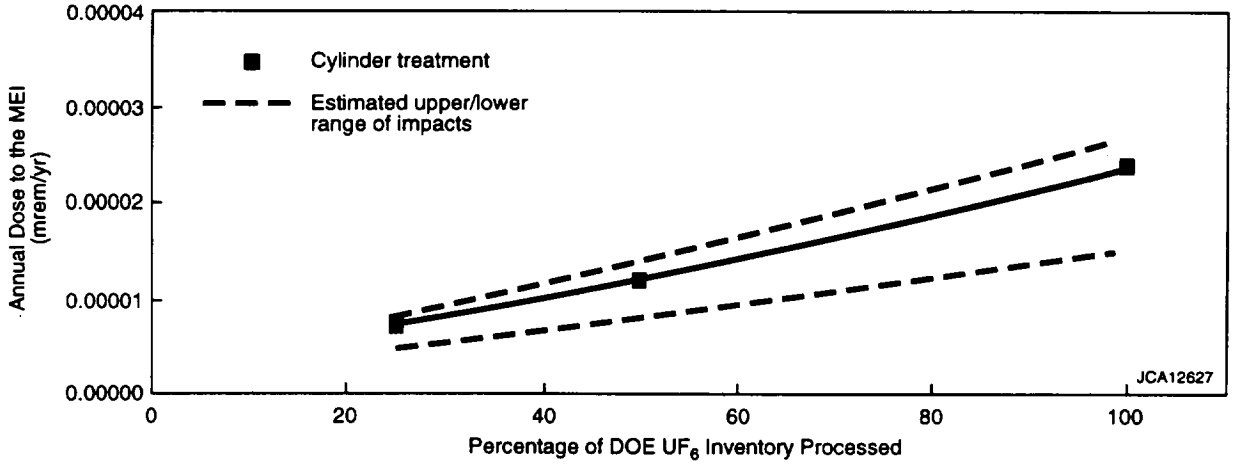

FIGURE K.20 Estimated Annual Dose to the General Public MEI from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

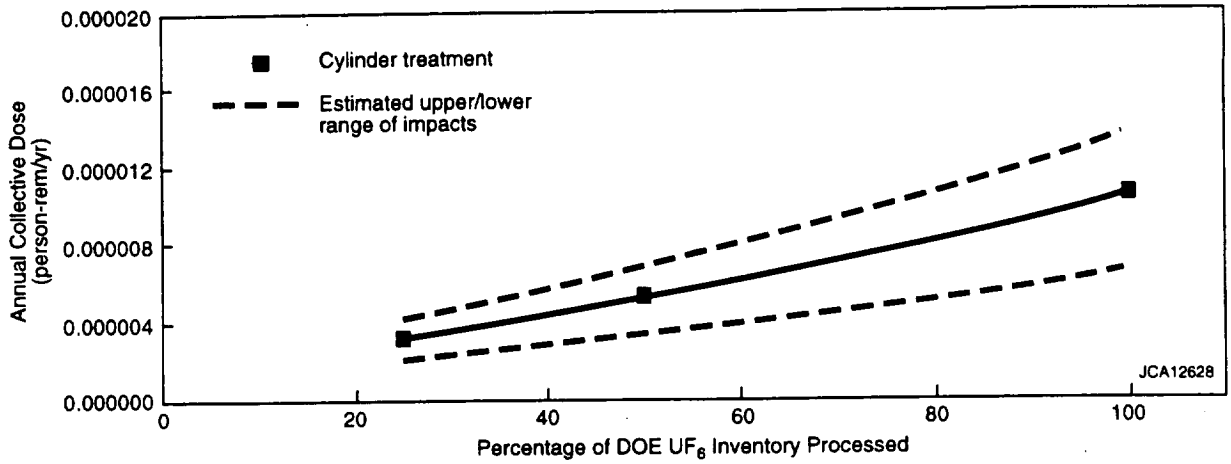

FIGURE K.21 Estimated Annual Collective Dose to Noninvolved Workers from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

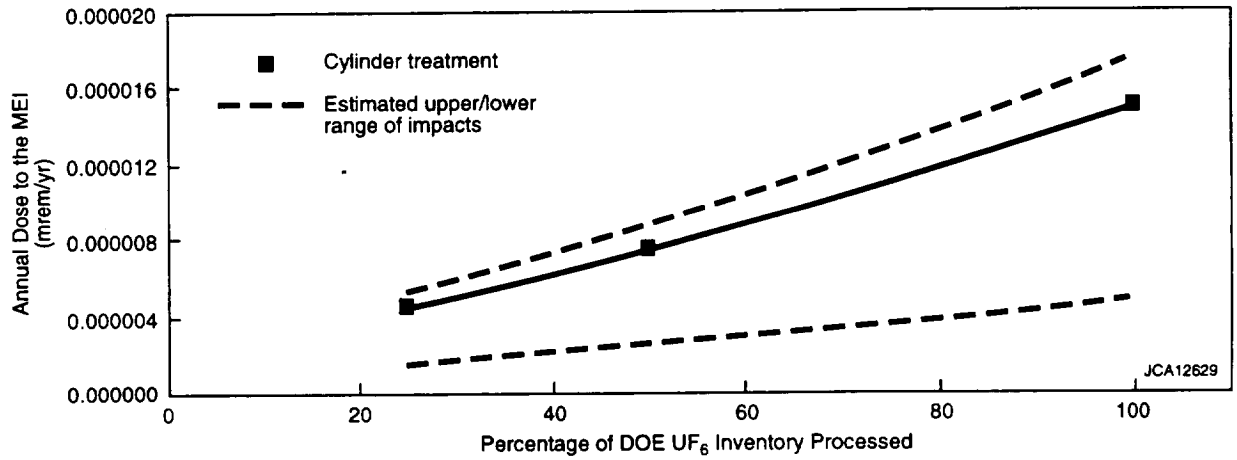

FIGURE K.22 Estimated Annual Dose to the Noninvolved Worker MEI from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

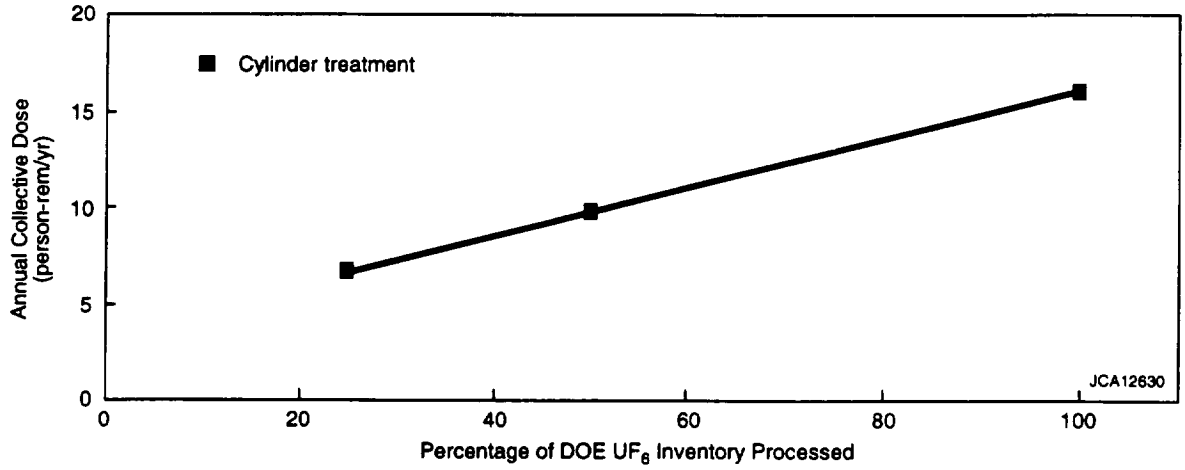

FIGURE K.23 Estimated Annual Collective Dose to Involved Workers from the Cylinder Treatment Facility

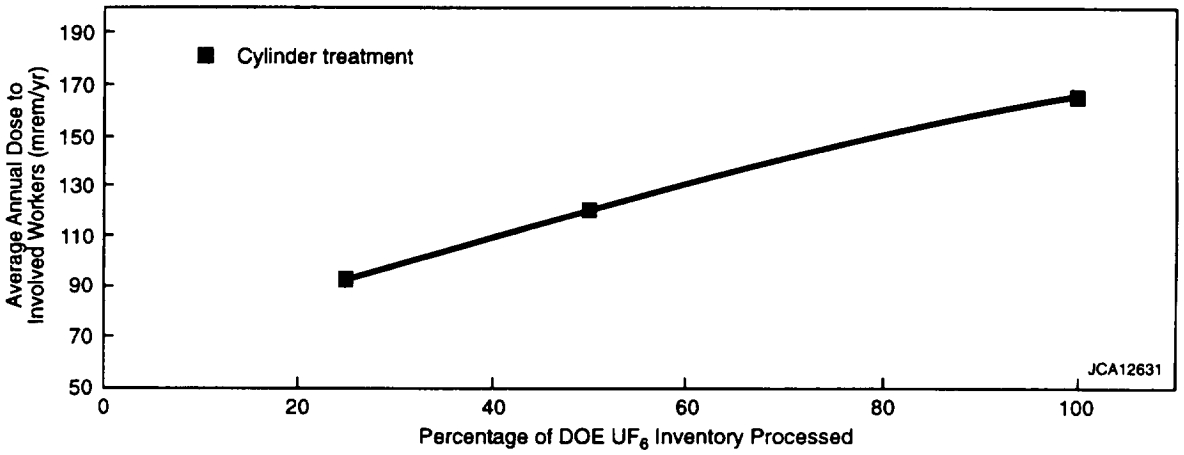

FIGURE K.24 Estimated Annual Average Individual Dose to Involved Workers from the Cylinder Treatment Facility

workers and members of the general public would receive very low exposures to chemicals from operation of the conversion facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all three conversion options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, calculated hazard indices for noninvolved workers and members of the general public were proportionally smaller than those for the 100% cases. Therefore, because the hazard indices are much less than 1, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100%.

The chemical impacts from operations of the cylinder treatment facility were estimated to be less than the impacts from operations of the conversion facilities, therefore resulting in no adverse health impacts to noninvolved workers and the general public for the 25%, 50%, and 100% cases.

K.2.2 Human Health — Accident Conditions

K.2.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during operation of the full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.1. Analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

On the basis of the assessment of the 25% and 50% conversion cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% cases in Appendix F. The impacts would be the same because the bounding accidents within each frequency category (those producing the greatest consequences) would be the same for all cases (100%, 50%, and 25%). The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding) would be different than those for the 100% cases. In general, the impacts of these nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Appendix F would be the same for the parametric analysis (LLNL 1997a). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents

would change the overall frequency category for those accidents. As a result, the accident impacts associated with the cylinder treatment facility would be the same for all parametric cases.

K.2.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

As for the radiological accident impacts, the chemical accidents producing the greatest consequences for the 25% and 50% parametric cases would be the same as those assessed for the 100% cases in Appendix F. The impacts would be similar because the bounding accidents within most frequency categories would be the same for the 100%, 50%, and 25% cases, and in those cases where the accidents were different, no adverse chemical impacts were estimated. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding accidents) would be different than those for the 100% cases. In general, the impacts of these other accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Appendix F would be the same for the parametric analysis (LLNL 1997a). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents would change the overall frequency category for those accidents. As a result, the overall chemical accident impacts associated with cylinder treatment would be the same for all parametric cases.

K.2.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.3. The impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case).

The estimated total fatalities over the entire period of construction and operations for the U_3O_8 conversion options for the 25%, 50%, and 100% cases would be 0.29, 0.32, and 0.35,

respectively (both conversion options analyzed resulted in the same fatality estimates). For the UO_2 conversion options, the estimated total fatalities for the 25%, 50%, and 100% cases would range from 0.35 to 0.49, 0.38 to 0.54, and 0.40 to 0.59, respectively. For the metal conversion options, total fatalities for the 25%, 50%, and 100% cases would range from 0.33 to 0.49, 0.36 to 0.52, and 0.4 to 0.55, respectively.

The total numbers of injuries over the entire period of construction and operation of the specific U_3O_8, UO_2, and metal conversion options analyzed parametrically are illustrated by the solid black line in Figures K.25 through K.27. The estimated upper ranges of impacts for all options examined in the PEIS are illustrated by the dotted lines in the figures (because both U_3O_8 options analyzed resulted in the same number of estimated injuries, only one line is shown in Figure K.25). The ranges of predicted injury incidence for the conversion options would be roughly comparable, reflecting the generally similar requirements for constructing and operating the three types of conversion facilities.

The estimated fatalities for the 25%, 50%, and 100% cases of construction and operation of a cylinder treatment facility would be 0.13, 0.16, and 0.19, respectively. The estimated number of injuries over the entire period of construction and operations would range from 122 to 170. The impacts are shown in Figure K.28 for throughputs ranging from 25% to 100%.

K.2.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.3. All of the pollutant concentrations produced by the 100% capacity version of the conversion facilities would be well below their respective air quality standards, with the possible exception of dust emissions during construction. During construction, short-term particulate concentrations were estimated to potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases, and impacts during operations would also be negligible. However, the air quality impacts from operations would not scale proportionally with facility capacities. The impacts from a 25% capacity plant would be from about 45% to 100% of those from the full-capacity plant, depending on the specific source of the emissions.

All of the pollutant concentrations produced by the 100% capacity version of the cylinder treatment facility would be well below the respective air quality standards (see Appendix F, Section F.3.3). The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

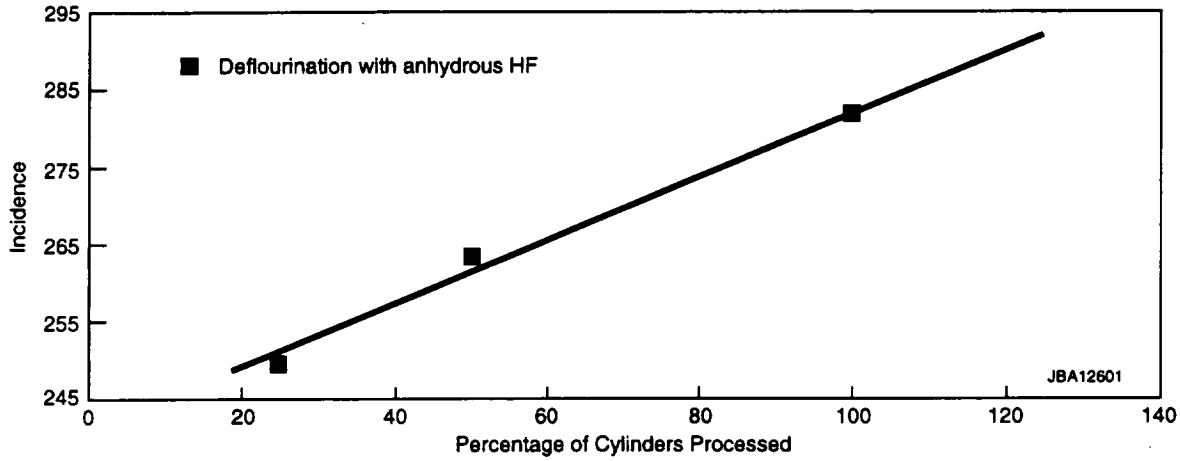

FIGURE K.25 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to U_3O_8 (No range is presented because the number of injuries would be almost identical between the U_3O_8 conversion technologies.)

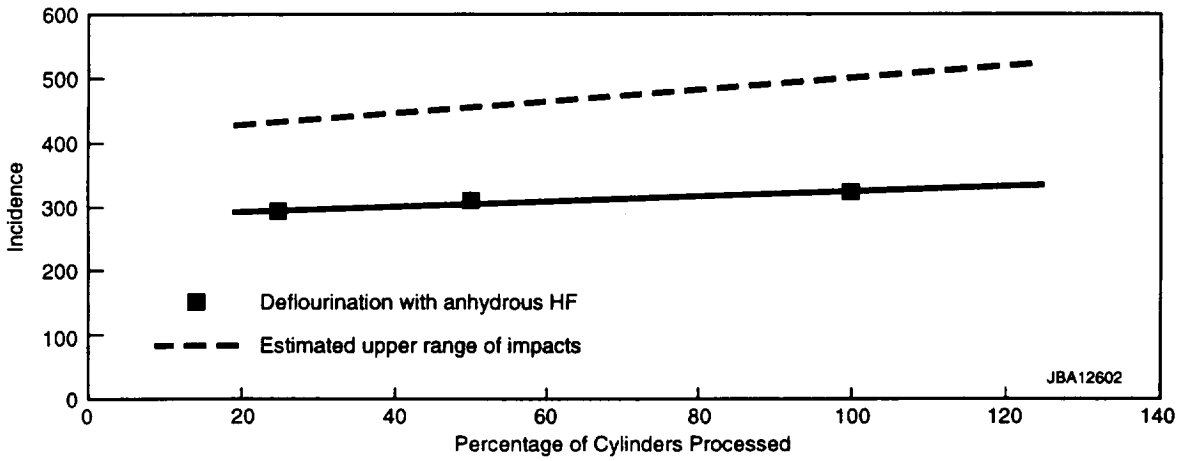

FIGURE K.26 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to UO_2 (The ranges reflect differences in UO_2 conversion technologies.)

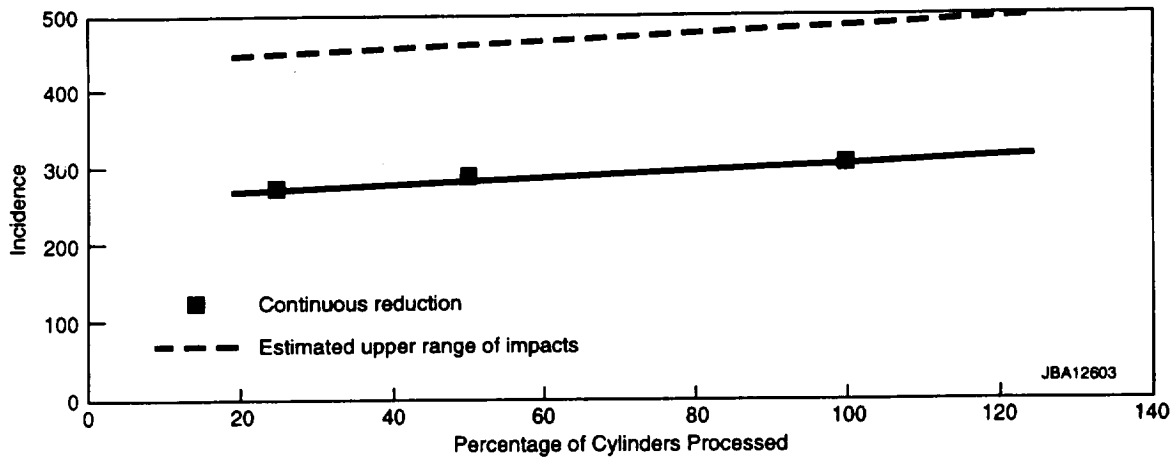

FIGURE K.27 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to Uranium Metal (The ranges reflect differences in uranium metal conversion technologies.)

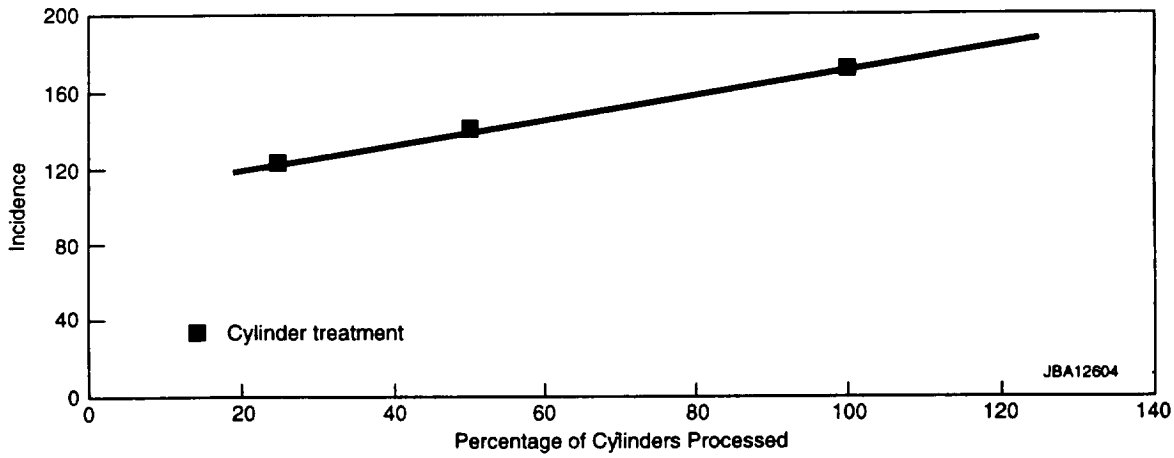

FIGURE K.28 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Cylinder Treatment Facility

K.2.4 Water and Soil

K.2.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all three conversion options. The impacts to surface water estimated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.2. The potential impacts evaluated included changes in the depth to groundwater, the direction of groundwater flow, recharge, and quality. The impacts to groundwater from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.5 Socioeconomics

The socioeconomic impacts of U_3O_8, UO_2, and metal conversion and cylinder treatment facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts

using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor between cases would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller conversion and cylinder treatment facilities would result in the following: less direct and indirect employment and income would be created in the region of influence (ROI) at each representative site; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

K.2.6 Ecology

Site preparation for the construction of conversion and cylinder treatment facilities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures, paved areas, and landscaping (see Section K.2.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Normal operations of the conversion facility would generate minor atmospheric emissions of criteria pollutants, HF, and uranium compounds. However, resulting air concentrations would be expected to be negligible under all three cases analyzed, resulting in negligible impacts to ecological resources.

Effluent discharges to surface water would contain low levels of contaminants, including uranium. However, under all three cases, contaminant concentrations in the undiluted effluent would be below levels that adversely affect aquatic biota.

Depending on the exact location of the conversion facility, the loss of approximately 10 to 30 acres (4 to 12 ha) of undeveloped land and habitat, representing the rounded 25-100% capacity range for oxide and metal conversion facilities, might constitute a minor to moderate adverse impact to vegetation and wildlife. For the cylinder treatment facility, the loss of 6.8 to 8.7 acres (2.8 to 3.5 ha) of undeveloped land and the permanent loss of 3.2 to 4.5 acres (1.3 to 1.8 ha) of habitat would constitute a negligible to low adverse impact. (See Section K.2.9 for details on land use assumptions.) When these facilities would be sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Impacts to air quality, surface water, groundwater, and soil during construction and operations would be expected to be negligible, as would the resulting derived impacts to ecological resources.

K.2.7 Waste Management

The estimated impacts from waste management operations for construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.7. Potential moderate impacts to site, regional, and national waste management operations were found for all 100% throughput conversion option cases. On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation of the conversion facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal waste management impacts would result from construction-generated wastes. The annual amounts of waste generated during facility operations are shown in Table K.2. Overall, the waste input resulting from normal operations at the conversion facilities would have a low to moderate impact on waste management capacities locally or across the DOE complex.

There is a significant possibility that the magnesium fluoride (MgF_2) waste generated in the conversion to metal option would be sufficiently contaminated with uranium to require disposal as low-level radioactive waste (LLW) rather than as solid nonhazardous waste. Such disposal might require the MgF_2 waste to be grouted, generating up to 12,300 m^3/yr of grouted waste for LLW disposal. This volume represents a low (5.8%) impact to the DOE complexwide LLW disposal capacity for the 100% throughput case (scales linearly for the three throughput cases).

K.2.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.8. The impacts on resources would be expected to be small for the 100% capacity conversion case. Although the resource requirements for the two conversion parametric analyses would be less than the 100% case, the reduction in requirements would not be linearly proportional to the decrease in throughput. For example, the amount of material required to construct a conversion facility for the 25% throughput case would be only about 10% to 20% less than the amount required for the 100% throughput facility due to "economies-of-scale."

Construction and operation of the proposed conversion options would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation. The conversion options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

TABLE K.2 Waste Generation from Conversion Facilities for 100%, 50%, and 25% Throughput Cases

Waste Category	Waste Generated (m^3/yr) by Conversion to U_3O_8, UO_2, or Uranium Metal for Three Throughput Cases								
	U_3O_8			UO_2			Uranium Metal		
	100%	50%	25%	100%	50%	25%	100%	50%	25%
Low-level radioactive waste									
Combustible	77	73	70	88	84	82	77	71	69
Noncombustible	62	45	33	82	63	45	112	88	69
Grouted	466	233	116	466	233	116	37	26	18
Low-level mixed waste	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Hazardous waste	7.3	6.7	6.1	7.3	6.7	6.1	7.3	6.7	6.1
Nonhazardous waste									
Solids	535	512	490	612	585	566	6,680[a]	3,590[a]	2,040[a]
Wastewater	58,000	36,300	24,600	74,900	47,300	31,000	96,500	57,500	37,500
Sanitary waste	4,920	4,730	4,540	5,680	5,380	5,220	5,300	4,950	4,800

[a] Includes the following volumes of MgF_2 waste: 6,120 m^3/yr for the 100% case; 3,060 m^3/yr for the 50% case, and 1,530 m^3/yr for the 25% case.

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Construction and operation of a cylinder treatment facility would also consume irretrievable amounts of electricity, fuel, concrete, steel, water, and miscellaneous gases and chemicals. Similar to the conversion facilities, the cylinder treatment facility option would not be expected to result in negative impacts relative to its resource requirements.

K.2.9 Land Use

K.2.9.1 Conversion to U_3O_8

Potential impacts to land use from the construction and operation of a U_3O_8 conversion facility would include the acquisition and clearing of required land, minor and temporary disruptions to contiguous land parcels, and increases in vehicular traffic. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to U_3O_8 by defluorination with anhydrous HF would require the disturbance of approximately 14, 16, and 20 acres (5.5, 6.4, and 8.1 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 9, 11, and 13 acres (3.6, 4.2, and 5.3 ha) with structures, paved areas, and landscaping. The amount of land required for the other U_3O_8 conversion technologies would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts, particularly if the facility was sited in a location already dedicated to similar use with immediate access to infrastructure and utility support.

Impacts to land use outside the boundaries of a U_3O_8 conversion facility at 25%, 50%, or 100% of throughput would be limited to negligible, temporary traffic impacts associated with project construction.

K.2.9.2 Conversion to UO_2

Impacts to land use from the construction and operation of a UO_2 conversion facility, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to UO_2 by the dry process with anhydrous HF would require the disturbance of approximately 16, 19, and 24 acres (6.4, 7.9, and 9.7 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 10, 13, and 15 acres (4.0, 5.2, and 5.9 ha) with structures, paved areas, and landscaping. The amount of land required for the other UO_2 conversion technologies would be roughly similar, except for gelation, which would require a slightly greater amount of land. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a UO_2 conversion facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

K.2.9.3 Conversion to Uranium Metal

Impacts to land use from the construction and operation of a facility for uranium metal conversion, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to uranium metal by the continuous metallothermic production technology would require the disturbance of approximately 17, 21, and 26 acres (6.8, 8.6, and 10.6 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 12, 14, and 15 acres (4.8, 5.5, and 6.2 ha) with structures, paved areas, and landscaping. The amount of land required for the other uranium metal conversion technology would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a conversion-to-metal facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

K.2.9.4 Cylinder Treatment Facility

Other than negligible and temporary disruptions to contiguous land parcels, and slight increases in vehicular traffic, virtually no impacts would be expected from a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity. Site preparation for construction of a stand-alone cylinder treatment facility for 25%, 50%, and 100% of the depleted UF_6 inventory would require the disturbance of approximately 6.8, 7.5, and 8.7 acres (2.8, 3.0, and 3.5 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 3.2, 3.7, and 4.5 acres (1.3, 1.5, and 1.8 ha) with structures and paved areas.

Potential impacts to land use outside the boundaries of a site containing a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity would be limited to negligible, temporary traffic impacts associated with project construction.

K.2.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the conversion options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as

to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of conversion facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier *National Environmental Policy Act* (NEPA) documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.3 LONG-TERM STORAGE OPTIONS

The parametric analysis of the long-term storage options considered the environmental impacts of storing 25% and 50% of the depleted UF_6 inventory as UF_6 or as an oxide form. In both cases, it was assumed that the uranium material would be actively placed into storage over a 20-year period (from 2009 through 2028), and then stored for an additional 11-year period (from 2029 through 2039) with only routine monitoring and maintenance. The assessment considered the environmental impacts that would occur during (1) construction of a storage facility, (2) routine operations, and (3) potential storage facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases discussed in detail in Appendix G. The supporting engineering data for the 25% and 50% parametric storage cases are provided in the engineering analysis report (LLNL 1997a).

The environmental impacts for the 100% case are presented in Appendix G for (1) storage as UF_6 in yards, buildings, and an underground mine; (2) storage as U_3O_8 in buildings, vaults, and a mine; and (3) storage as UO_2 in buildings, vaults, and a mine. For the purposes of the parametric analysis, storage as UF_6 in buildings and storage as UO_2 in buildings were considered in detail. These options were chosen to simplify the parametric analysis because all options were evaluated in detail for the 100% base case. The relationships between the options that were identified for the 100% case were used to infer the impacts for all of the long-term storage options for the parametric analysis.

K.3.1 Human Health — Normal Operations

K.3.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from the normal operation of full-scale (100%) storage facilities for depleted UF_6 cylinders, UO_2 drums, and U_3O_8 drums are described in Appendix G, Section G.3.1.1. Similar impacts were calculated for the 50% and 25% storage facilities for the parametric analysis. Radiological impacts from the storage as UF_6, UO_2, and U_3O_8 would be limited to involved workers because emissions of uranium to the air and water would be expected to be negligible during normal operations. The radiological impacts for involved workers for the 100%, 50%, and 25% cases are shown in Figures K.29 through K.34. The range of impacts resulting from technology differences (i.e., differences between building, vault, and mine storage facilities) are represented by dashed lines in the figures. The results for the two parametric cases for storage in buildings are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts would vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds of impacts for the 25% and 50% cases were estimated on the basis of the range determined for the different technologies for the 100% case. The area enclosed by the lines in the figures indicates the range of impacts expected for throughputs between 25% and 100%.

The results of the parametric analysis (as shown in Figures K.29 and K.34) indicate that the collective radiological impacts would scale relatively linearly with the total quantity of depleted UF_6 processed. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix G, Section G.3.1.1.

K.3.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) storage facilities are described in Appendix G, Section G.3.1.2. The results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from operation of all storage facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all long-term storage options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions of depleted uranium and HF during normal operations would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the 100% case results, no adverse health

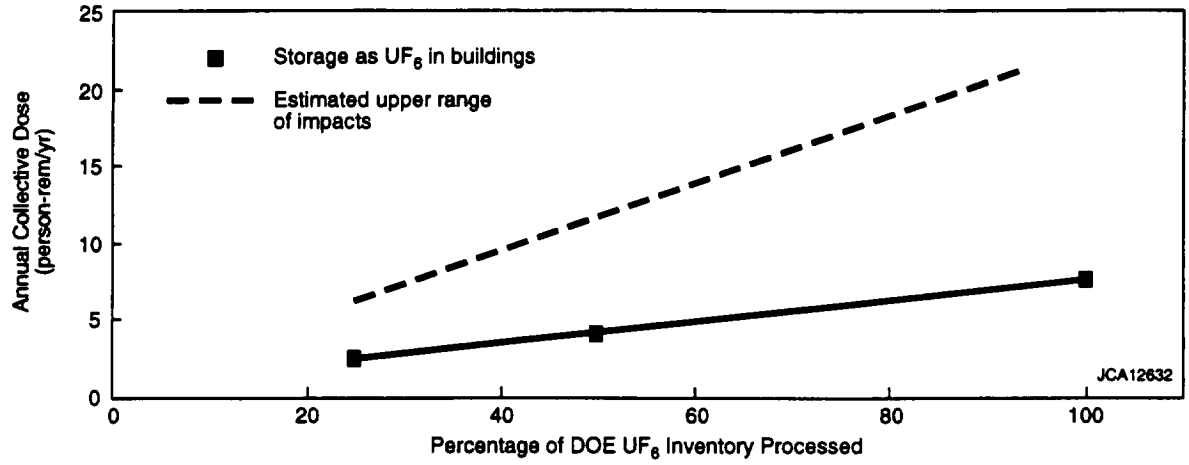

FIGURE K.29 Estimated Annual Collective Dose to Involved Workers from Storage as UF_6 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

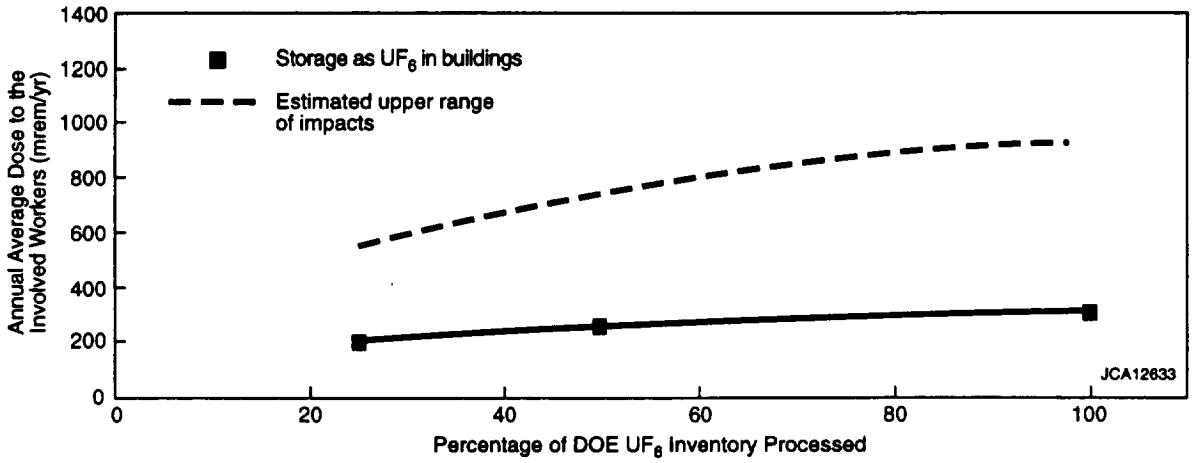

FIGURE K.30 Estimated Annual Average Individual Dose to Involved Workers from Storage as UF_6 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

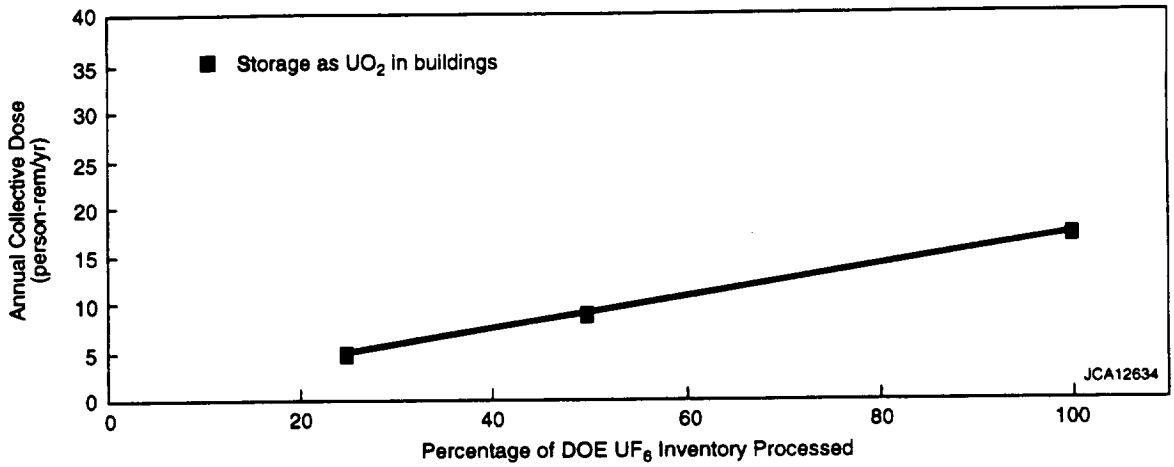

FIGURE K.31 Estimated Annual Collective Dose to Involved Workers from Storage as UO_2 (The collective doses for the different storage technologies would be essentially the same.)

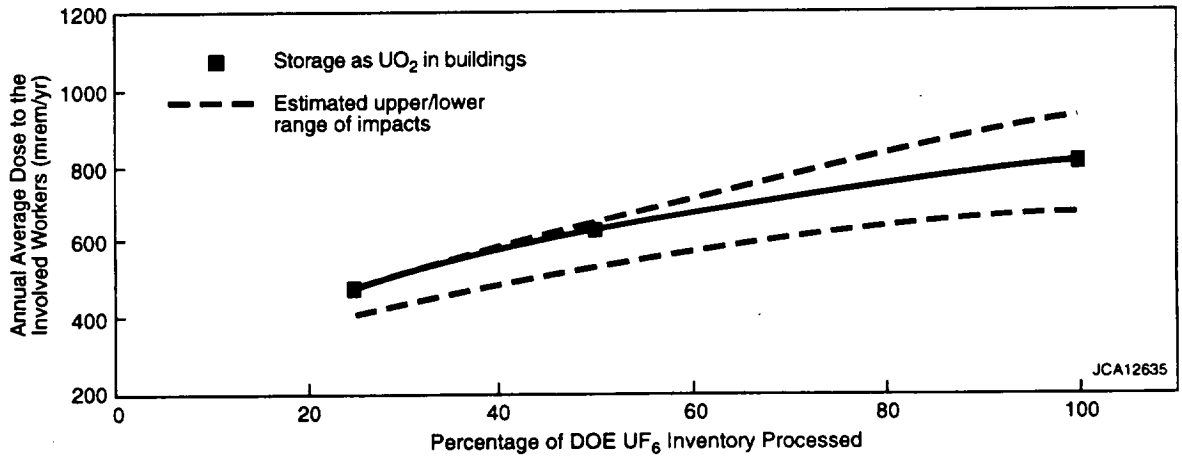

FIGURE K.32 Estimated Annual Average Individual Dose to Involved Workers from Storage as UO_2 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

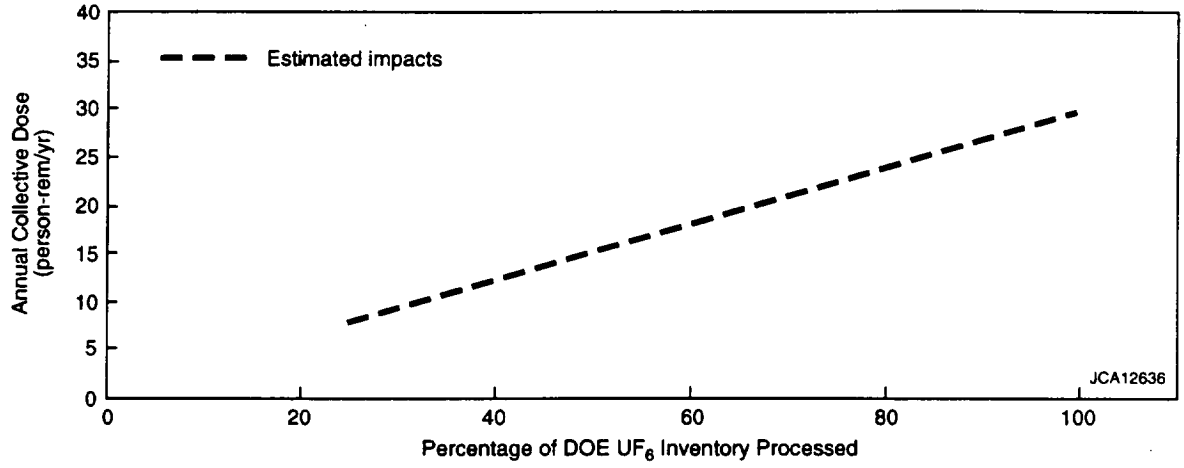

FIGURE K.33 Estimated Annual Collective Dose to Involved Workers from Storage as U_3O_8

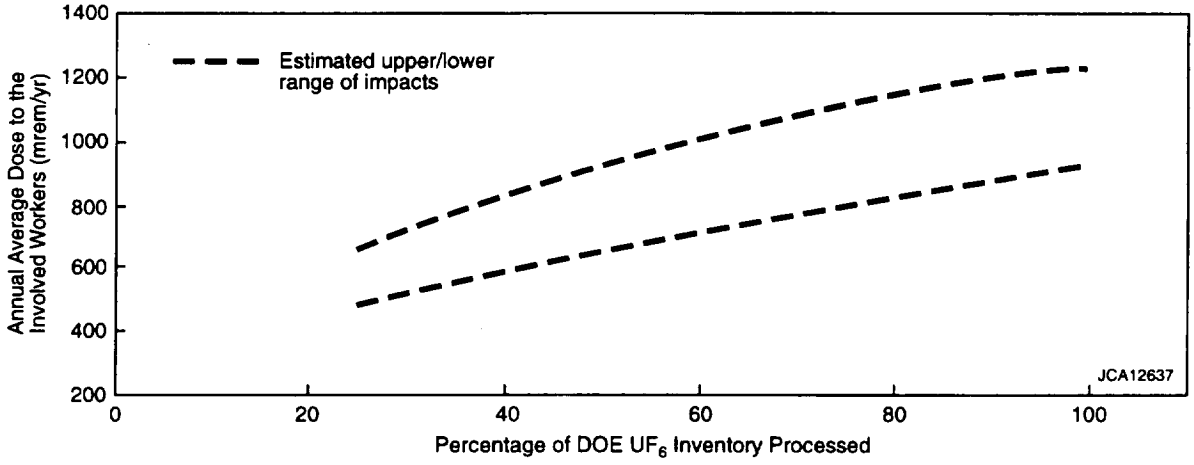

FIGURE K.34 Estimated Annual Average Individual Dose to Involved Workers from Storage as U_3O_8 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

impacts from chemical exposures would be expected for throughput rates between 25% and 100% for all long-term storage options.

K.3.2 Human Health — Accident Conditions

K.3.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during the operation of full-scale (100%) storage facilities for depleted UF_6, U_3O_8, and UO_2 are presented in Appendix G, Section G.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Appendix G, Section G.3.2.1. The impacts would be identical because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents that were related to handling operations (i.e., the "mishandle/drop of drum" accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

K.3.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) storage facilities for UF_6 and oxide are presented in Appendix G, Section G.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the chemical accident impacts associated with each of the parametric cases would be the same as those presented

for the 100% case in Appendix G, Section G.3.2.2. As for radiological accidents, the impacts would be the same because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents related to handling operations (i.e., the "mishandle/drop of drum" accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

K.3.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) storage facilities are presented in Appendix G, Section G.3.2.3. For the 100% storage cases, worker fatalities ranged from about 0.10 to 0.36 for storage as UF_6, 0.16 to 0.24 for storage as UO_2, and 0.29 to 0.43 for storage as U_3O_8 (see Table G.11 in Section G.3.2.3). On-the-job worker injuries for the 100% cases ranged from about 90 to 190 for storage as UF_6, from 150 to 220 for storage as U_3O_8, and from 100 to 140 for storage as UO_2. For the two options analyzed in detail in the parametric analysis, the impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

For parametric cases, the number of on-the-job worker fatalities for storage as UF_6 would range from 0.05 to 0.23 at 25% capacity and from about 0.10 to 0.29 at 50% capacity. For storage as UO_2, fatalities would range from 0.07 to 0.15 at 25% capacity and from about 0.10 to 0.19 at 50% capacity. The number of on-the-job worker injuries for storage as UF_6 would range from about 50 to 125 at 25% capacity and from about 60 to 150 at 50% capacity. For storage as UO_2, injuries would range from about 50 to 90 at 25% capacity and from about 75 to 110 at 50% capacity. The predicted number of injuries for UF_6 and UO_2 are shown as a function of throughput in Figures K.35 and K.36, respectively.

Although parametric cases for the U_3O_8 storage options were not explicitly analyzed, if it is assumed that the relative difference in magnitude of impacts for U_3O_8 and UO_2 is similar to that for the 100% cases, then the number of on-the-job fatalities for storage as U_3O_8 would range from about 0.12 to 0.26 for 25% capacity and from about 0.19 to 0.36 at 50% capacity. Estimated injuries for parametric cases of storage as U_3O_8 would range from about 75 to 135 for 25% capacity and from about 113 to 176 for 50% capacity.

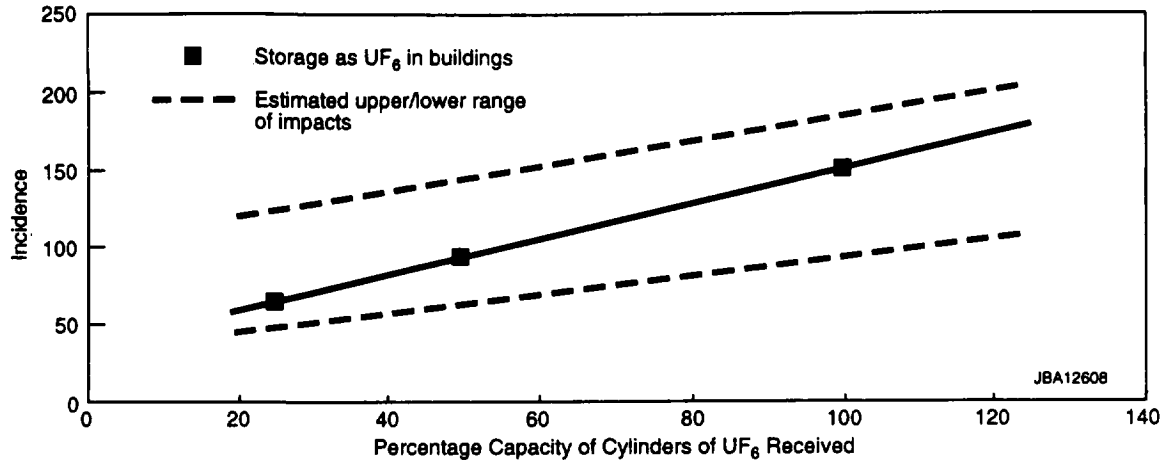

FIGURE K.35 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UF_6 (The ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

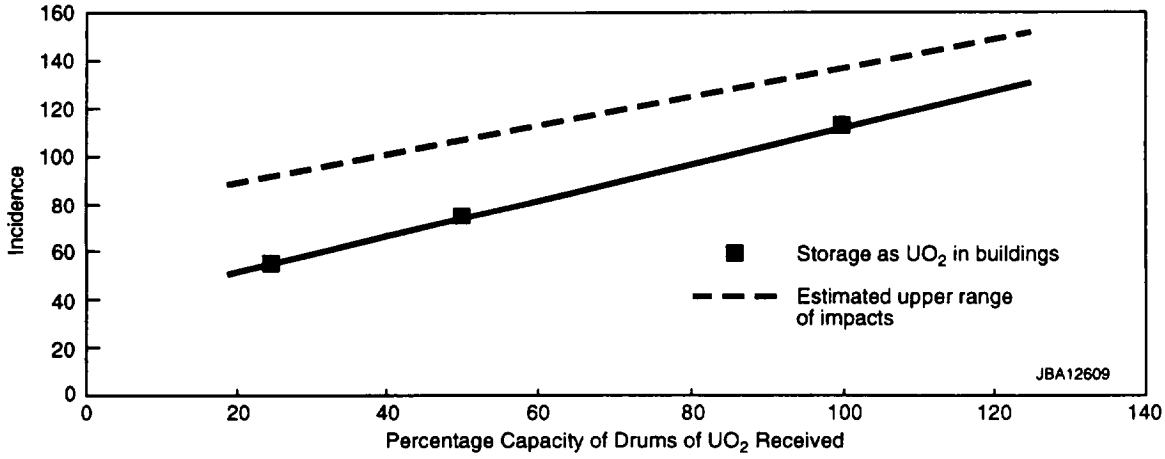

FIGURE K.36 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UO_2 (The ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

K.3.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.3. All of the pollutant concentrations resulting from 100% throughput would be below the respective air quality standards. During construction, short-term particulate concentrations would potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. During operations, the pollutant concentrations would be less than 0.1% of the corresponding air quality standards, resulting in negligible impacts.

The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases; impacts during operations would also be negligible. The air quality impacts from storage were found to scale roughly proportionally with throughput. The impacts from the 50% case for both construction and operations would be about 0.6 of those from the 100% case for both UF_6 and UO_2; the impacts for construction for the 25% case would be 0.25 and 0.32 times the 100% case for UF_6 and UO_2, respectively; and the impacts for operations for the 25% case would be only about 0.2 times the 100% case for both UF_6 and UO_2.

K.3.4 Water and Soil

K.3.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all storage options for both UF_6 and oxide (including storage of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.3.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.2. The potential impacts evaluated included changes in depth to groundwater, direction of groundwater flow, recharge, and groundwater quality. The impacts to

groundwater from the 100% cases were found to be negligible for all storage options for both UF_6 and oxide (including storage of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.3.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to have potentially moderate, but temporary, impacts for all storage options. These moderate impacts would result from material excavated during construction that would be left on-site. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be negligible. The impacts calculated for the 25% and 50% parametric cases for storage of UF_6 and UO_2 in buildings, based on information provided in the engineering analysis report (LLNL 1997a), were also found to have moderate, but temporary, impacts on soil, similar to the 100% cases. In the long term, impacts on soil would be negligible for all storage options.

K.3.5 Socioeconomics

The socioeconomic impacts of UF_6 and UO_2 long-term storage facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller UF_6 and UO_2 long-term storage facilities would result in the following: less direct and indirect employment and income in the ROI would be created at each representative site; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

K.3.6 Ecology

Impacts to ecological resources could occur during construction of UF_6 storage facilities for all options, although impacts during operations would be negligible. Impacts due to construction and operation of a facility to store UO_2 in buildings would be similar to impacts from storage of UF_6. Site preparation activities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas (see Section K.3.9). Existing

vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Depending on the exact location of the UF_6 facility, the loss of 40 to 130 acres (16 to 53 ha) of undeveloped land and habitat might constitute a moderate to large adverse impact to vegetation and wildlife. (See Section K.3.9 for details on land use assumptions.) Depending on the exact location of the UO_2 facility, the loss of 40 to 80 acres (16 to 32 ha) of undeveloped land and habitat might constitute a moderate adverse impact. However, when these facilities were sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas and site-specific surveys for protected species would be included during facility planning.

K.3.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.7. On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation of the long-term storage facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal to moderate, but temporary, waste management impacts would result from construction wastes. Negligible impacts would be associated with all waste forms generated during operations. Overall, the waste input resulting from storage facilities would have negligible impact on waste management capacities locally or across the DOE complex.

K.3.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.8. The impacts on resources would be expected to be small for the 100% capacity storage case for all options. Resource requirements for the two parametric cases considered would be less than those for the 100% case (LLNL 1997a). In general, the amounts of construction materials would be roughly proportional to the storage capacity because the majority of the construction materials would be for the actual storage buildings and the number of storage buildings required would be linearly related to the required storage capacity.

Construction and operation of the proposed storage facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be

consumed during construction or operation for all long-term storage options. The storage options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

K.3.9 Land Use

Impacts to land use from the construction and operation of UF_6 storage buildings would be limited to the clearing of required land, potential minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic. Site preparation for construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory in buildings would require the disturbance of approximately 42, 72, and 131 acres (17, 29, and 53 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 16, 30, and 62 acres (6.5, 12, and 25 ha) with structures and paved areas. The amount of land required for the other UF_6 storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. Also, the areal requirement of 131 acres (53 ha) for the 100% capacity case could result in land-use changes if an existing site with limited open space were chosen.

Road and rail access within a storage site would be designed to minimize on-site traffic conflicts. For off-site traffic, only temporary, minor impacts associated with construction vehicles would be expected.

Storage as UO_2 would be expected to generate only negligible impacts to land use and would result in a lower areal requirement and less land disturbance compared with storage as UF_6. Site preparation for the construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory as UO_2 in buildings would require the disturbance of approximately 37, 49, and 79 acres (15, 20, and 32 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 13, 20, and 35 acres (5.1, 8.1, and 14 ha) with structures and paved areas. The amount of land required for the other uranium oxide storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. The peak labor force during the 20-year construction period, regardless of throughput capacity, would not be large enough to generate other than negligible off-site traffic impacts.

K.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the long-term storage options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of storage facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.4 MANUFACTURE AND USE OPTIONS

The parametric analysis of the manufacture and use options considered the environmental impacts of using 25% and 50% of the depleted UF_6 inventory in the form of either uranium metal or dense UO_2 to manufacture uranium-shielded casks. The analysis of both options (uranium metal or dense UO_2) was based on the assumption that depleted uranium would be used as the primary shielding material in containers, called "casks," used to store spent nuclear fuel. The assessment considered the environmental impacts that would occur during (1) construction of a cask manufacturing facility, (2) routine operation of the cask manufacturing facility, and (3) potential manufacturing plant accidents. The manufacturing of casks was assumed to take place over a 20-year period, from 2009 through 2028. Impacts during use of depleted uranium shielded casks were not estimated in the PEIS.

The areas of impact and the methodologies used to evaluate the parametric cases for the manufacture and use options were the same as those used to evaluate the 100% cases. The evaluation of the 100% cases is presented in detail in Appendix H. The supporting engineering data for the 25% and 50% parametric cases are provided in the engineering analysis report (LLNL 1997a).

K.4.1 Human Health — Normal Operations

K.4.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from normal operation of a full-scale (100%) UO_2 cask manufacturing facility are described in Appendix H, Section H.3.1.1. Similar impacts were calculated for the manufacture of casks using 50% and 25% of the depleted UF_6 inventory. The radiological impacts estimated for the 100%, 50%, and 25% case are shown in Figures K.37 through K.42 as radiation doses to each of the six receptor scenarios considered in the PEIS: members of the general public — annual collective dose and annual dose to the MEI; noninvolved workers — annual collective dose and annual dose to the MEI; and involved workers — annual collective dose and annual average individual dose. Because the radiological impacts to involved workers (Figures K.41 and K.42) would not depend on the location of the manufacturing facility, no ranges of impact are presented. Ranges of impacts are presented for noninvolved workers and the general public in Figures K.37 through K.40. The range of impacts for noninvolved workers would be related only to possible differences in site meteorological conditions. The impact range for members of the general public would be related to differences in both meteorological conditions and population density (i.e., from rural to urban areas).

The results of the parametric analysis (as shown in Figures K.37 through K.42) indicate that the collective radiological impacts would scale relatively linearly with the total quantity of depleted UF_6 used to manufacture the casks. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix H, Section H.3.1.1.

The estimated radiation doses from the manufacture of uranium metal casks for the 100%, 50%, and 25% throughput cases are presented in Figures K.43 through K.48. The general relationship between radiological impacts and throughput would be similar to that for UO_2 casks; that is, the radiological impacts would decrease with decreasing throughput, although at a rate not proportional to the reduction in throughput.

K.4.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) cask manufacturing facilities for UO_2 and uranium metal are described in Appendix H, Section H.3.1.2. The results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from the normal

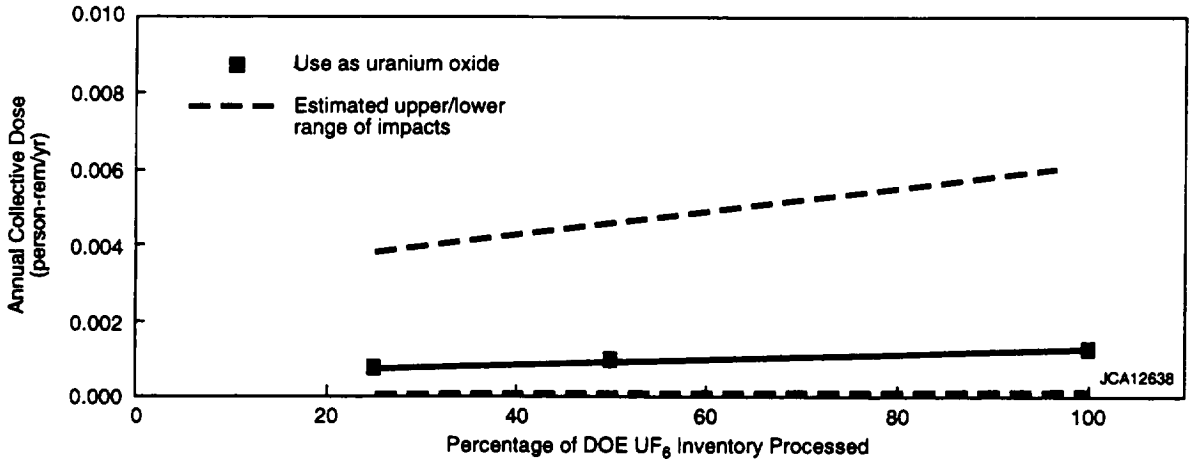

FIGURE K.37 Estimated Annual Collective Dose to Members of the Public from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, such as meteorological conditions and rural or urban area.)

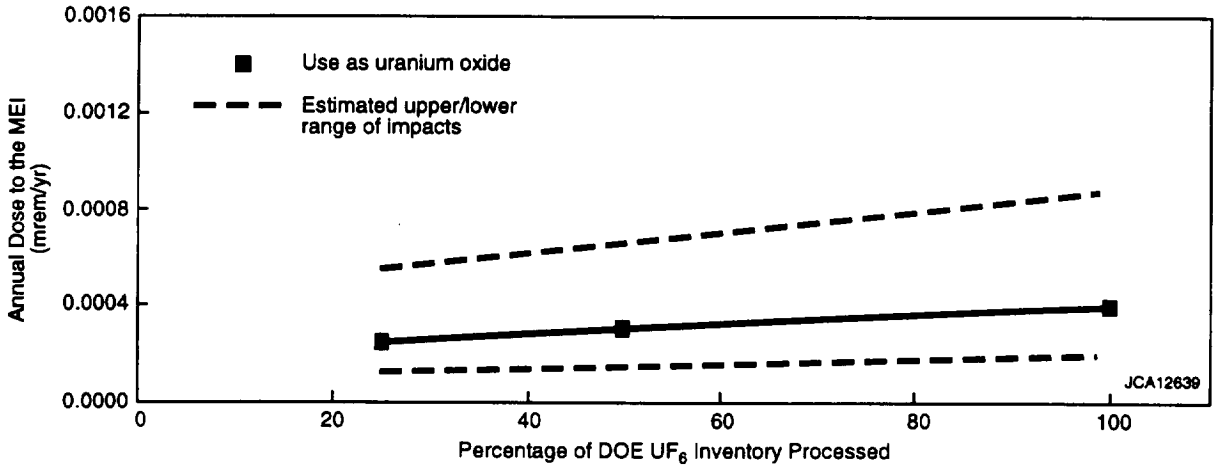

FIGURE K.38 Estimated Annual Dose to the General Public MEI from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences between site characteristics, primarily meteorological conditions.)

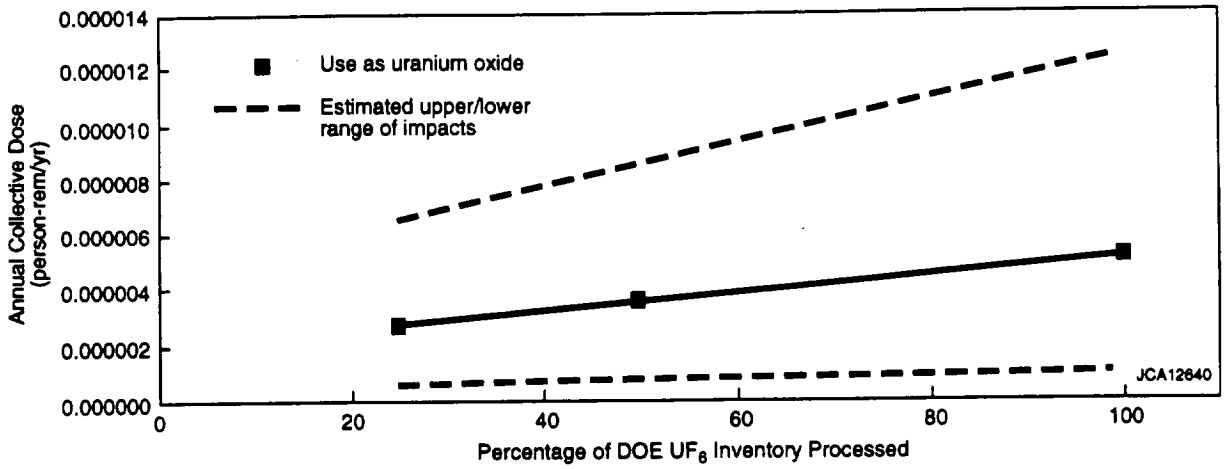

FIGURE K.39 Estimated Annual Collective Dose to Noninvolved Workers from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

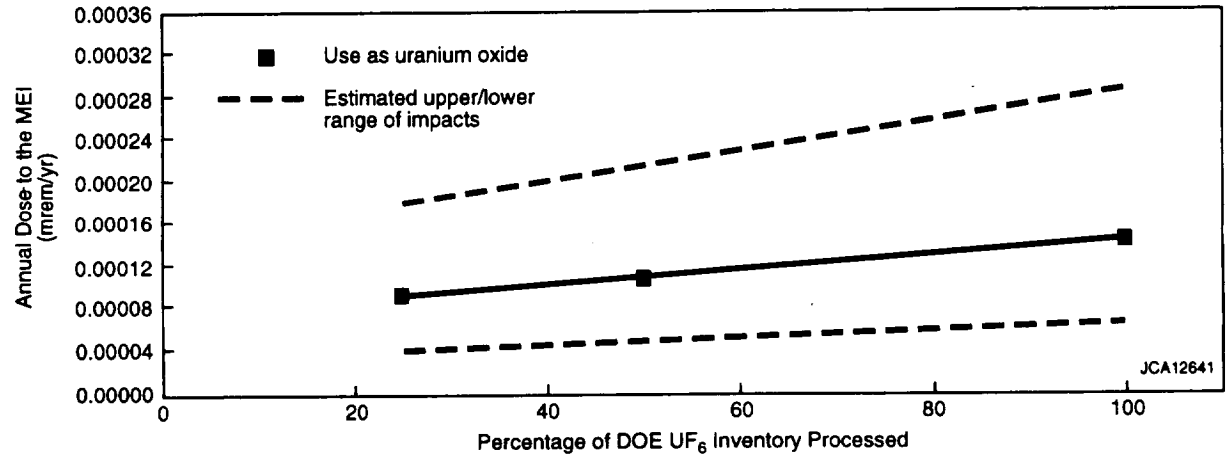

FIGURE K.40 Estimated Annual Dose to the Noninvolved Worker MEI from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

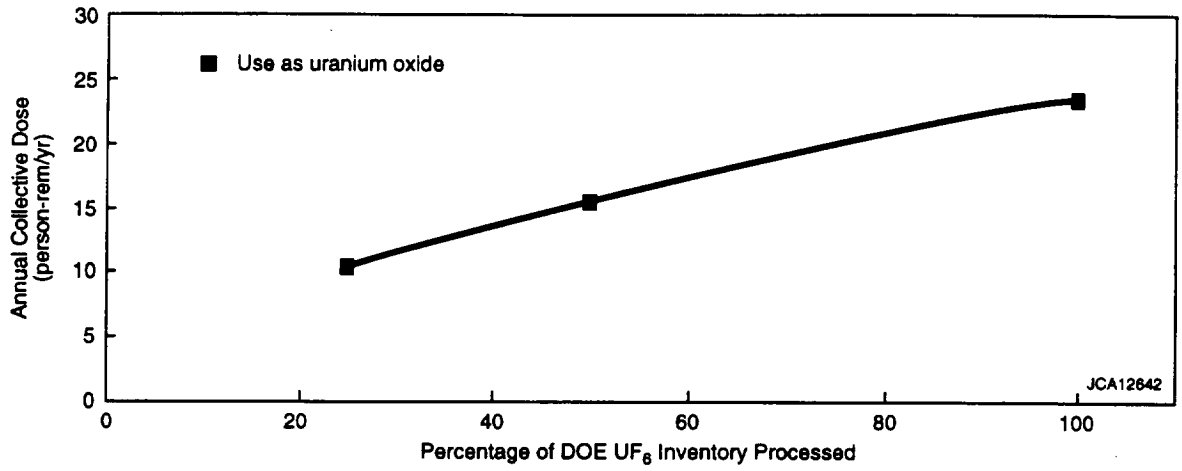

FIGURE K.41 Estimated Annual Collective Dose to Involved Workers from the Manufacture of Casks Using UO_2

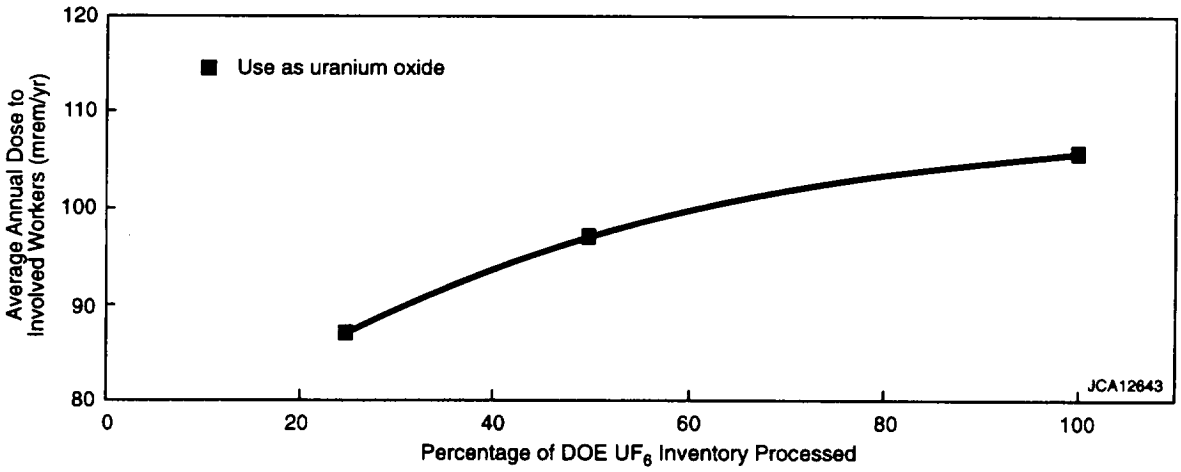

FIGURE K.42 Estimated Annual Average Individual Dose to Involved Workers from the Manufacture of Casks Using UO_2

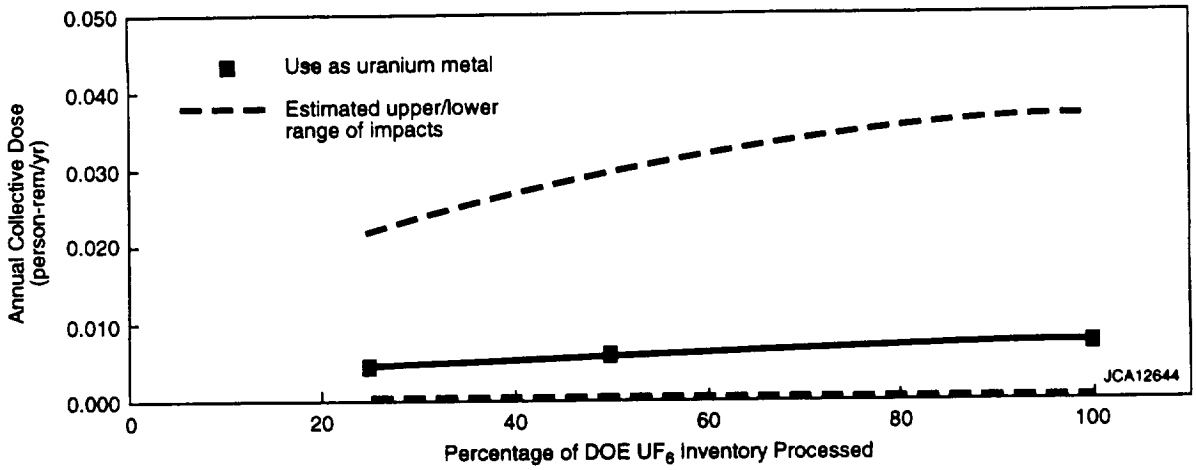

FIGURE K.43 Estimated Annual Collective Dose to Members of the Public from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, such as meteorological conditions and rural or urban area.)

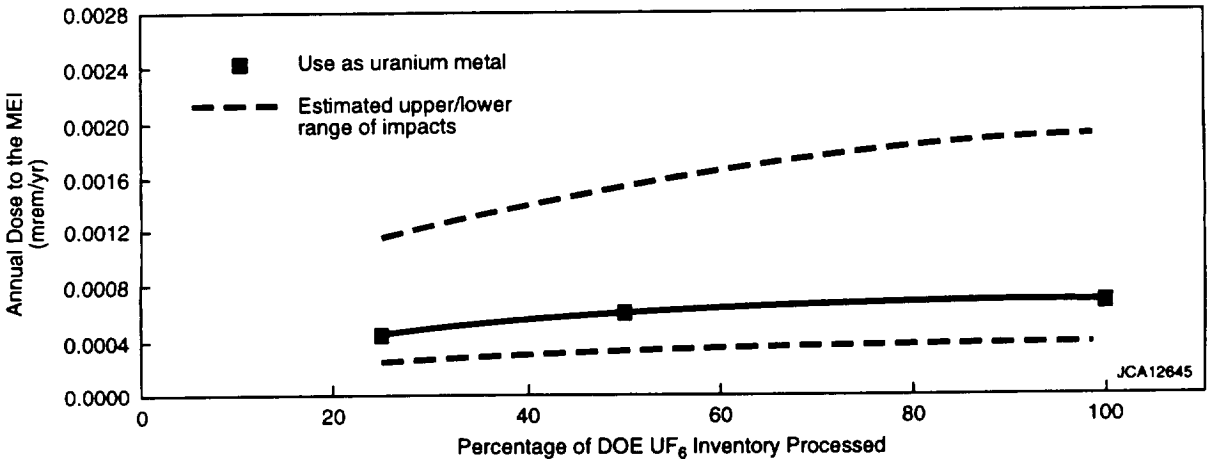

FIGURE K.44 Estimated Annual Dose to the General Public MEI from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

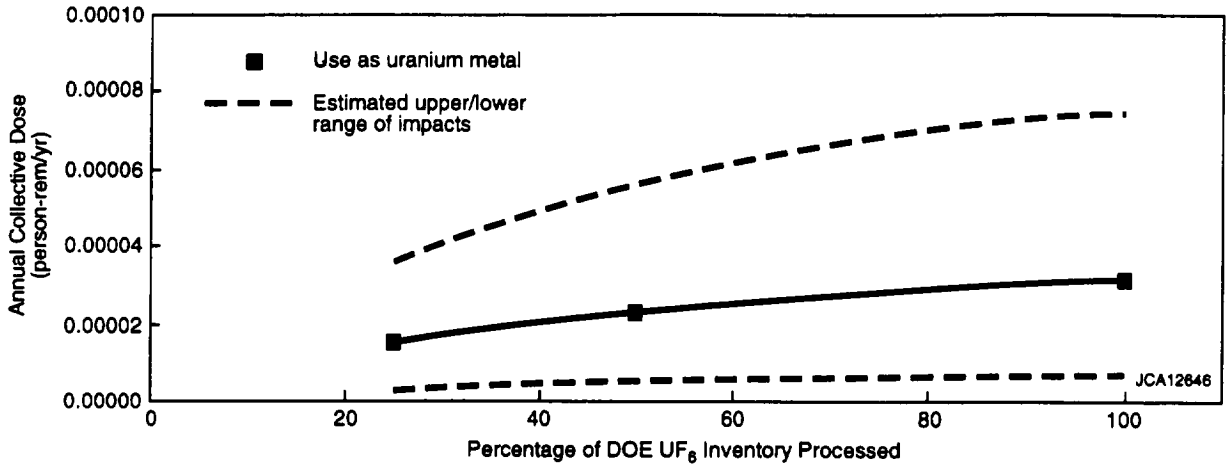

FIGURE K.45 Estimated Annual Collective Dose to Noninvolved Workers from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

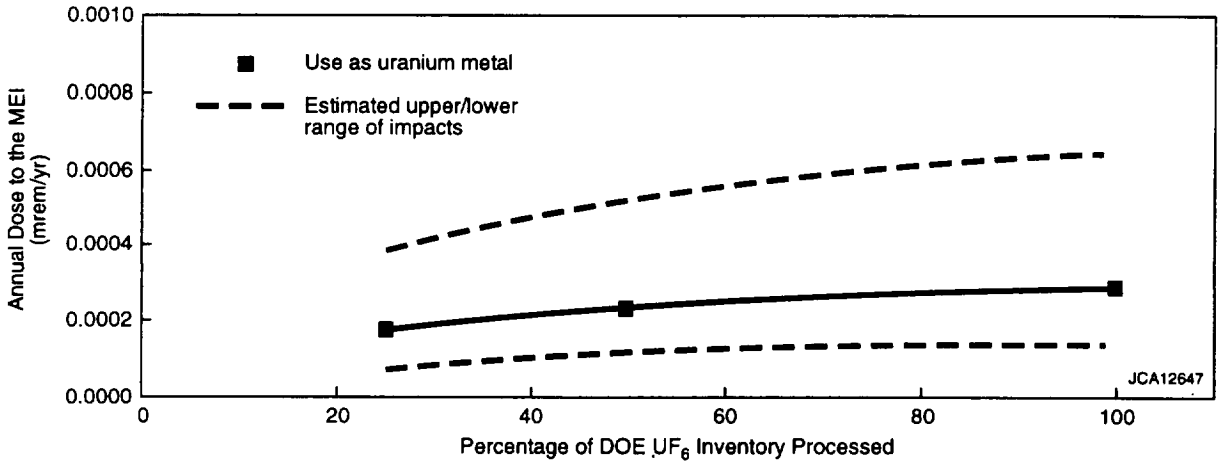

FIGURE K.46 Estimated Annual Dose to the Noninvolved Worker MEI from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

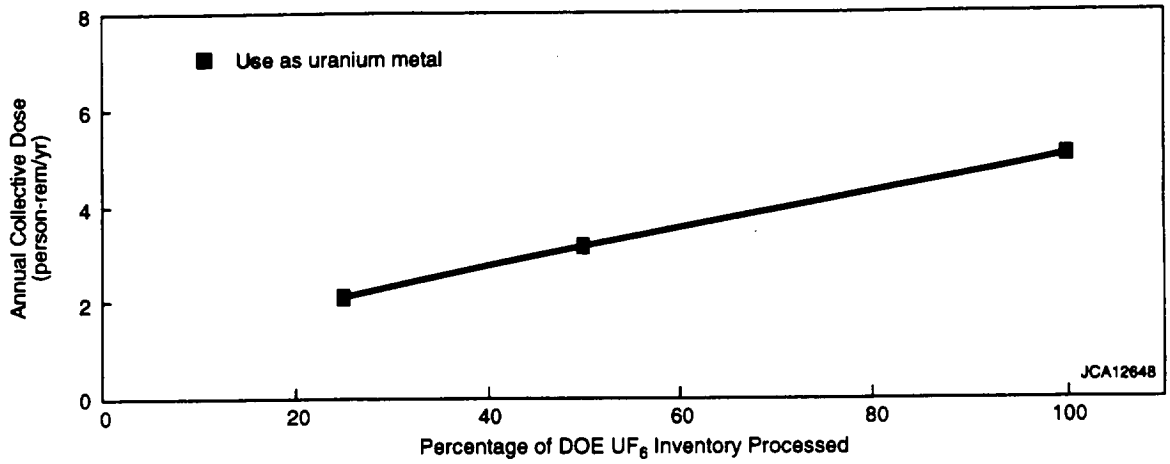

FIGURE K.47 Estimated Annual Collective Dose to Involved Workers from the Manufacture of Casks Using Uranium Metal

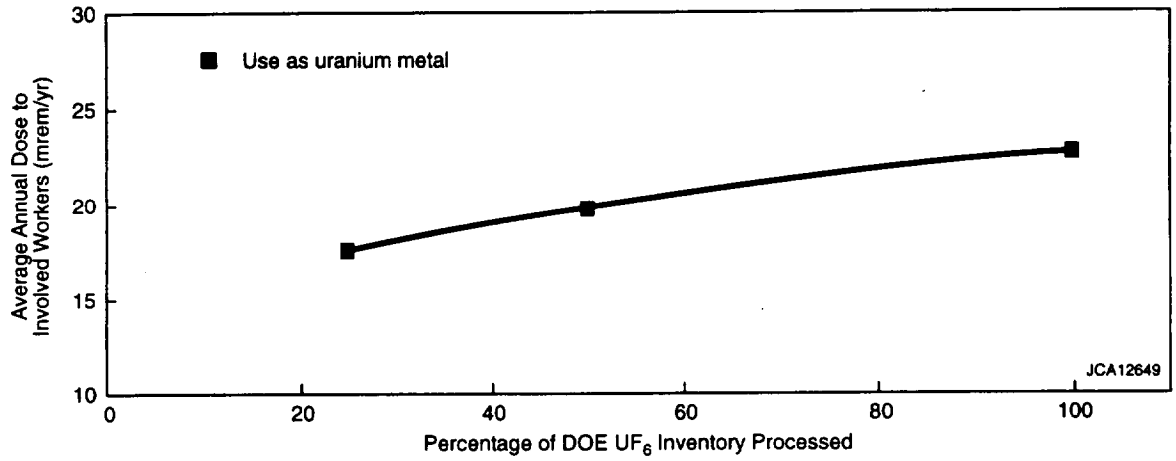

FIGURE K.48 Estimated Annual Average Individual Dose to Involved Workers from the Manufacture of Casks Using Uranium Metal

operation of manufacturing facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 during normal operations (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions during normal operations would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the 100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for the manufacture of UO_2 and uranium metal shielded casks.

K.4.2 Human Health — Accident Conditions

K.4.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during the operation of full-scale (100%) cask manufacturing facilities are presented in Appendix H, Section H.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The impacts from bounding accidents for the 25% and 50% throughput cases would be the same as those presented in Appendix H, Section H.3.2.1 for the 100% case, with two exceptions. For the manufacture of both uranium oxide and uranium metal shielded casks, the bounding accident impacts for the "unlikely" frequency category would be less for the 25% and 50% cases than for the 100% case. The radiological impacts for these accident categories are presented in Tables K.3 and K.4 for the 100%, 50%, and 25% cases.

K.4.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) cask manufacturing facilities using uranium oxide and uranium metal are presented in Appendix H, Section H.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The bounding chemical accidents associated with the 25% and 50% throughput cases would be the same as those presented for the 100% cases in Appendix H. The impacts would be similar because the bounding accidents within most frequency categories would be the same as the 100%,

TABLE K.3 Estimated Radiological Doses per Accident Occurrence for the Manufacture and Use Options

Option/ Accident[a]	Frequency Category[b]	Capacity (%)	Maximum Dose[c]				Minimum Dose[c]			
			Noninvolved Workers		General Public		Noninvolved Workers		General Public	
			MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Use as Uranium Oxide Casks										
Earthquake	Unlikely	100	7.7×10^{-2}	2.9×10^{-2}	2.3×10^{-3}	3.2×10^{-1}	3.2×10^{-3}	1.2×10^{-3}	9.2×10^{-5}	1.1×10^{-3}
		50	3.9×10^{-2}	1.5×10^{-2}	1.1×10^{-3}	1.6×10^{-1}	1.6×10^{-3}	6.1×10^{-4}	4.6×10^{-5}	5.4×10^{-4}
		25	1.9×10^{-2}	7.3×10^{-3}	5.7×10^{-4}	7.9×10^{-2}	8.1×10^{-4}	3.0×10^{-4}	2.3×10^{-5}	2.7×10^{-4}
Use as Uranium Metal Casks										
Earthquake	Unlikely	100	1.1×10^{-2}	4.3×10^{-3}	3.4×10^{-4}	4.6×10^{-2}	4.7×10^{-4}	1.8×10^{-4}	1.3×10^{-5}	1.6×10^{-4}
		50	5.5×10^{-3}	2.2×10^{-3}	1.7×10^{-4}	2.3×10^{-2}	2.3×10^{-4}	9.0×10^{-5}	6.5×10^{-6}	8.0×10^{-5}
		25	2.8×10^{-3}	1.1×10^{-3}	8.5×10^{-5}	1.2×10^{-2}	1.2×10^{-4}	4.5×10^{-5}	3.3×10^{-6}	4.0×10^{-5}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[b] An unlikely accident is estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

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TABLE K.4 Estimated Radiological Health Risks per Accident Occurrence for the Manufacture and Use Options

Option/ Accident[a]	Frequency Category[b]	Capacity (%)	Maximum Risk[c] (LCFs)				Minimum Risk[c] (LCFs)			
			Noninvolved Workers		General Public		Noninvolved Workers		General Public	
			MEI	Population	MEI	Population	MEI	Population	MEI	Population
Use as Uranium Oxide Casks										
Earthquake	Unlikely	100	3×10^{-5}	1×10^{-5}	1×10^{-6}	2×10^{-4}	1×10^{-6}	5×10^{-7}	5×10^{-8}	5×10^{-7}
		50	2×10^{-5}	6×10^{-6}	6×10^{-7}	8×10^{-5}	6×10^{-7}	2×10^{-7}	2×10^{-8}	3×10^{-7}
		25	8×10^{-6}	3×10^{-6}	3×10^{-7}	4×10^{-5}	3×10^{-7}	1×10^{-7}	1×10^{-8}	1×10^{-7}
Use as Uranium Metal Casks										
Earthquake	Unlikely	100	4×10^{-6}	2×10^{-6}	2×10^{-7}	2×10^{-5}	2×10^{-7}	7×10^{-8}	7×10^{-9}	8×10^{-8}
		50	2×10^{-6}	9×10^{-7}	8×10^{-8}	1×10^{-5}	1×10^{-7}	4×10^{-8}	3×10^{-9}	4×10^{-8}
		25	1×10^{-6}	4×10^{-7}	4×10^{-8}	6×10^{-6}	5×10^{-8}	2×10^{-8}	2×10^{-9}	2×10^{-8}

[a] The accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[b] An unlikely accident is estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

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50%, and 25% cases, and in those cases where these accidents were different, no adverse chemical impacts were estimated to occur. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding) would be different from those for the 100% cases. In general, the impacts of these nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

K.4.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) cask manufacturing facilities are presented in Appendix H, Section H.3.2.3. For the 100% analysis, up to 1 on-the-job fatality was predicted for the manufacture of both uranium oxide and uranium metal shielded casks. The predicted number of on-the-job worker injuries for the 100% case was 640 for manufacturing uranium oxide shielded casks and 670 for uranium metal shielded casks. For the two options analyzed in detail in the parametric analysis, the impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

The predicted number of on-the-job worker fatalities over the entire 20 years of the manufacture of uranium oxide or uranium metal shielded casks is about 1 (including construction and operations). For uranium oxide shielded casks, the number would range from 0.6 for the 25% case to 0.76 for the 100% case; whereas for uranium metal shielded casks, the number would range from 0.7 for the 25% case to 0.85 for the 100% case. The predicted number of on-the-job injuries (including construction and operations) would range from 480 to 640 for uranium oxide casks and from 510 to 670 for uranium metal casks. The estimated numbers of fatalities and injuries for uranium oxide and uranium metal shielded casks are shown as a function of throughput in Figures K.49 and K.50, respectively.

K.4.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.3. All of the pollutant concentrations produced by the 100% capacity version of the storage facilities would be below their respective air quality standards. During construction, the largest impacts relative to air quality standards would occur for nitrogen oxides (NO_x). During construction, all pollutant concentrations would be less than 10% of the corresponding standards. During operations, all pollutant concentrations would also be less than 10% of the standards.

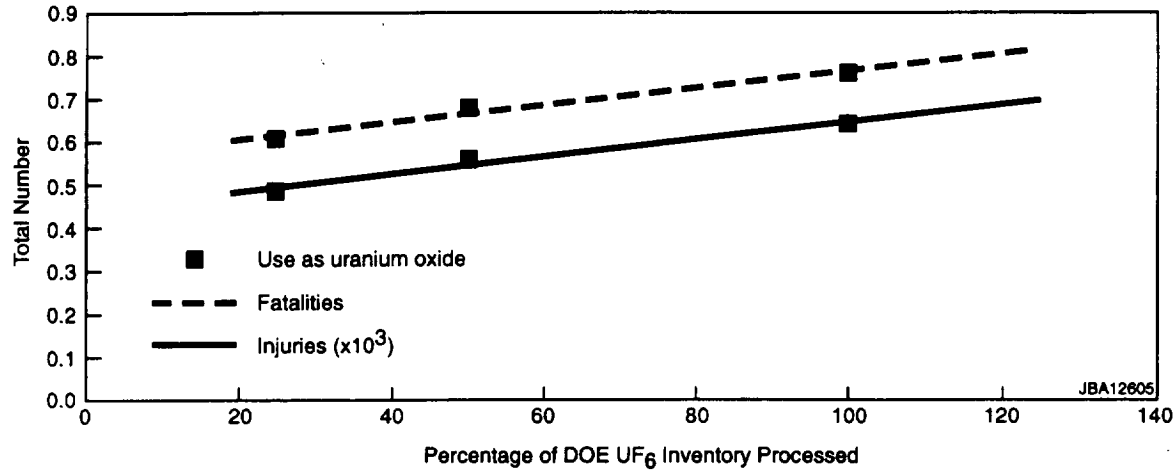

FIGURE K.49 Estimated Number of On-the-Job Fatalities and Injuries (for entire construction and operational periods) from the Manufacture of Uranium Oxide Shielded Casks

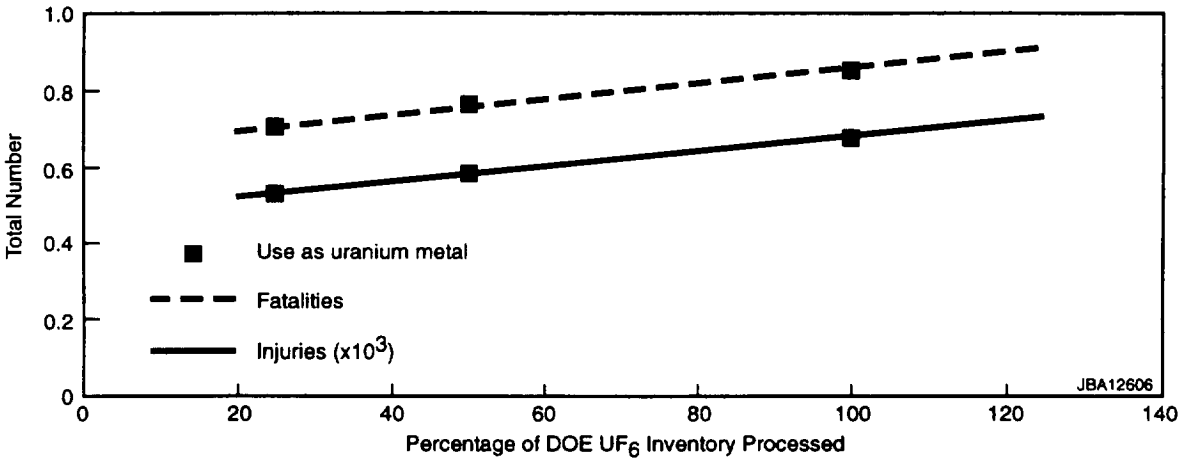

FIGURE K.50 Estimated Number of On-the-Job Fatalities and Injuries (for entire construction and operational periods) from the Manufacture of Uranium Metal Shielded Casks

The air quality impacts calculated for the 25% and 50% parametric cases, based on the information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases, and impacts during operations would also be less. The 25% case impacts would not be much smaller than the 50% case impacts, and the operations impacts in all cases would be less than 10% of the corresponding construction impacts.

K.4.4 Water and Soil

K.4.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts estimated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in the depth to groundwater, the direction of groundwater flow, recharge, and quality. The impacts to groundwater from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts calculated for the 25% and 50%

parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.5 Socioeconomics

The socioeconomic impacts of UO_2 and metal manufacturing facilities for the 25% and 50% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller UO_2 and metal manufacturing facilities would create less direct employment and income at the site.

K.4.6 Ecology

For both uranium oxide and uranium metal shielded cask manufacturing facilities, impacts to air quality, surface water, groundwater, and soil during construction and operations would be expected to be well below levels harmful to biota for the 25%, 50%, and 100% cases. Resulting contaminant-derived impacts to ecological resources would be expected to be negligible. Potential impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Site preparation for the construction of cask manufacturing facilities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas (see Section K.4.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence. Depending on the exact location of the uranium oxide or uranium metal cask manufacturing facility, the loss of 27 to 90 acres (11 to 36 ha) of undeveloped land and habitat might constitute a moderate impact to vegetation and wildlife. However, when the uranium oxide and uranium metal cask manufacturing facilities were sited, all appropriate measures would be taken to preclude or minimize such impacts to ecological resources.

K.4.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.7. The impacts on regional and national waste management operations from construction and operation of manufacturing facilities were found to be negligible for the 100% throughput case.

On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal waste management impacts would result from wastes generated during either construction or operations. Overall, the waste input resulting from normal operations at the manufacturing facilities would have negligible impact on waste management capacities locally or across the DOE complex. No assumptions were made regarding the fate of the oxide- and metal-shielded casks after use.

K.4.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.8. The impacts on resources would be expected to be small for the 100% capacity case. Resource requirements for the two parametric cases considered would be less than those for the 100% case (LLNL 1997a).

Construction and operation of the cask manufacturing facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation of the facilities. Although high-grade graphite would be required for the metal shielded cask (as a lining for the crucibles containing molten uranium), the amounts required would not be significant. The manufacturing facility requirements would not be resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

K.4.9 Land Use

Impacts to land use from the construction and operation of a uranium oxide shielded cask manufacturing facility, regardless of throughput capacity case, would be potentially moderate but limited to temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a uranium oxide shielded cask manufacturing facility for 25%, 50%, and 100% of the depleted UF_6 inventory would require approximately 79, 84, and 90 acres (32, 34, and 36 ha), respectively. Within this area, the facility would require the permanent replacement of approximately 27, 28, and 31 acres (11, 11, and 13 ha) with structures and paved areas. Off-site impacts could occur from peak-year construction force vehicles, especially if the site had limited access from existing roadways.

Impacts to land use from the uranium metal shielded cask manufacturing facility would be the same as those discussed for the construction and operation of a uranium oxide shielded cask

manufacturing facility, with no difference in the magnitude of impacts when the three throughput capacity cases are compared. For off-site impacts, traffic patterns could experience potentially adverse level-of-service impacts during the 7-year construction period from the peak-year construction labor force.

K.4.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the manufacture and use options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of manufacturing facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.5 DISPOSAL OPTIONS

The parametric analysis of the disposal options considered the environmental impacts of disposing of 25% and 50% of the depleted UF_6 inventory as an oxide form. It was assumed that the uranium material would be actively placed into disposal units over a 20-year period (from 2009 through 2028). The assessment considered the environmental impacts that would occur during (1) construction of a disposal facility, (2) routine disposal facility operations, (3) potential disposal facility accidents, and (4) the post-closure phase, defined as 1,000 years in the future after the disposal facility had failed. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases discussed in Appendix I. The supporting engineering data for the 25% and 50% parametric cases are provided in the engineering analysis report (LLNL 1997a).

The environmental impacts for the 100% disposal case are presented in Appendix I for (1) disposal of grouted and ungrouted U_3O_8 in shallow earthen structures, vaults, and a mine; and (2) disposal of grouted and ungrouted UO_2 in shallow earthen structures, vaults, and a mine. Two representative locations, described in Chapter 3 of the PEIS, were considered for each option: a "dry" location and a "wet" location. For purposes of the parametric analysis, disposal of ungrouted U_3O_8 in a mine at both wet and dry locations was considered in detail. This option was chosen to simplify

the parametric analysis because all options were evaluated in detail for the 100% base case. Impacts for the other disposal options, such as disposal of UO_2 and disposal in shallow earthen structures and vaults, were inferred from the relationships among the options identified from the 100% case analysis and from the additional relationships identified by the detailed parametric analysis conducted for the disposal of grouted U_3O_8 in a mine.

K.5.1 Human Health — Normal Operations

K.5.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from the normal operation of a full-scale (100%) disposal facility are described in Appendix I, Section I.3.1.1. Similar impacts were calculated for the 50% and 25% disposal facilities for the parametric analysis. Radiological impacts were calculated for the operational phase, during which time material would be disposed of, and for the post-closure phase, assumed to be 1,000 years in the future after the disposal facility had failed.

K.5.1.1.1 Operational Phase

The radiological impacts estimated for the 100%, 50%, and 25% cases during the operational phase are shown in Figures K.51 through K.66 for all disposal options. The impacts have been presented for the disposal of both grouted and ungrouted U_3O_8 and UO_2 as a function of the amount of material requiring disposal. The disposal of ungrouted U_3O_8 or UO_2 would not result in any airborne or waterborne emissions during operations because the material would be delivered to the disposal facility in packages that would be disposed of without being opened. Therefore, for the disposal of ungrouted waste, no impacts would be expected to the noninvolved workers and the off-site general public. The range of impacts resulting from technology and site differences are presented by dashed lines in the figures. The results for the disposal of ungrouted U_3O_8 in a mine, the case selected for detailed analysis, are shown in Figures K.63 and K.64 as solid points, with a curve drawn between the points to indicate how the impacts would vary as a function of the percent of material requiring disposal. The area enclosed by the dashed lines in Figures K.51 through K.66 indicates the range of impacts expected for throughputs between 25% and 100%, taking into account both technology and site differences.

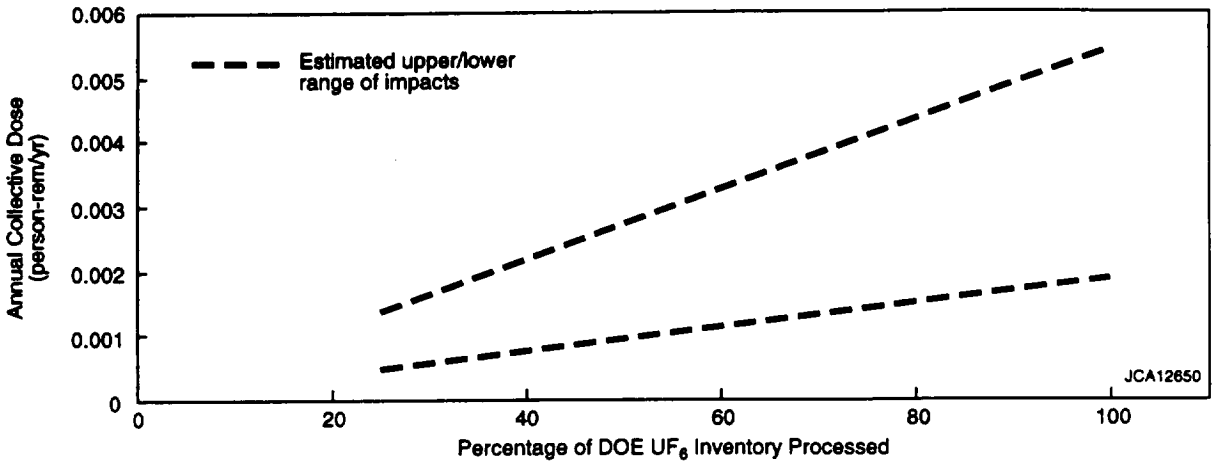

FIGURE K.51 Estimated Annual Collective Dose to Members of the Public from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

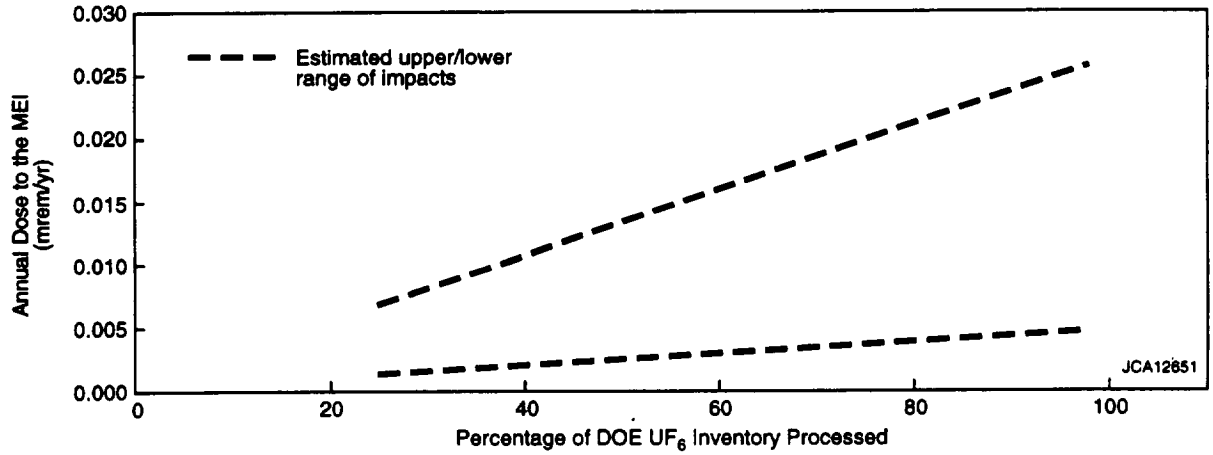

FIGURE K.52 Estimated Annual Dose to the General Public MEI from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

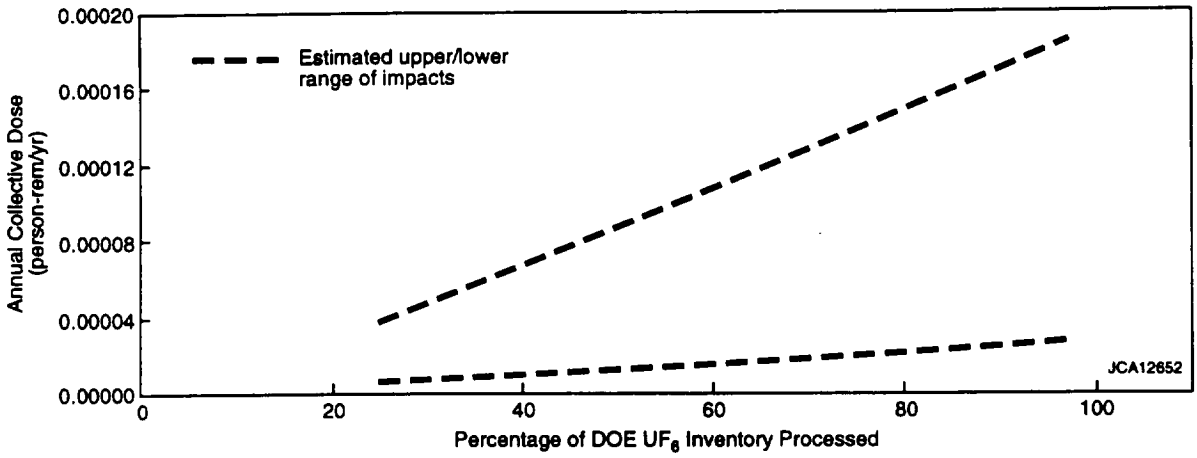

FIGURE K.53 Estimated Annual Collective Dose to Noninvolved Workers from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

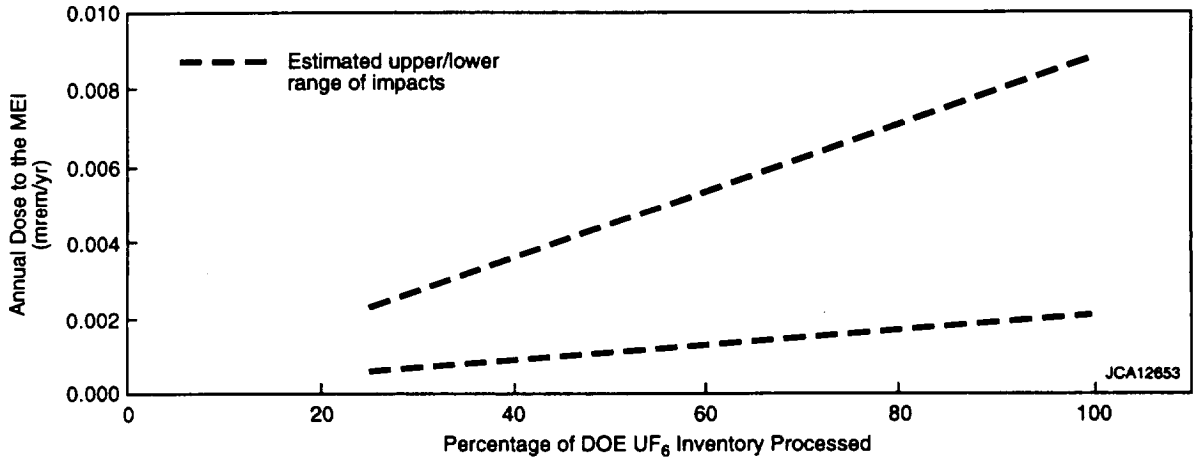

FIGURE K.54 Estimated Annual Dose to the Noninvolved Worker MEI from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

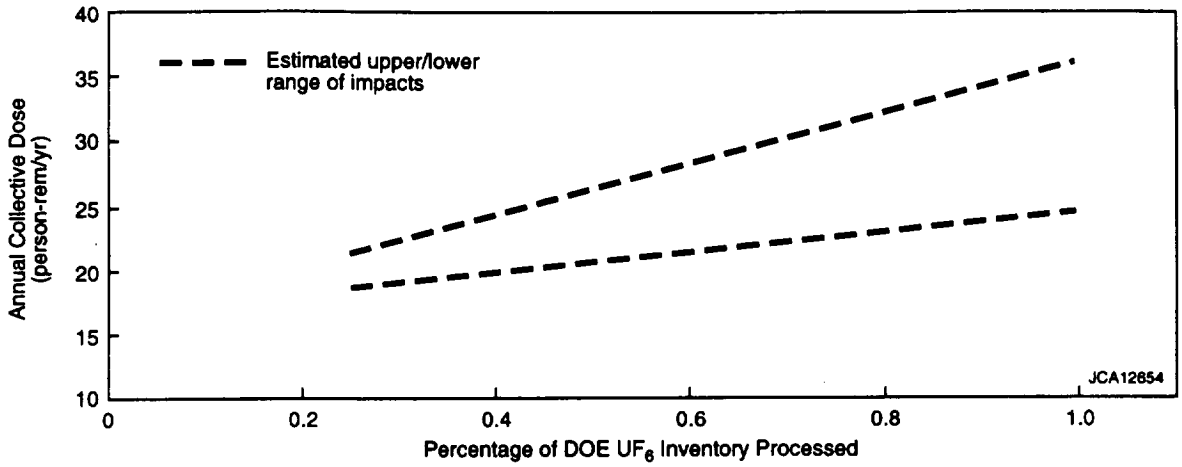

FIGURE K.55 Estimated Annual Collective Dose to Involved Workers from the Disposal of Grouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

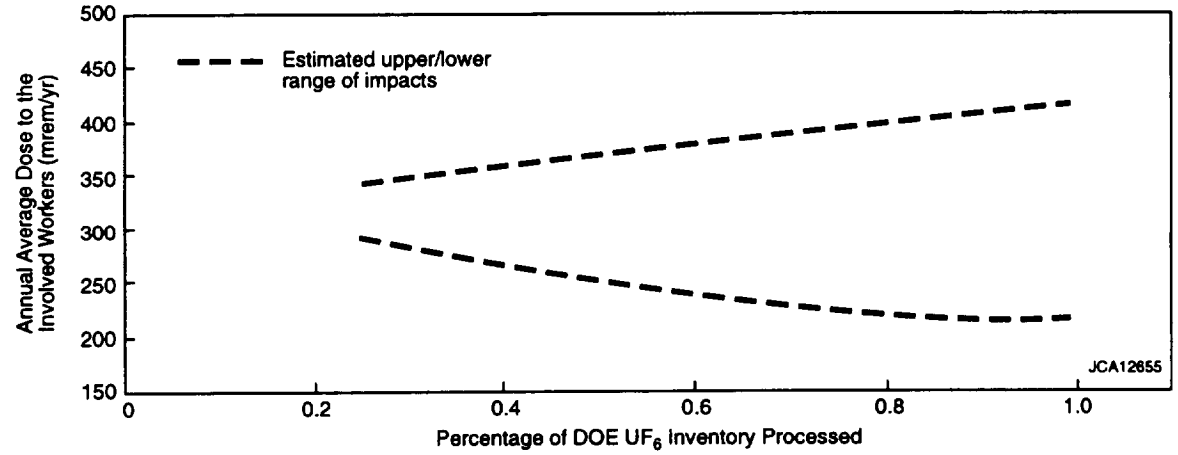

FIGURE K.56 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Grouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

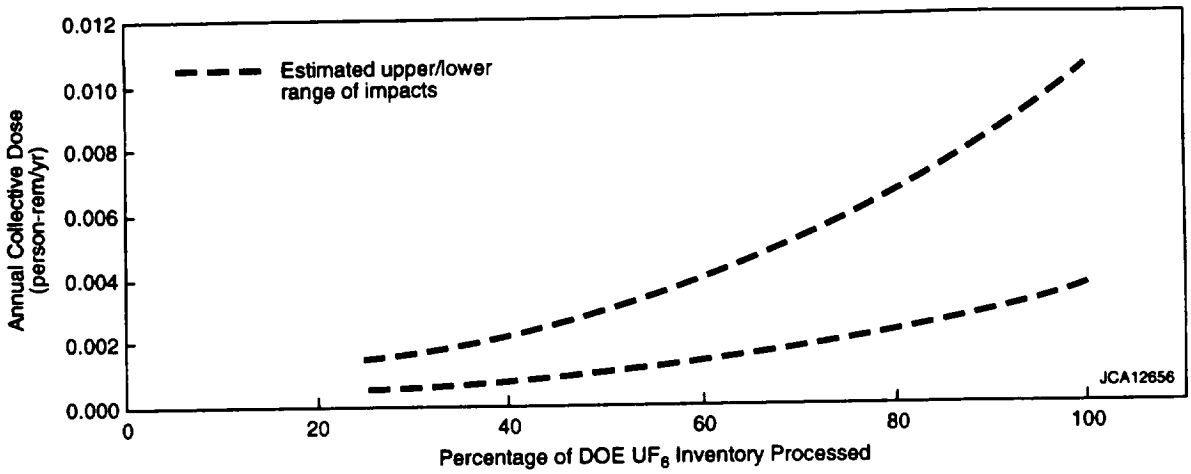

FIGURE K.57 Estimated Annual Collective Dose to Members of the Public from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

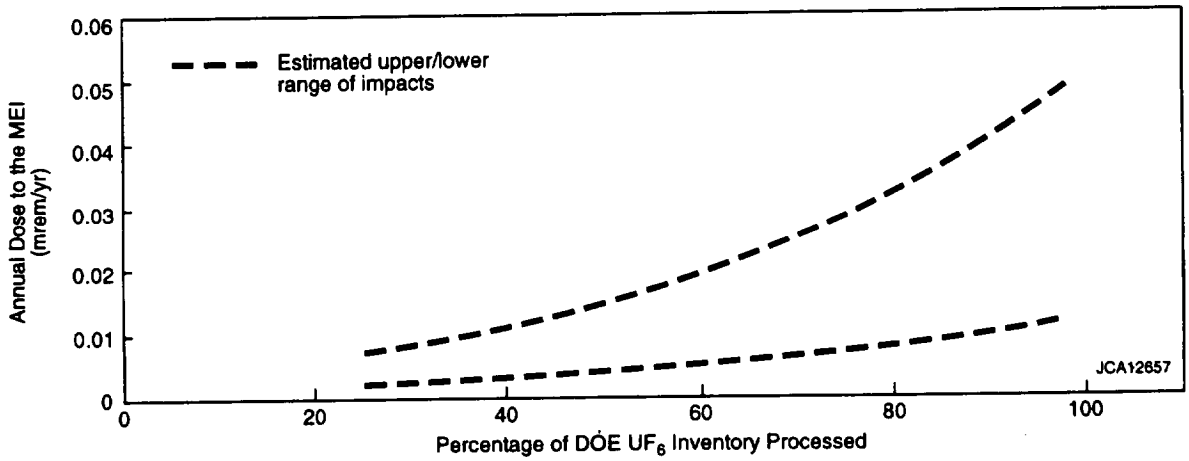

FIGURE K.58 Estimated Annual Dose to the General Public MEI from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

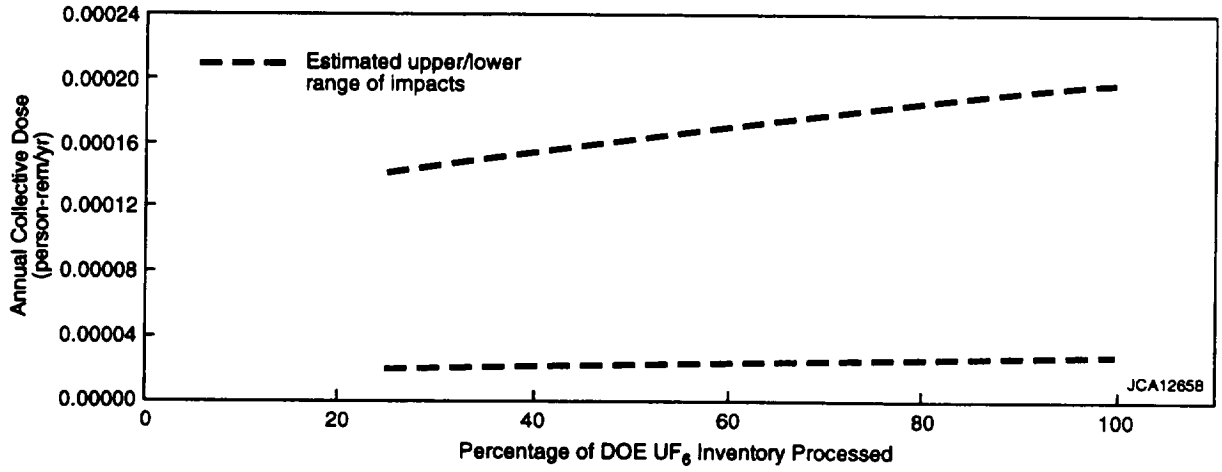

FIGURE K.59 Estimated Annual Collective Dose to Noninvolved Workers from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

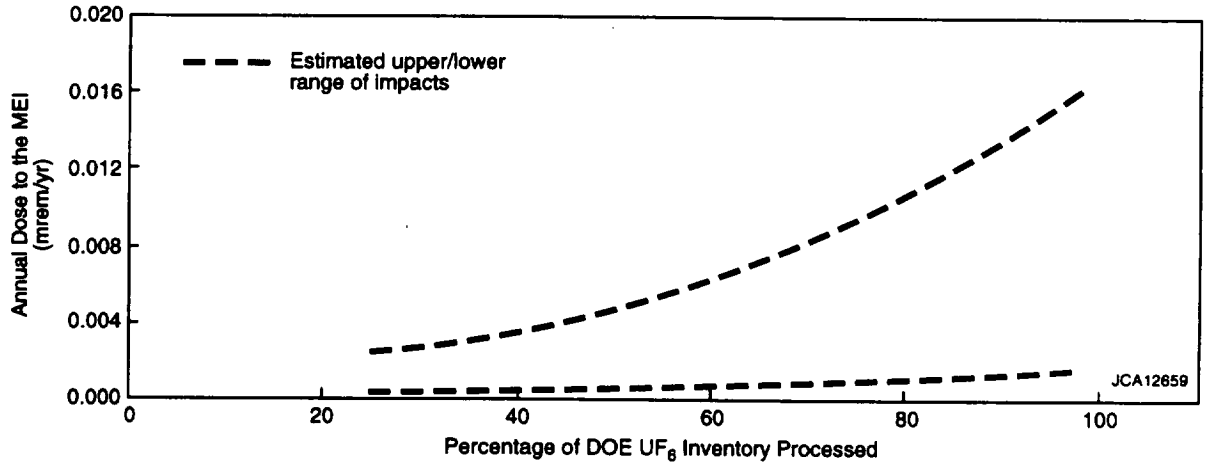

FIGURE K.60 Estimated Annual Dose to the Noninvolved Worker MEI from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

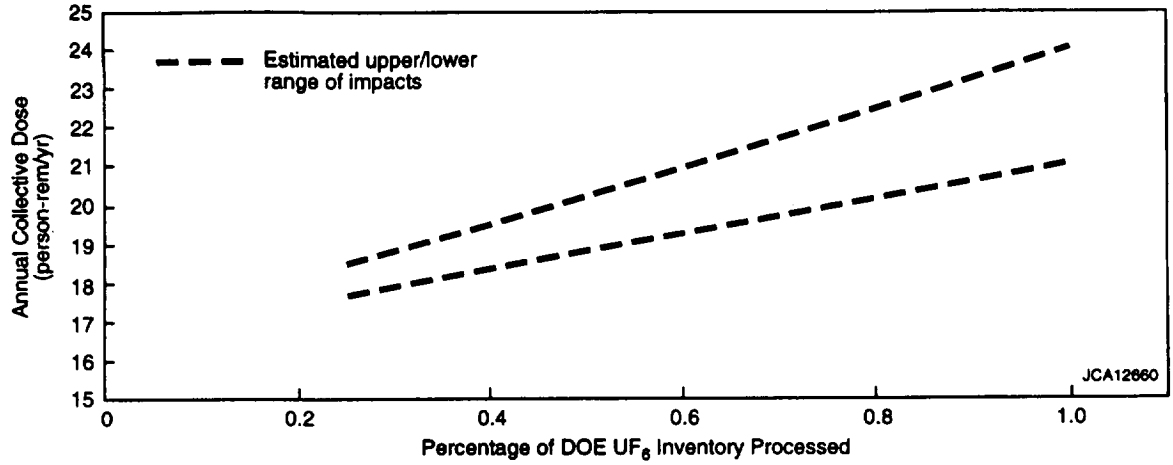

FIGURE K.61 Estimated Annual Collective Dose to Involved Workers from the Disposal of Grouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

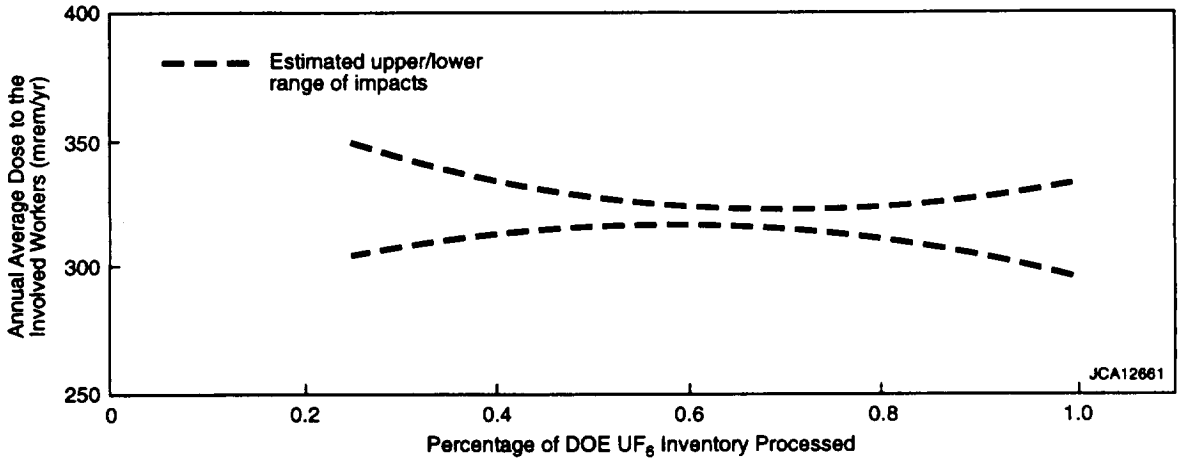

FIGURE K.62 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Grouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

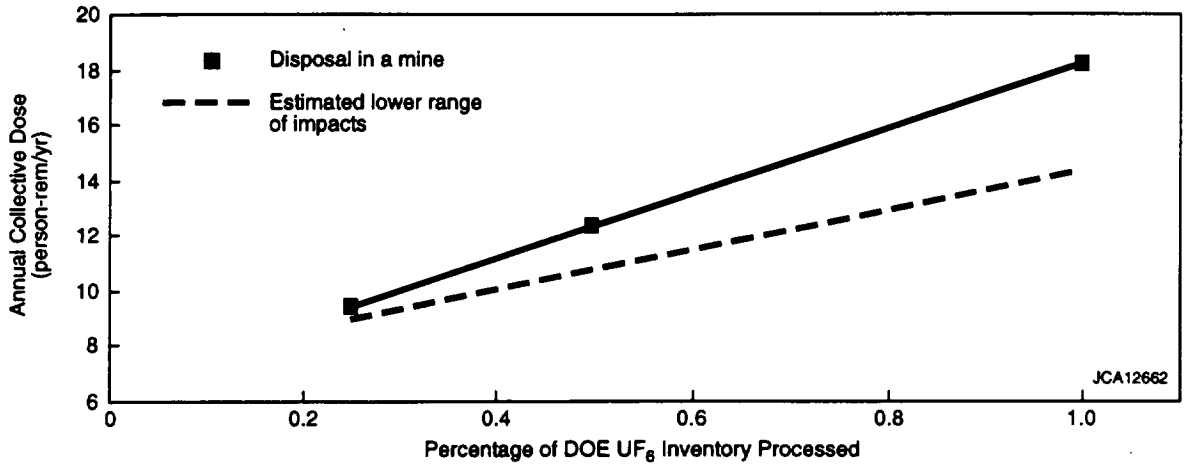

FIGURE K.63 Estimated Annual Collective Dose to Involved Workers from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

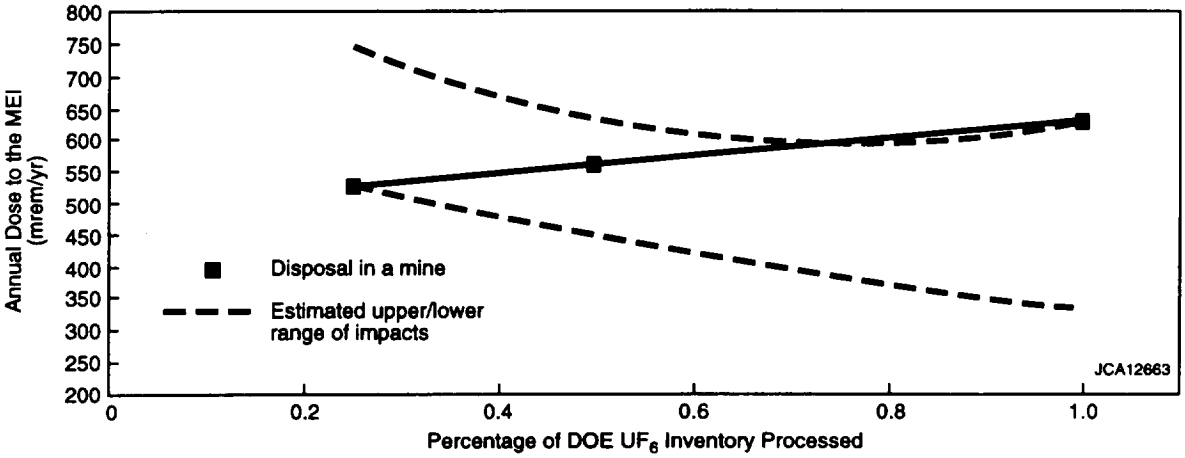

FIGURE K.64 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

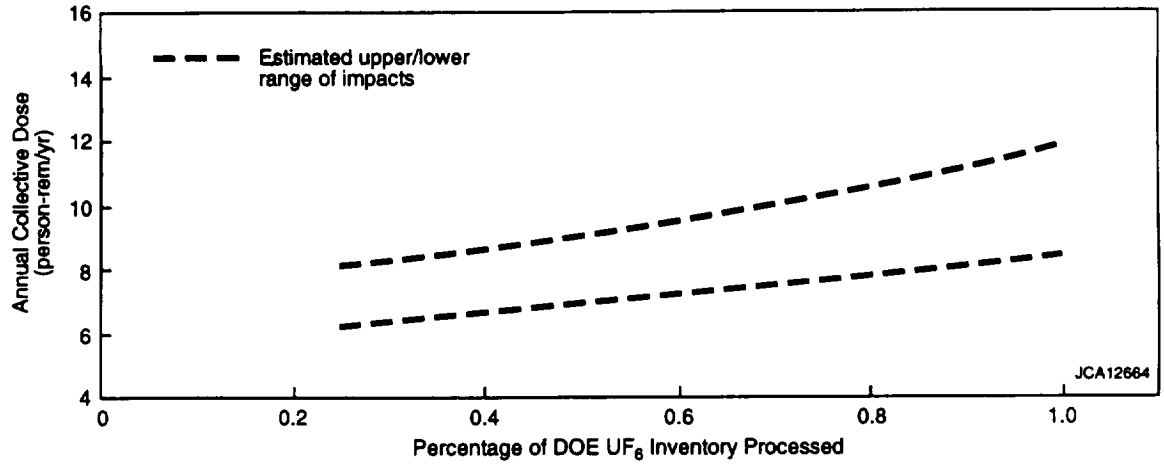

FIGURE K.65 Estimated Annual Collective Dose to Involved Workers from the Disposal of Ungrouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

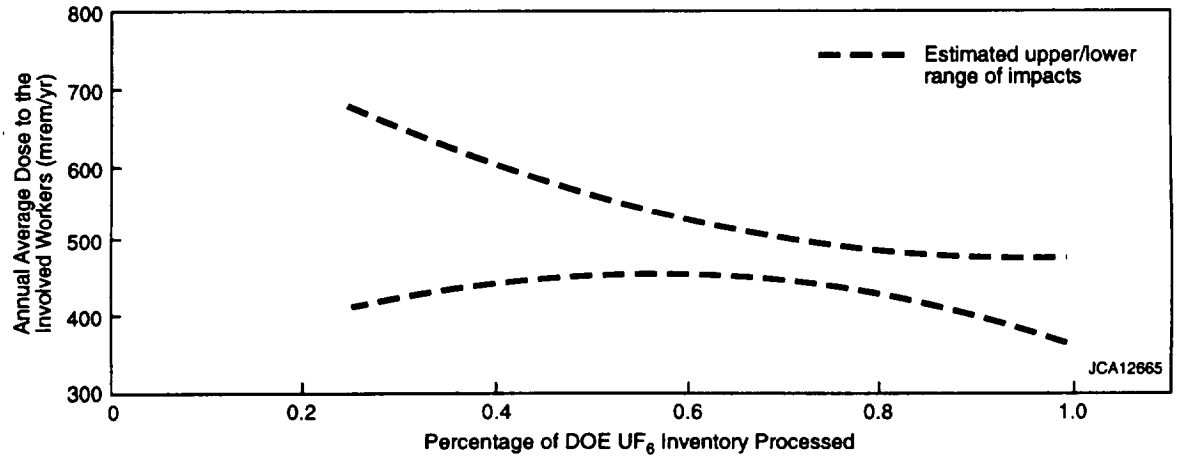

FIGURE K.66 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Ungrouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

In general, the results of the parametric analysis (as shown in Figures K.51 through K.66) indicate that the collective radiological impacts during the operational phase would decrease with the total quantity of depleted uranium disposed of. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). Overall, radiation doses would be larger for the disposal of grouted waste compared with ungrouted waste because of the additional activities required and the small emissions resulting from the grouting process. In some cases, the average individual worker dose might increase or decrease as the throughput increased, primarily because the number of workers required would not increase at the same rate as the collective dose. The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the general public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix I.

K.5.1.1.2 Post-Closure Phase

At some time in the future after the closure of the disposal facility, potential impacts could occur to the public through the use of contaminated groundwater and from external radiation if the cover materials eroded away. In general, the complete erosion of the cover material, especially for a vault or mine, would not occur until thousands of years after the facility had been closed. Therefore, external radiation exposures would not be expected within the time frame considered (i.e., 1,000 years). Even if complete erosion occurred, the radiation exposure could be reduced by adding new cover material. Groundwater contamination would not be expected to occur until hundreds to thousands of years after the disposal facility had been closed. The estimated groundwater concentrations and associated uncertainty are discussed in Appendix I. For assessment purposes, the MEI was assumed to live at the edge of the disposal site and to use groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. The potential radiation doses from using contaminated groundwater were based on groundwater concentrations calculated in the groundwater analysis that is discussed in detail in Section K.5.4.2.

The results of the groundwater analysis for a representative dry location indicate that measurable groundwater contamination would not occur until over 10,000 years after failure of the disposal facility. Therefore, no radiation exposures of the public would be expected for thousands of years following disposal in a dry environment.

Potential radiation exposures of the general public would be much greater if the disposal site was located in a wet environment. The results of the analysis indicate that the radiation dose to an individual using contaminated groundwater could reach about 80 mrem/yr for the 25% case, 96 mrem/yr for the 50% case, and 110 mrem/yr for the 100% case (considering both grouted and ungrouted wastes and different disposal technologies); these impacts could occur 1,000 years after failure of the containers and engineering barriers if the soil properties were such that uranium was transported rapidly toward the groundwater (mobile situation). If the depleted uranium was classified

as LLW, the radiation doses from using contaminated groundwater would exceed the dose limit of 25 mrem/yr specified in the *Code of Federal Regulations* (10 CFR Part 61) and DOE Order 5820.2a. However, radiation doses from contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

K.5.1.2 Chemical Impacts

K.5.1.2.1 Operational Phase

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) disposal facilities are described in Appendix I, Section I.3.1.2. The results of the 100% case analyses for the operational phase indicated that noninvolved workers and members of the general public would receive essentially no exposures to chemicals for the disposal of ungrouted uranium material and very low exposures from disposal of grouted uranium material for all disposal facilities. No adverse health impacts would be expected for any of the disposal facilities considered. For the 100% cases, the calculated hazard indices were much less than 1 for all disposal options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the 100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for all disposal options.

K.5.1.2.2 Post-Closure Phase

As for radiological impacts, potential chemical impacts could occur to the general public at sometime in the future through use of contaminated groundwater. The potential chemical impacts to an MEI resulting from use of contaminated groundwater were determined on the basis of the same assumptions discussed in Section K.5.1.1 for radiological exposures. Chemical exposures were calculated for a time 1,000 years after the disposal facility was assumed to fail. The potential chemical impacts from using contaminated groundwater were based on the groundwater concentrations calculated in the groundwater analysis (see Section K.5.4.2).

Because of the low precipitation rate in a dry location, it would take more than 10,000 years for the uranium compounds to reach the groundwater after the first contact with infiltration water. Therefore, no chemical exposures would occur to an individual living next to the disposal site in a dry environment within 10,000 years.

Chemical exposures to the MEI could potentially be much greater if the disposal site was located in a wet environment. The concentrations of uranium in groundwater at 1,000 years after failure of the disposal facility would be such that potential adverse health impacts from chemical

exposures could result to an individual using contaminated groundwater for all cases. Risks from chemical exposures were quantified on the basis of calculated hazard indices. Assuming that the soil properties were such that uranium compounds could be transported rapidly toward the groundwater following failure of the containers and engineering barriers (at 1,000 years), the maximum hazard indices were estimated to be greater than 1, indicating a potential for adverse health effects. The hazard indices were calculated to be 8 for the 25% case, 10 for the 50% case, and 11 for the 100% case. However, chemical exposures from contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

K.5.2 Human Health — Accident Conditions

K.5.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during operation of full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% disposal cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Appendix I. The impacts would be identical because the bounding accidents producing the greatest consequences within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at-risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents related to handling operations (i.e., the "mishandle/drop of drum" accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the disposal options would be the same for all parametric cases.

K.5.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during full-scale (100%) operation of disposal as grouted or ungrouted UO_2 or U_3O_8 in shallow earthen structures, vaults, or a mine are presented in Appendix I, Section I.3.2.2. The analysis of 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the

same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The bounding chemical accidents associated with the 25% and 50% throughput cases that would produce the greatest consequences would be the same as those presented for the 100% case. The impacts would be similar because the accidents within most frequency categories would be the same for the 100%, 50%, and 25% cases, and in those cases where these accidents were different, no adverse chemical impacts were estimated to occur. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, some of the impacts for other accidents (nonbounding) considered for the 25% and 50% cases would be different from those for the 100% cases. In general, the impacts of the nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

K.5.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.2.3. For the 100% analysis, no on-the-job fatalities were estimated during construction and operation of a mine disposal facility (for ungrouted U_3O_8). The predicted number of on-the-job worker injuries for the 100% case is about 240. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

The predicted number of on-the-job worker fatalities over the duration of disposal operations is less than 1, ranging from 0.4 for the 25% case to 0.53 for the 100% case (including construction and operations). The predicted number of on-the-job injuries (including construction and operations) ranges from 160 to 240. The number of injuries is shown as a function of throughput in Figure K.67.

K.5.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.3. All of the pollutant concentrations produced by the 100% capacity version of the disposal facilities would be below their respective air quality standards. The annual average concentrations of NO_x might be as high as one-third of the air quality standards during operation of vault disposal facilities for grouted U_3O_8 in a wet environmental setting. During operations, all pollutant concentrations would be much less than the corresponding standards.

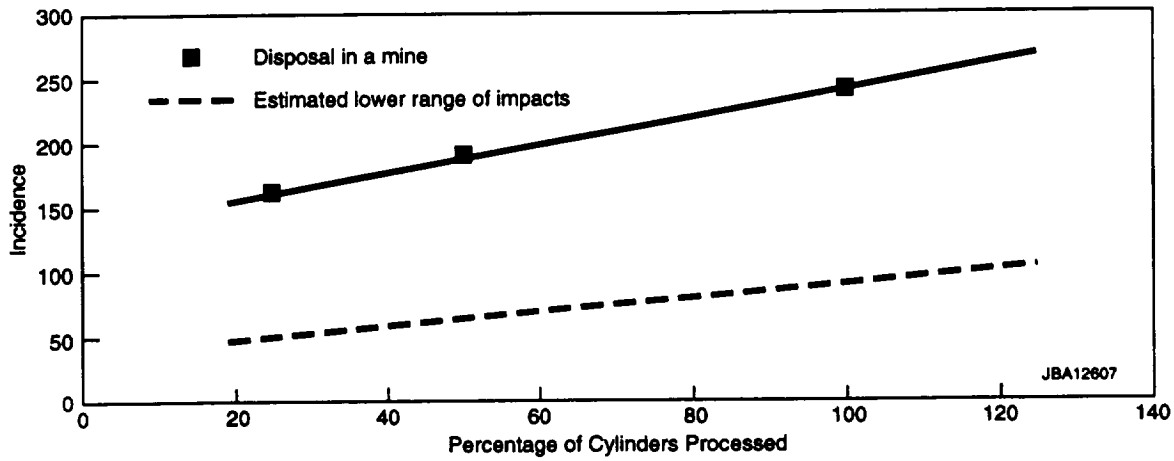

FIGURE K.67 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, or mine.)

The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case. During construction, short-term impacts for the parametric cases would be less than those for the 100% case, and impacts during operations would also be less. Annual pollutant concentrations from construction of 50% and 25% capacity disposal facilities would be about 0.7 and 0.5 times as large as the full-capacity facility, respectively. For all the other disposal options, criteria pollutant levels would be lower percentages of their respective standards during both construction and operations.

K.5.4 Water and Soil

K.5.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) disposal facilities are discussed in Appendix I, Section I.3.4. The actual impacts to surface water would depend on the ultimate site selected for disposal. However, for the generic sites considered in the PEIS, the impacts to surface water from the 100% case were found to be negligible for all disposal options for both the operational and post-closure phases. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case, and thus would also be negligible.

K.5.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.4. The actual impacts to groundwater would depend on the ultimate site selected for disposal. However, during the operational phase, which would include construction and disposal activities, negligible impacts to groundwater would be expected. As described in Appendix I, the impacts to groundwater from the 100% case were expected to be negligible for the operational phase of all disposal options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case, and thus would also be negligible.

Impacts to groundwater during the post-closure phase are discussed in Section I.4.2. Groundwater impacts during the post-closure phase would be limited to changes in quality caused by contamination migrating from the disposal facility hundreds to thousands of years in the future after failure of the engineered barriers. There would be no impacts to effective recharge, depth to groundwater, or flow direction once the facility was constructed.

Disposal facility failure would generally occur hundreds to thousands of years in the future (assuming no sustained effort to maintain the facility). This failure would be caused by natural degradation of the disposal structures over time, primarily from physical processes such as the intrusion of water. Following failure, the release of uranium from the facility would occur very slowly as water moved through the disposed material. The amount of groundwater contamination, as well as the length of time it would take for the groundwater to become contaminated, would depend on the integrity of the drums and the engineering barriers, as well as the site-specific properties of the soil surrounding the disposal facility. Without more precise information concerning the expected lifetimes of the containers and engineering barriers in the specific disposal facility environment, as well as site-specific soil and hydrological properties, the groundwater concentrations estimated for the analysis presented in this appendix using generic assumptions are subject to a large degree of uncertainty. Nevertheless, if no remedial actions were taken, once the release of uranium from the disposal facility began, it could last for millions of years for all three cases (25%, 50%, and 100%).

If the disposal site were located in a dry environment, all of the resulting uranium concentrations in groundwater would be essentially zero for at least 1,000 years in the future (Tomasko 1997) for disposal of 25%, 50%, and 100% of the uranium material. In a wet climate, however, the uranium concentrations in the groundwater beneath a mined facility for ungrouted U_3O_8 would range from about 260 pCi/L (1,000 µg/L) for the 25% capacity case to 350 pCi/L (1,400 µg/L) for 100% capacity if the soil properties were such that the uranium moved rapidly through the soil (a retardation factor of 5). These uranium concentrations would exceed the U.S. Environmental Protection Agency (EPA) proposed maximum contaminant level of 20 µg/L (EPA 1996) used as a guideline in this PEIS. If the uranium were less mobile in the soil surrounding the disposal facility (retardation coefficient of 50), uranium concentrations in the groundwater beneath the facility after

1,000 years for disposal of 25%, 50%, and 100% would be less than 20 µg/L. However, the concentrations would increase with time, ultimately approaching the concentrations that would occur under the mobile situation and exceeding 20 µg/L.

Post-closure impacts to groundwater quality resulting from disposal in an underground mine could be reduced by decreasing the size of the facility in a direction parallel to the direction of groundwater flow, thereby increasing dilution (Tomasko 1997).

K.5.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.4. The potential impacts evaluated included changes in topography (land elevation), permeability (ability to let water enter the ground), quality, and erosion potential for a dry and wet location. Although impacts were evaluated for dry and wet conditions, the impacts would be essentially the same for both locations.

As discussed in Appendix I, the impacts to soil from the 100% cases were found to have potentially moderate to large, but temporary, impacts for the disposal options. These impacts would result from material excavated during disposal facility construction that would be left on-site. For example, construction of a mine for ungrouted U_3O_8 disposal would require excavating about 1.2 million yd^3 (920,000 m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions to their former state, and the impacts would be minor. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were also found to have potentially large, but temporary, impacts on soil, similar to the 100% cases. In the long term, impacts on soil would be minor for all disposal options.

K.5.5 Socioeconomics

The socioeconomic impacts of ungrouted U_3O_8 mine disposal facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller U_3O_8 mine disposal facilities would create less direct employment and income at the site.

K.5.6 Ecology

Site preparation for the construction of a facility for the disposal of ungrouted U_3O_8 in a mine would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas. Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

This disposal option would result in elevation of the soil surface by approximately 2.8 to 4.1 ft (0.85 to 1.2 m) and a reduction in soil permeability. The excavated material would primarily consist of rock removed from the drifts and ramps. The consequent decrease in surface soil moisture would make reestablishment of vegetation difficult and delay the establishment of native plant communities. Construction of a disposal facility for ungrouted U_3O_8 in a mine would result in a large adverse impact to existing vegetation and wildlife.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to air, surface water, groundwater, and soil quality during construction are expected to be negligible for the 25%, 50%, and 100% cases (Sections K.5.3 and K.5.4). Resulting construction-derived impacts to ecological resources would also be expected to be negligible. Impacts to ecological resources from air and water emissions would also be negligible during the operational phase of the disposal options.

During the post-closure phase, failure of facility integrity could result in contamination of groundwater (see Section K.5.4.2). Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium calculated for 1,000 years after failure of a mined facility for ungrouted U_3O_8 would range from about 260 to 350 pCi/L for the 25% and 100% cases, respectively. Similarly, groundwater concentrations for a mined facility for grouted U_3O_8 would range from about 310 to 425 pCi/L for the 25% and 100% cases, respectively. Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range. Resulting dose rates to maximally exposed organisms would be less than 2% of the dose limit of 1 rad/d, for aquatic organisms, as specified in DOE Order 5400.5.

K.5.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.7. The impacts on national waste management operations from construction of disposal facilities were found to be negligible for the 100% throughput case. The impacts that would result from construction for the 25% and 50% parametric cases, based on information provided in the

engineering analysis report (LLNL 1997a), would be less than those for the 100% case, and thus would also be negligible.

Operation of a disposal facility would generate radioactive, hazardous, and nonhazardous wastes (Section I.3.7). All of the secondary wastes listed would have a negligible impact on waste management capacities across the DOE complex. However, the product waste would represent a significant volume when compared with the complexwide total of LLW for disposal. Disposal of 100% of the depleted uranium inventory could represent from 1.1 to 7.3% of the total DOE LLW generated over roughly the same time period. Overall, the waste input resulting from the normal operation of the U_3O_8 disposal facility would have a negligible to low impact on DOE's complexwide waste management activities.

The parametric analysis of operational waste loads was conducted for throughput values of 25%, 50%, and 100% (Table K.5). Some of these analyses showed nonlinear effects, but the estimated impacts would be very small. The volume of product waste was shown to be linear with throughput. Thus, it was assumed that a linear interpolation could be used to estimate waste loads for throughput values other than 25%, 50%, and 100%.

K.5.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.8. The impacts on resources, except for electrical consumption for a mine disposal facility, would be expected to

TABLE K.5 Wastes Generated during Facility Operations from the Disposal of Ungrouted U_3O_8

	Annual Waste Generated for Three Throughput Cases		
Waste Type	100%	50%	25%
Waste (m^3/yr)			
Solid LLW	81	57	40
Mixed liquid LLW	0.31	0.22	0.15
Nonhazardous waste (million L/yr)			
Solids	0.64	0.45	0.32
Wastewater	0.92	0.68	0.48
Product waste volume (m^3/yr)			
Ungrouted U_3O_8	7,440	3,720	1,860

be small for the 100% capacity case. Resource requirements for the 25% and 50% parametric cases considered would be less than those for the 100% case (LLNL 1997a).

Construction and operation of the disposal facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. However, for a mine disposal facility, significant quantities of electrical energy would be required during construction (up to 1,100 MW-yr, orders of magnitude greater than that required for other disposal facility types) because the majority of the construction equipment used in the underground portion would be powered by electricity to avoid polluting the air in the underground work area. Similarly, compared with the other options, a relatively higher annual amount of electricity would be needed during underground operations. No strategic and critical materials would be expected to be consumed during construction or operation of the facilities. The disposal facility operations requirements would generally not be resource-intensive, and the resources required are not considered rare or unique. Furthermore, committing any of these resources (except for electrical consumption) would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases. The magnitude of impact of the high electrical requirement for a mine disposal facility on local energy resource usage would be dependent on the extent of existing site infrastructure.

K.5.9 Land Use

Potential moderate to large impacts from the construction and operation of a mined disposal facility would be expected from on-site disposal of excavated material. Potential traffic volume impacts would be associated with the construction labor force. Site preparation for the construction of a facility for the disposal of ungrouted U_3O_8 in a mine for 25%, 50%, and 100% of the depleted UF_6 inventory would require the disturbance of approximately 97, 165, and 232 acres (39, 66, and 93 ha), respectively. On-site topographical modifications associated with disposition of the excavated material could potentially affect future on-site land use, although such impacts would be small. Land use impacts from shallow earthen structure and vault options would range from negligible to moderate.

Impacts to land use outside the boundaries of a disposal facility would consist of temporary traffic impacts associated with project construction. The actual impacts would depend on the specific site chosen.

K.5.10 Other Impacts Considered But Not Analyzed in Detail

There are other impacts that can potentially occur if the disposal options considered in this PEIS are implemented. They include impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts

associated with decontamination and decommissioning of surface disposal facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.6 TRANSPORTATION

The estimated environmental impacts were presented in Appendix J for transportation of materials associated with the 100% cases considered for the depleted uranium inventory options. Because the locations of the various facilities are not determined, impacts for three shipment distances (250, 1,000, and 5,000 km) were presented to give the reader a basis for understanding the ramifications of shipment distance on the impacts. In this appendix, all transportation impacts are presented for a single shipment distance of 1,000 km because the objective here is the comparison among the three cases of throughput (25%, 50%, and 100%) associated with the depleted uranium.

The transportation impacts are presented in the form of line graphs in terms of risk (estimated fatalities) as a function of the number of total shipments over the 20-year life of the project. Each graph pertains to a single type of shipment either by truck or rail mode. As in Appendix J, estimated fatality risks from radiological (routine and accident), chemical (accident), and vehicle (routine and accident) causes are presented in each graph. The 25%, 50%, and 100% throughput cases are denoted with vertical lines on each graph.

K.6.1 Conversion Options

The conversion of the depleted UF_6 to an oxide or a metal form might require shipment of the depleted uranium to an off-site facility. Impacts for the 100% case are presented in Appendix J, Section J.3.4. Figures K.68 and K.69 present the results for shipping the depleted uranium cylinders either by truck or rail, respectively, for the three parametric cases. The 100% case risks for cylinder shipment are presented in Tables J.5 and J.6 in Section J.3.4.1. The impacts from routine external radiation if overcontainers were to be used are also presented. The radiological and chemical risks from accidents are not presented because these risks would be at least 100 times less than the other estimated risks.

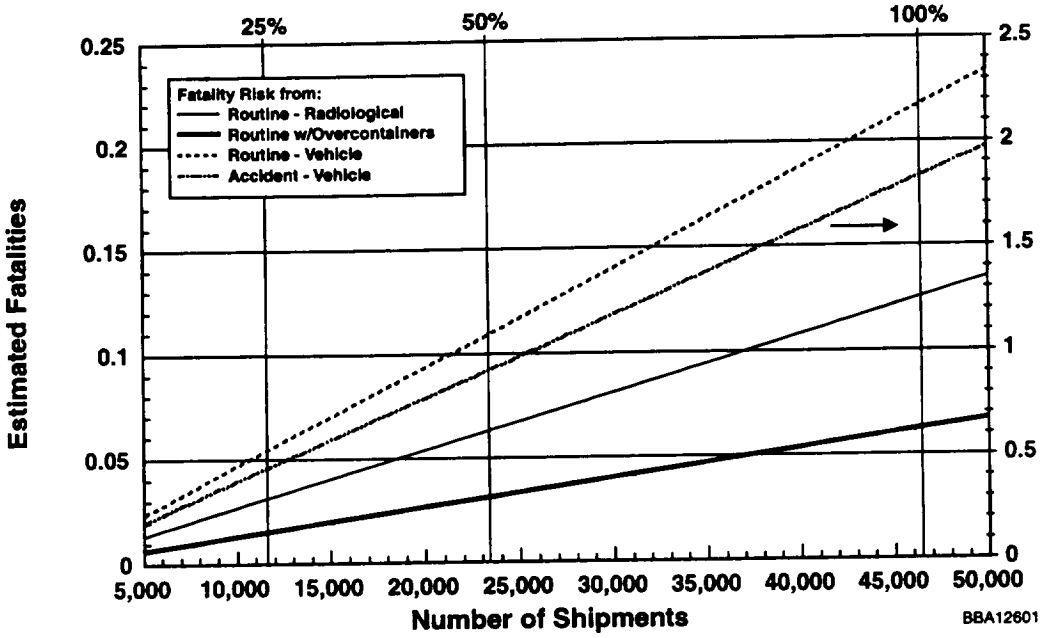

FIGURE K.68 Estimated Truck Transportation Risks for Depleted UF_6 Cylinders

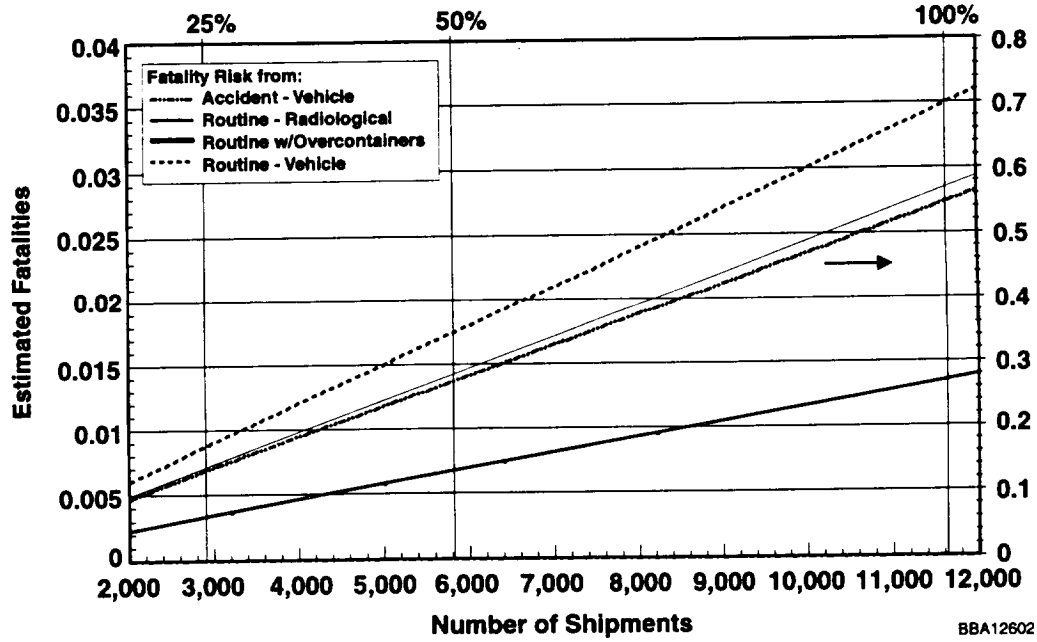

FIGURE K.69 Estimated Rail Transportation Risks for Depleted UF_6 Cylinders

Conversion of the depleted UF_6 to an oxide or uranium metal would involve transportation of input materials and output waste forms, as discussed in Appendix J, Section J.3.4. Ammonia might be used as an input material for oxide and metal conversion; Figure K.70 presents the chemical and vehicle risks from transportation of ammonia for shipment by rail for UO_2 or metal conversion. Anhydrous HF is a common product of the three conversion technologies studied for the parametric analysis. The two oxide technologies would produce about the same amount of HF for the same amount of depleted UF_6 input, an amount that is about three times the amount of HF produced in the conversion to metal. Figure K.71 presents the parametric risks for HF transport. The conversion-to-metal process would produce a large quantity of nonhazardous MgF_2 as another by-product. The vehicle-related parametric risks for transport of MgF_2 by truck and rail are shown in Figures K.72 and K.73, respectively.

Both LLW and low-level mixed waste (LLMW) would be produced at a conversion facility and would require transport for disposal, as discussed in Appendix J, Section J.3.4.2. The number of shipments required for LLMW disposal in all three options is not expected to change with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the conversion process. The estimated transportation risks for the LLW generated at the three different conversion facilities shipped to a disposal site are presented in Figures K.74 through K.76.

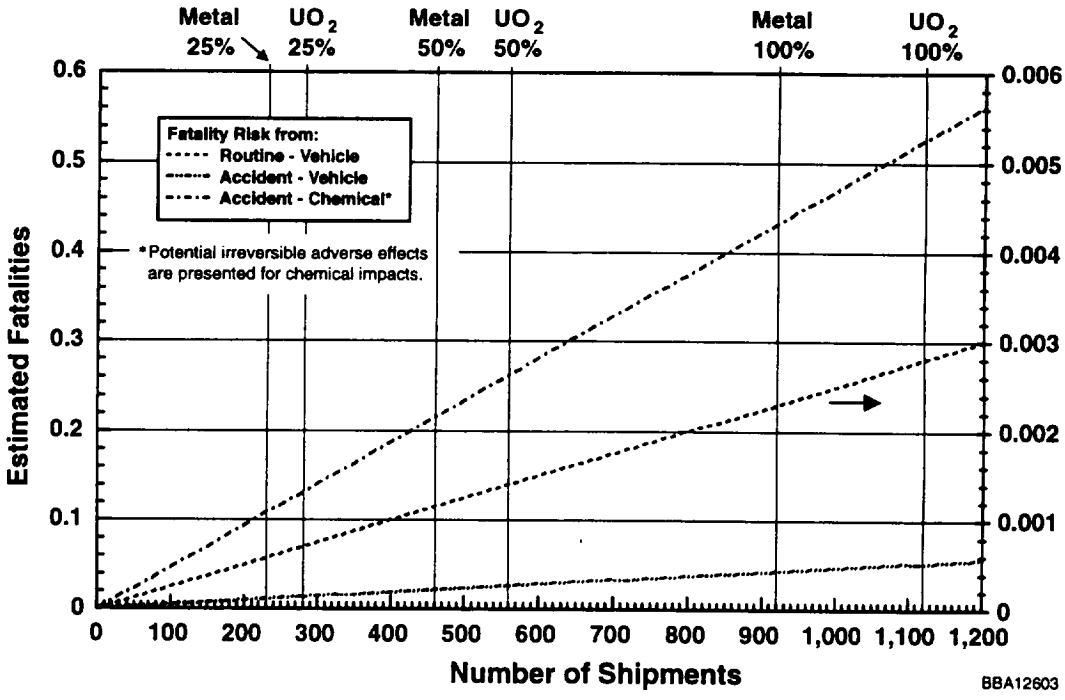

FIGURE K.70 Estimated Rail Transportation Risks for the Ammonia Used in the Conversion of Depleted UF_6 to UO_2 or Uranium Metal

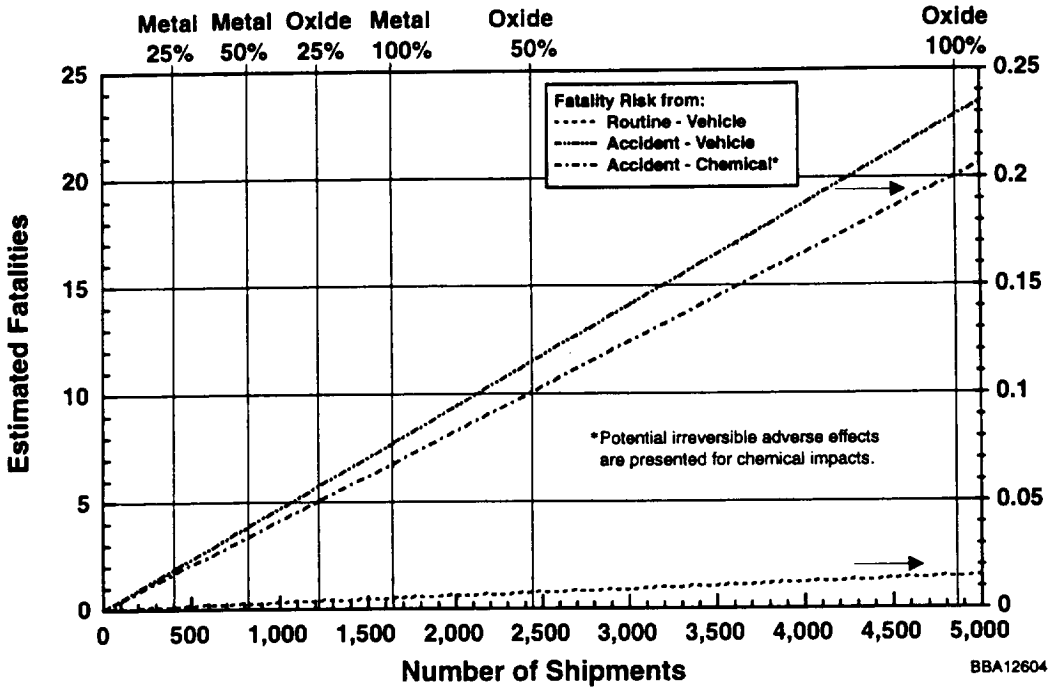

FIGURE K.71 Estimated Rail Transportation Risks for the HF Produced in the Conversion of Depleted UF_6 to U_3O_8, UO_2, or Uranium Metal

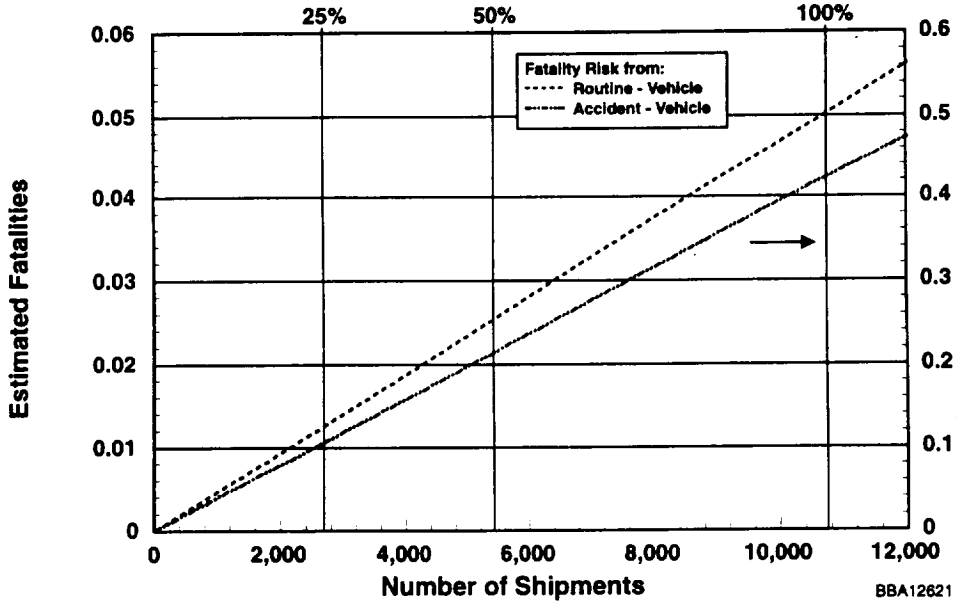

FIGURE K.72 Estimated Truck Transportation Fatality Risks for the MgF_2 Generated in the Conversion of Depleted UF_6 to Uranium Metal

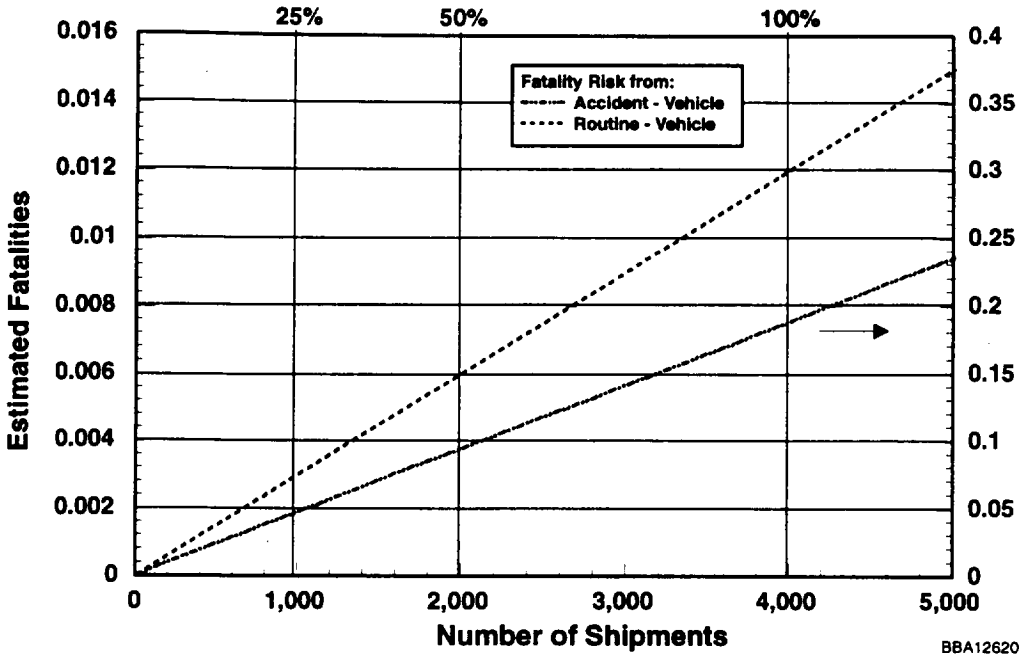

FIGURE K.73 Estimated Rail Transportation Fatality Risks for the MgF_2 Generated in the Conversion of Depleted UF_6 to Uranium Metal

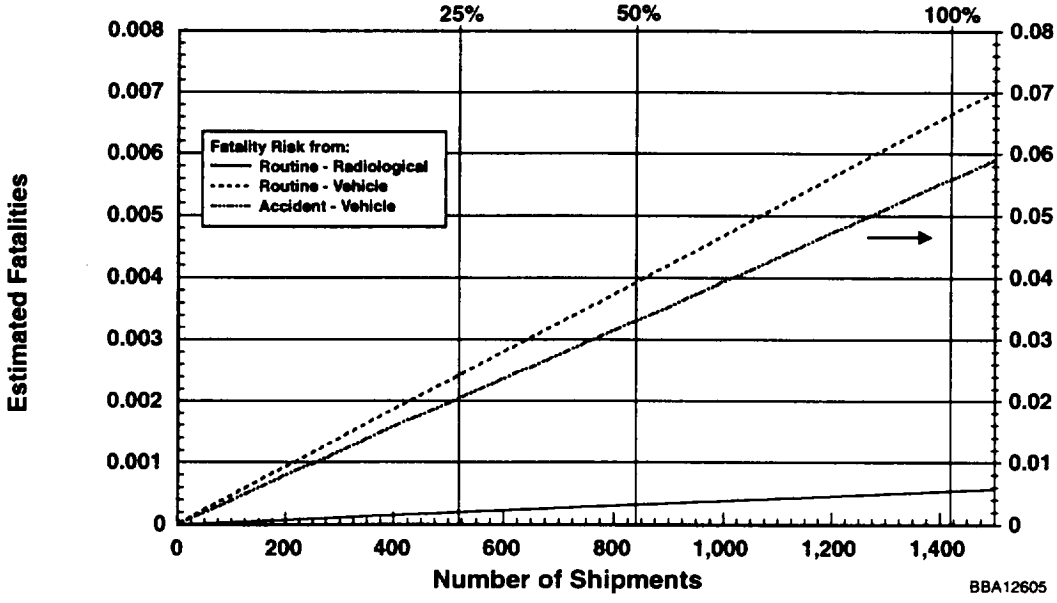

FIGURE K.74 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF_6 to U_3O_8

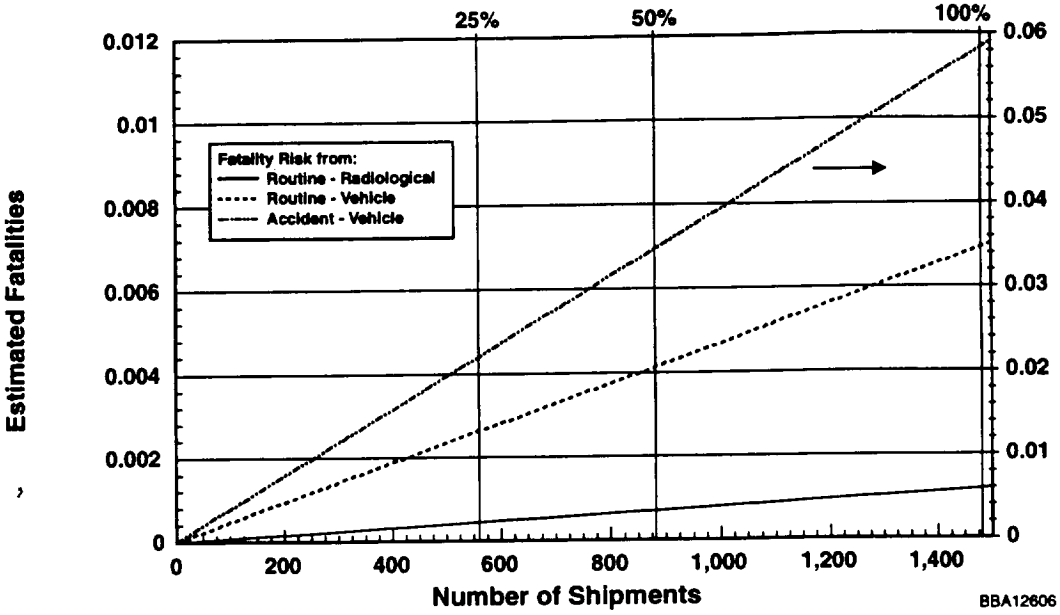

FIGURE K.75 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF_6 to UO_2

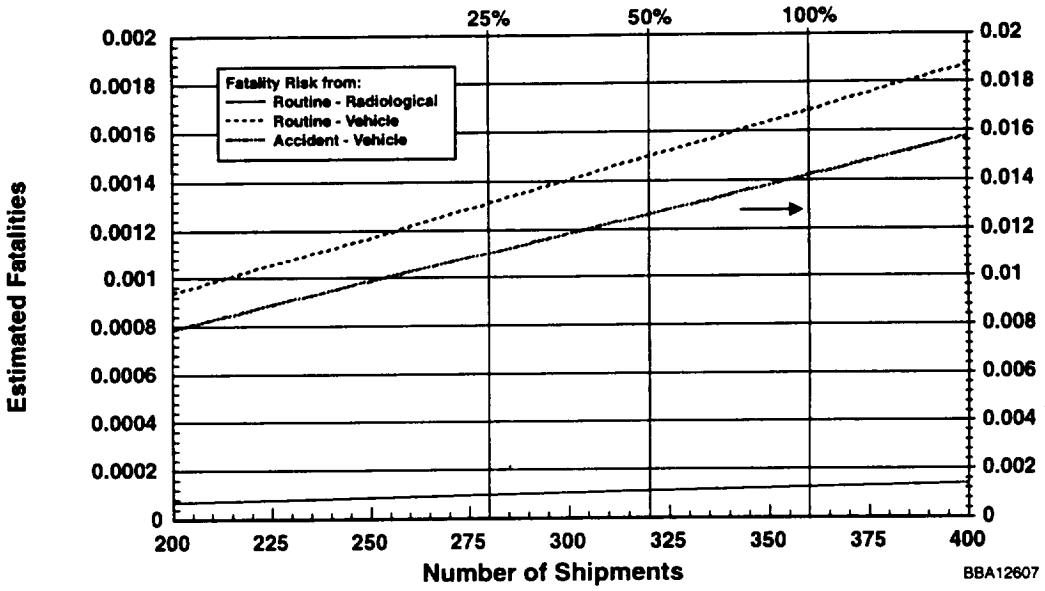

FIGURE K.76 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF_6 to Uranium Metal

Radiological and chemical risks from accidents are not presented because they would be at least 100 times less than the other estimated risks.

Parametric transportation risks for the shipment of U_3O_8 are provided in Section K.6.4 under the U_3O_8 disposal option. Parametric transportation risks for the UO_2 conversion product are discussed in Section K.6.2 under the UO_2 long-term storage option, and the risks for the metal conversion product are discussed in Section K.6.3 for the manufacture and use option.

Each conversion option would require cleaning of the empty depleted UF_6 cylinders at the cylinder treatment facility, as discussed in Appendix J, Section J.3.4.3. The parametric transportation risks for the resulting LLW and U_3O_8 are presented in Figures K.77 and K.78, respectively. For the LLW shipments, the radiological and chemical risks are not presented because they are at least 100 times less than the vehicle emission risks, as shown in Appendix J, Section J.3.4.3. The number of shipments required for the LLMW generated at the cylinder treatment facility is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the cleaning process.

K.6.2 Long-Term Storage Options

Storage as UF_6 in buildings assumes transportation of the depleted UF_6 cylinders to a storage site. Parametric risks from transportation of the depleted UF_6 cylinders is discussed in Section K.6.1. A very small amount of LLW and LLMW would be generated from occasional cylinder failure during the surveillance phase of this option. The type of waste generated would be similar to that generated at the cylinder treatment facility and would have similar single shipment risks. As discussed in Appendix J, Section J.3.5, less than one shipment per year is expected for the 100% case, with slightly fewer shipments necessary for the 50% and 25% cases.

Transportation of UO_2 from a conversion facility might be required for long-term storage as oxide, as discussed in Appendix J, Section J.3.5. Figures K.79 and K.80 present the results for shipping the UO_2 conversion product exclusively by truck or rail, respectively, for the three parametric cases. The chemical accident risks for UO_2 are not presented because they would be more than 100 times less than the routine radiological risks shown in Tables J.11 and J.12 for the 100% case.

K.6.3 Manufacture and Use Options

K.6.3.1 Use as Uranium Oxide

The estimated transportation risks for shipment of all the UO_2 from a conversion facility to a manufacturing site for uranium oxide cask production are presented in Appendix J,

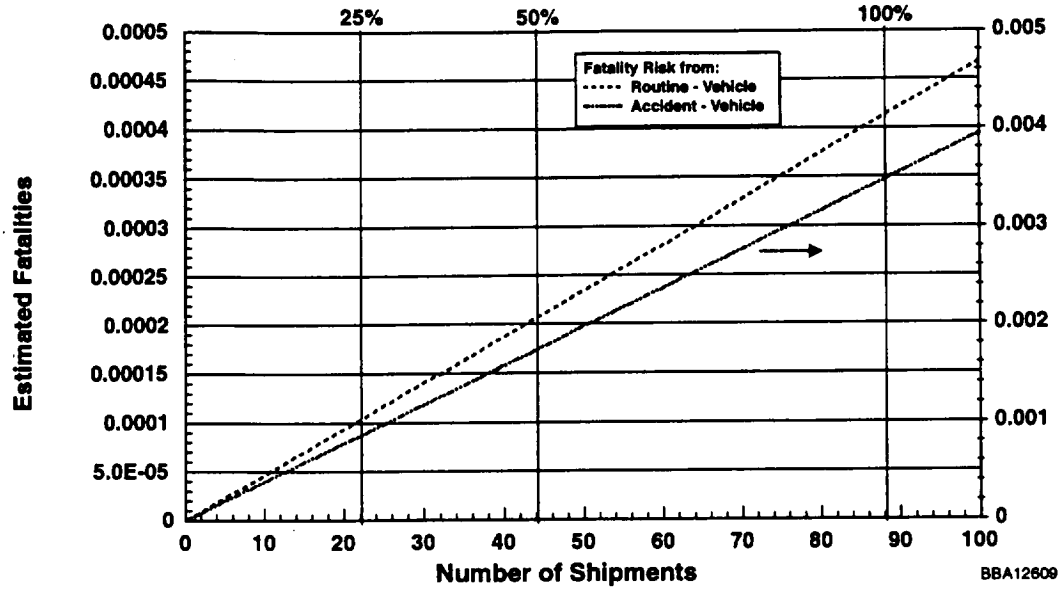

FIGURE K.77 Estimated Truck Transportation Risks for the LLW Generated at the Cylinder Treatment Facility

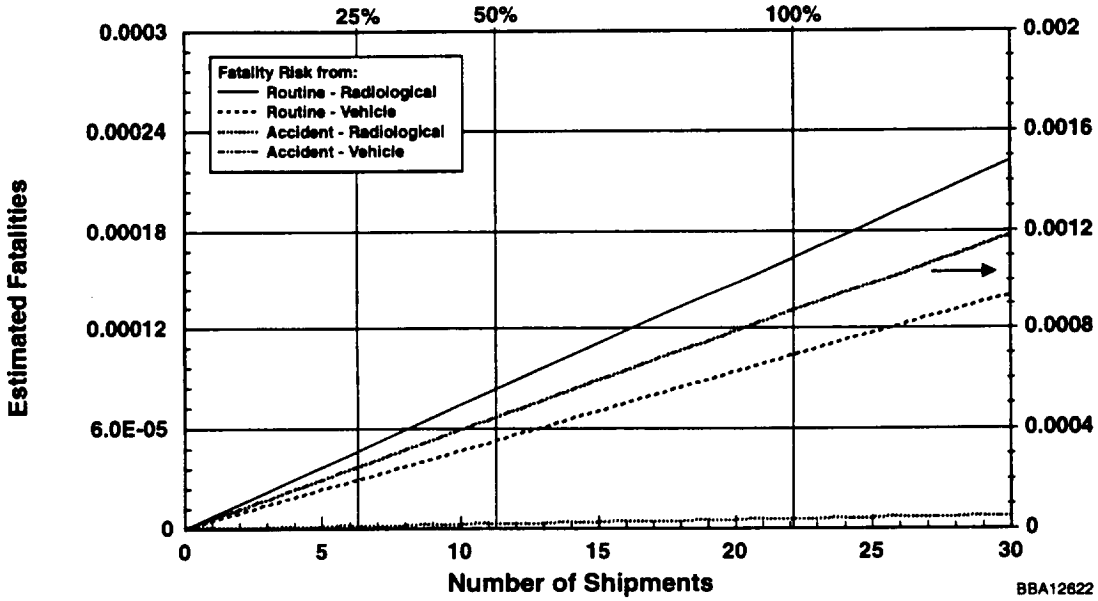

FIGURE K.78 Estimated Truck Transportation Risks for the U_3O_8 Generated at the Cylinder Treatment Facility

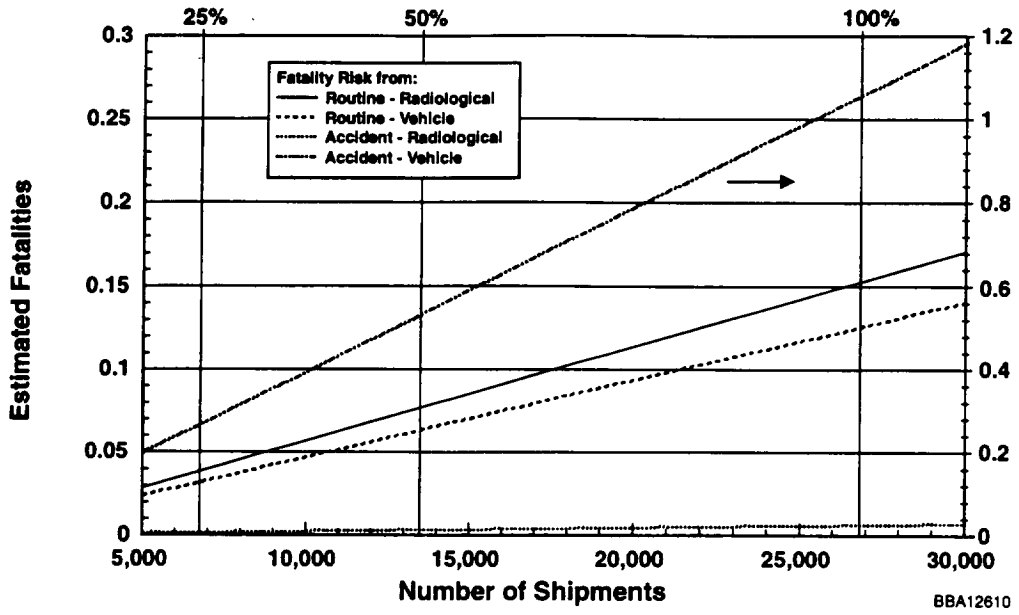

FIGURE K.79 Estimated Truck Transportation Risks for UO_2 Shipped from the Conversion Facility to Long-Term Storage or Oxide Cask Manufacture

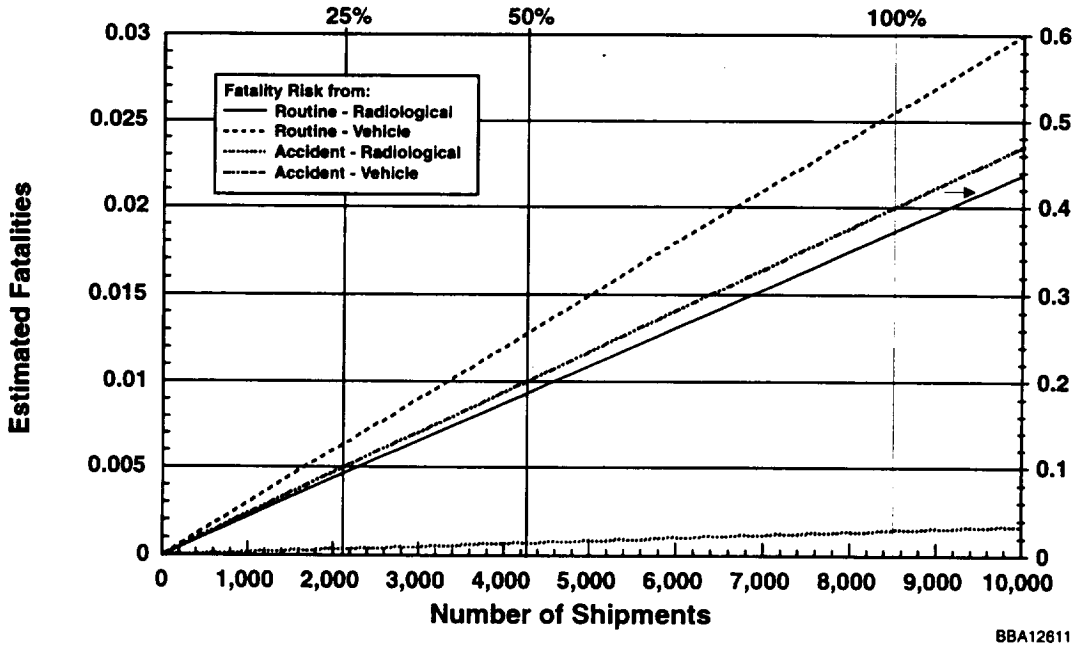

FIGURE K.80 Estimated Rail Transportation Risks for UO_2 Shipped from the Conversion Facility to Long-Term Storage or Oxide Cask Manufacture

Section J.3.6.1. The parametric risks for UO_2 are shown in Figures K.79 and K.80 for shipment by truck and rail, respectively.

Uranium oxide cask production would result in the generation of some LLW and LLMW, as discussed in Appendix J, Section J.3.6. The parametric results for the shipment of the LLW by truck to a disposal site are shown in Figure K.81. Radiological and chemical accident risks are not presented because they are more than 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case. The number of shipments required for LLMW disposal is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the manufacturing process.

The transportation risks for shipment of the uranium oxide cask by rail from the manufacturing facility to an end-user are given in Appendix J, Section J.3.6.1. Figure K.82 shows the risks associated with rail shipments of the uranium oxide casks for the three parametric cases. Radiological and chemical accident risks are not presented because they are approximately 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case.

K.6.3.2 Use as Uranium Metal

The estimated transportation risks for shipment of all of the uranium metal from a conversion facility to a manufacturing site for metal cask production are presented in Appendix J, Section J.3.6.2. The parametric risks for the metal shipments are presented in Figures K.83 and K.84 for shipment by truck or rail, respectively. Radiological and chemical accident risks are not presented because they would be more than 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case.

The metal cask production would result in the generation of some LLW and LLMW, as discussed in Appendix J, Section J.3.6.2. The parametric results for the shipment of the LLW by truck to a disposal site are shown in Figure K.85. Radiological and chemical accident risks are not presented because they would be more than 100 times less than the other risks shown. The number of shipments required for LLMW disposal is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount is generated by the manufacturing process.

The transportation risks for shipment of the metal cask by rail from the manufacturing facility to an end-user are given in Appendix J, Section J.3.6.2. Figure K.86 shows the risks associated with rail shipment of the metal casks for the three parametric cases. Routine radiological risks are not presented because these risks would be about 100 times less than the risks for the 100% case; radiological and chemical accident risks are also not presented because they would be approximately 100 million times less than the other risks for the 100% case, as shown in Tables J.15 and J.16.

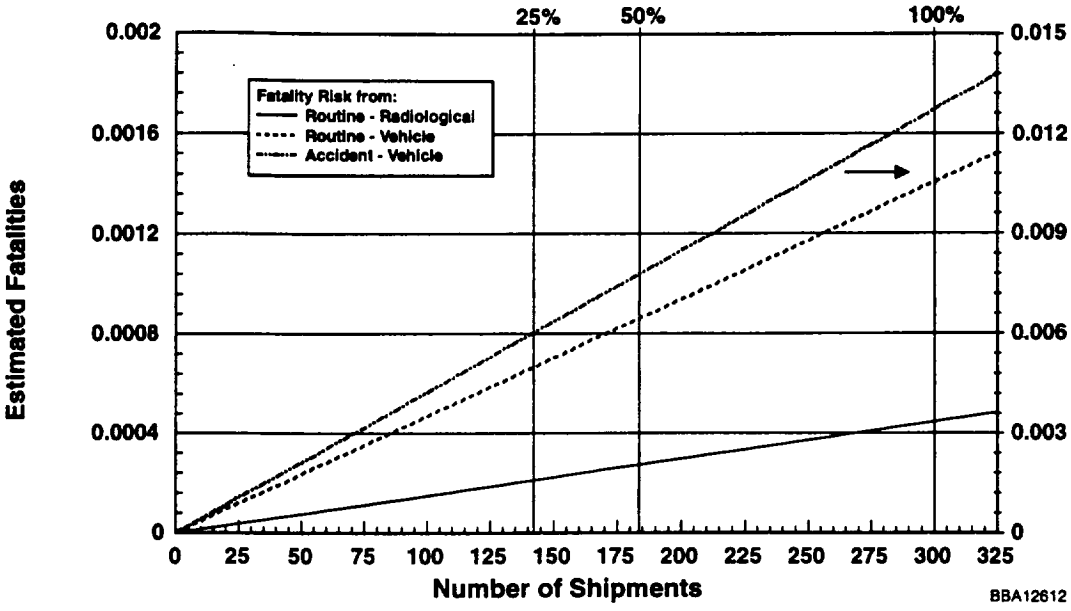

FIGURE K.81 Estimated Truck Transportation Risks for Shipment of LLW from the Oxide Cask Manufacturing Facility to a Disposal Site

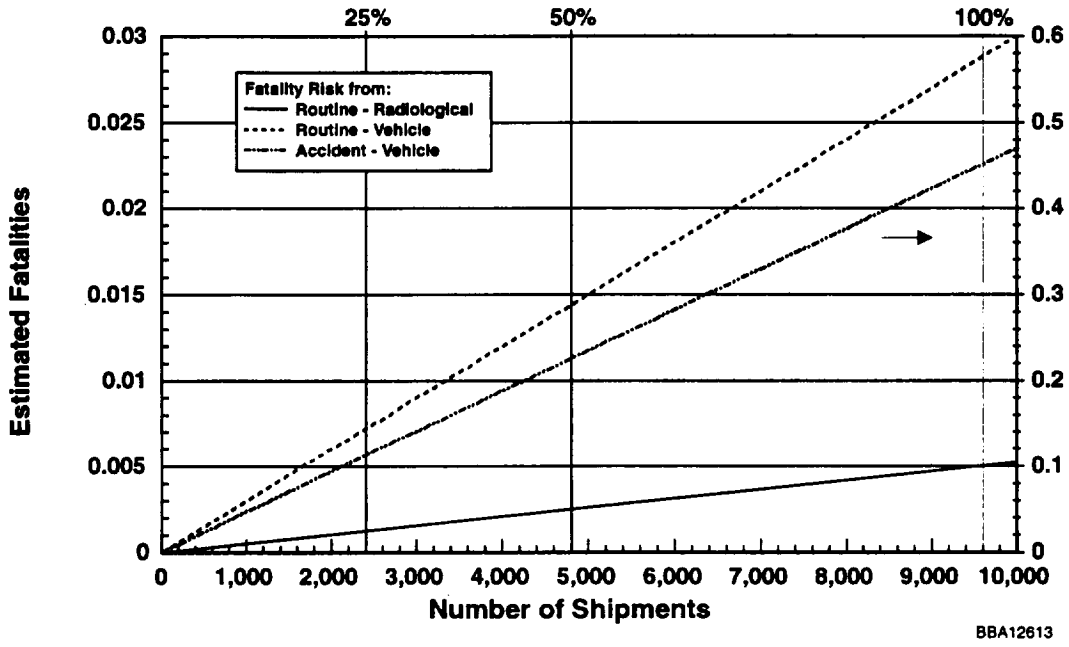

FIGURE K.82 Estimated Rail Transportation Risks for Shipment of Oxide Casks from the Cask Manufacturing Facility to an End-User Site

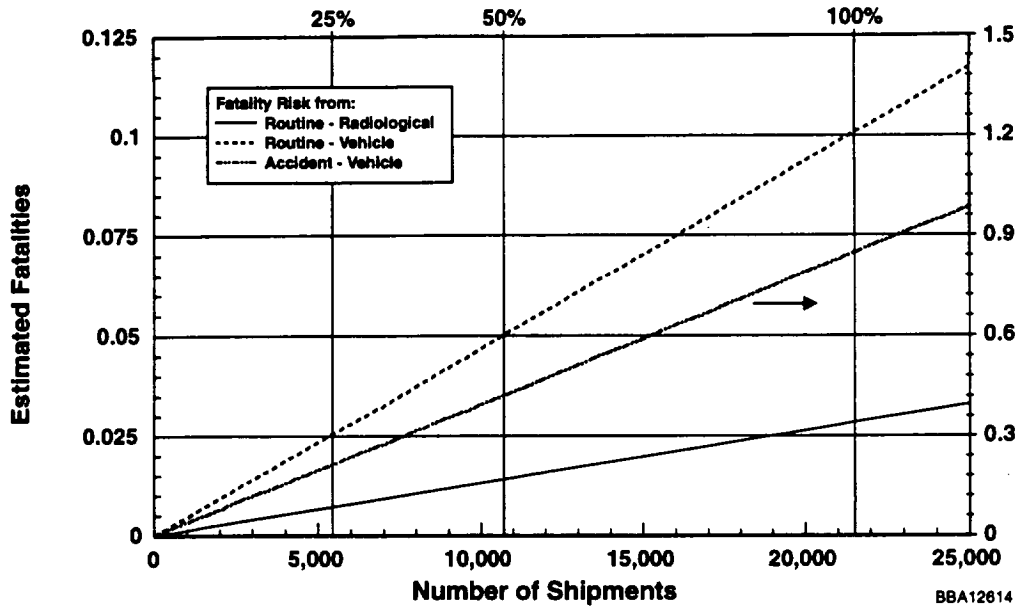

FIGURE K.83 Estimated Truck Transportation Risks for Uranium Metal Shipped from the Conversion Facility to Metal Cask Manufacture

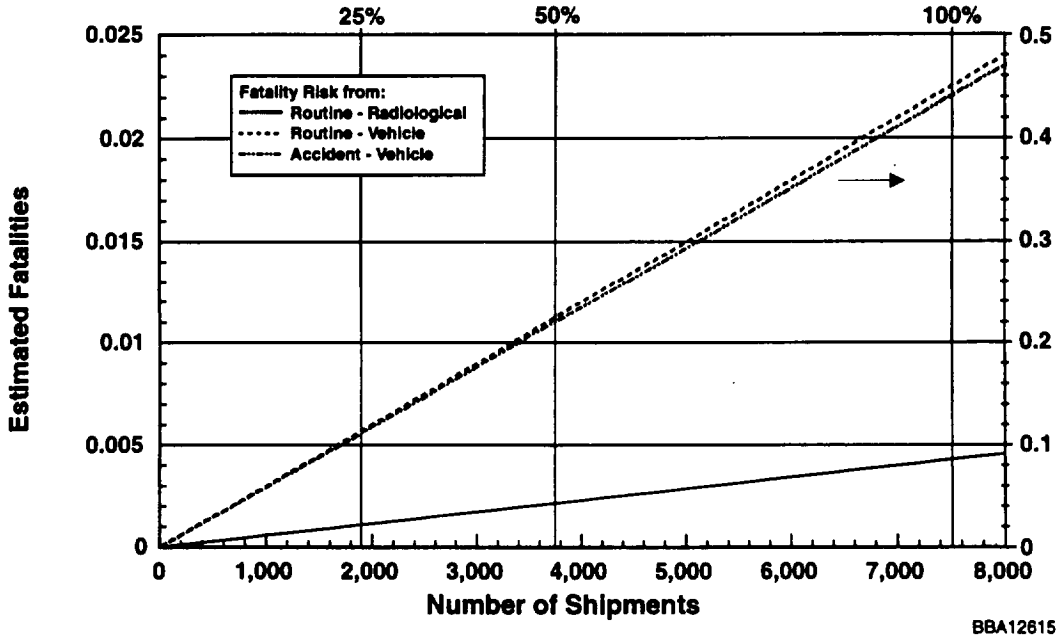

FIGURE K.84 Estimated Rail Transportation Risks for Uranium Metal Shipped from the Conversion Facility to Metal Cask Manufacture

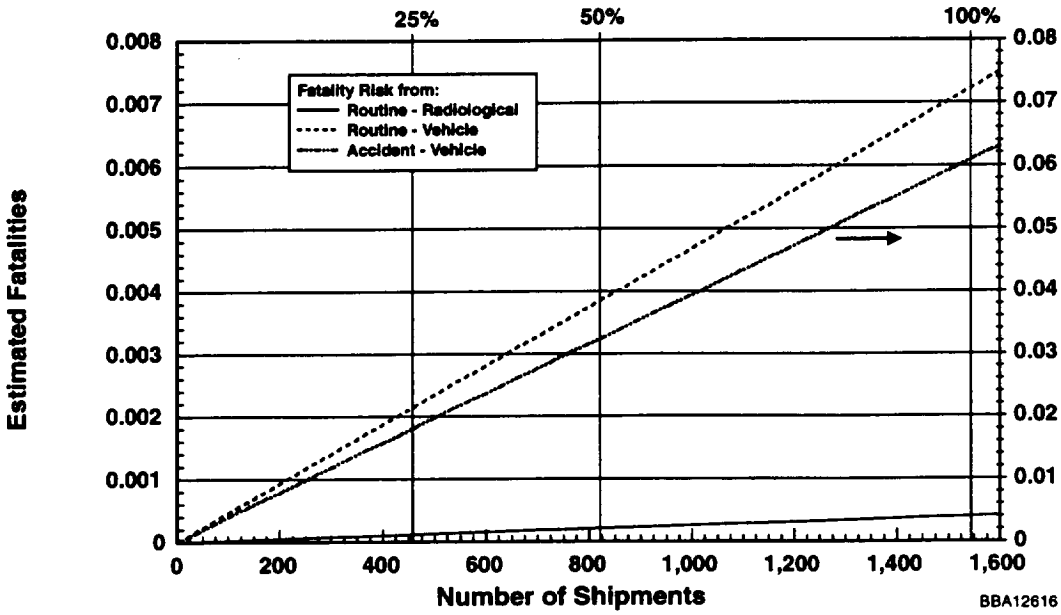

FIGURE K.85 Estimated Truck Transportation Risks for Shipment of LLW from the Metal Cask Manufacturing Facility to a Disposal Site

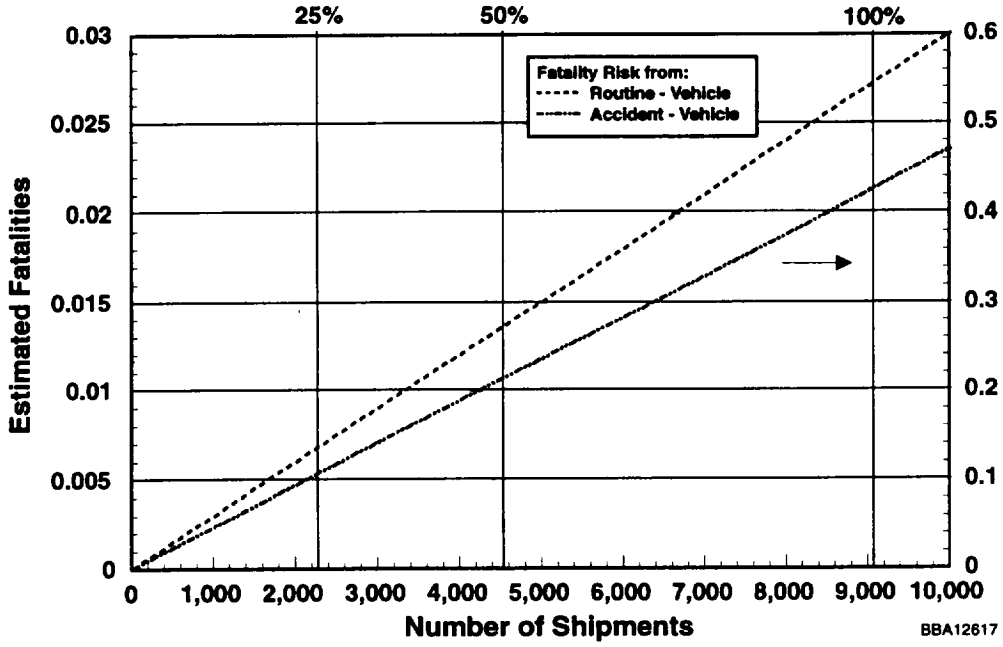

FIGURE K.86 Estimated Rail Transportation Risks for Shipment of Metal Casks from the Cask Manufacturing Facility to an End-User Site

K.6.4 Disposal as Ungrouted U_3O_8

The estimated transportation risks for shipment of all the U_3O_8 from a conversion facility to a disposal site are presented in Appendix J, Section J.3.7. The parametric risks for the oxide shipments are presented in Figures K.87 and K.88 for shipment by truck or rail, respectively.

K.7 IMPACTS OF COMBINATIONS OF ALTERNATIVES

The alternatives evaluated in detail in the PEIS are no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is also considered in the PEIS. This section provides examples of how the impacts of parametric cases for continued storage, cylinder preparation, conversion, long-term storage, manufacture and use, disposal, and transportation activities (as presented in Appendixes D and E and Sections K.2-K.6 of Appendix K) can be added together to assess the impacts of strategies that combine one or more of the alternatives evaluated in the PEIS. Six example combinations of use as oxide, use as metal, and continued storage as UF_6 are evaluated (cases 1 through 6); an additional combination of 50% use as oxide, 50% use as metal (case 7) is also evaluated. Although these combinations were chosen as examples, the methods to calculate potential environmental impacts for them can be used to calculate impacts for other combinations as well (e.g., 50% disposal, 50% long-term storage).

The example combinations assessed (Table K.6) were selected to provide a reasonable range of possible combinations that might occur in the future as uses are identified. A summary of potential environmental consequences associated with these cases is presented in Tables K.9 and K.10 (tables follow Section K.7.2 of this appendix).

K.7.1 Example Calculation of Impacts for a Combination of Alternatives

The results of a sample calculation for Case 1 are presented in Sections K.7.1.1 through K.7.1.11. Under Case 1, 50% of the depleted UF_6 inventory would continue to be stored as UF_6, 25% would be converted and used as uranium oxide, and the remaining 25% would be converted and used as uranium metal. This sample is intended to illustrate how the impacts can be estimated for any combination of alternatives.

The impacts for this sample combination include impacts during continued cylinder storage, preparation of cylinders for shipment, conversion of UF_6 to uranium oxide and metal, treatment of empty cylinders, manufacture of uranium oxide and uranium metal casks, and transportation of cylinders, conversion products (oxide, metal, HF, ammonia, and waste), and casks. The potential impacts of Case 1 were calculated by adding the impacts from each of the individual components, as appropriate. Certain impacts, such as the dose to MEIs, are not additive because the MEI at each

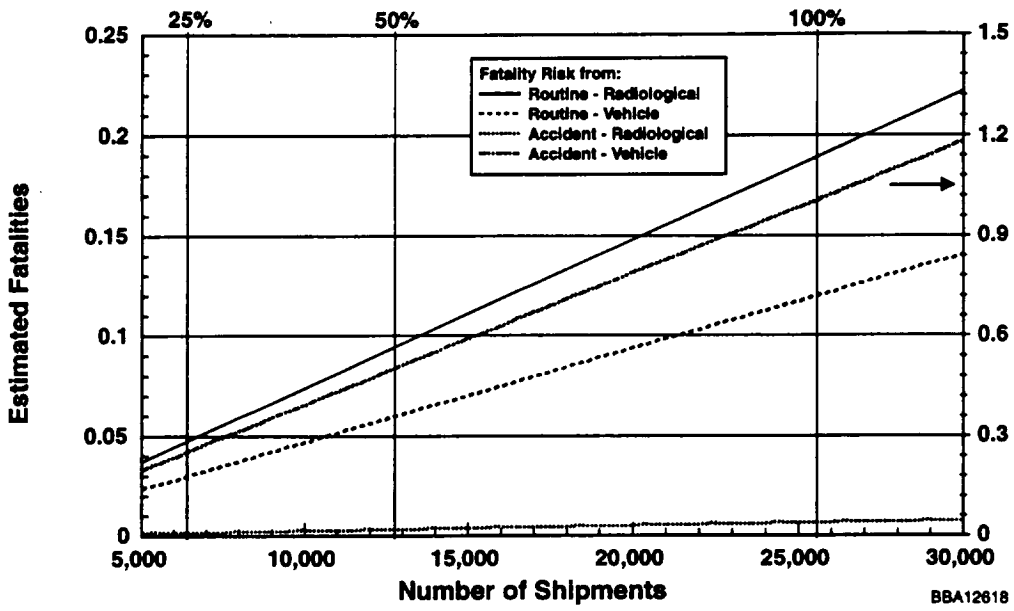

FIGURE K.87 Estimated Truck Transportation Risks for U_3O_8 Shipped from the Conversion Facility to Disposal

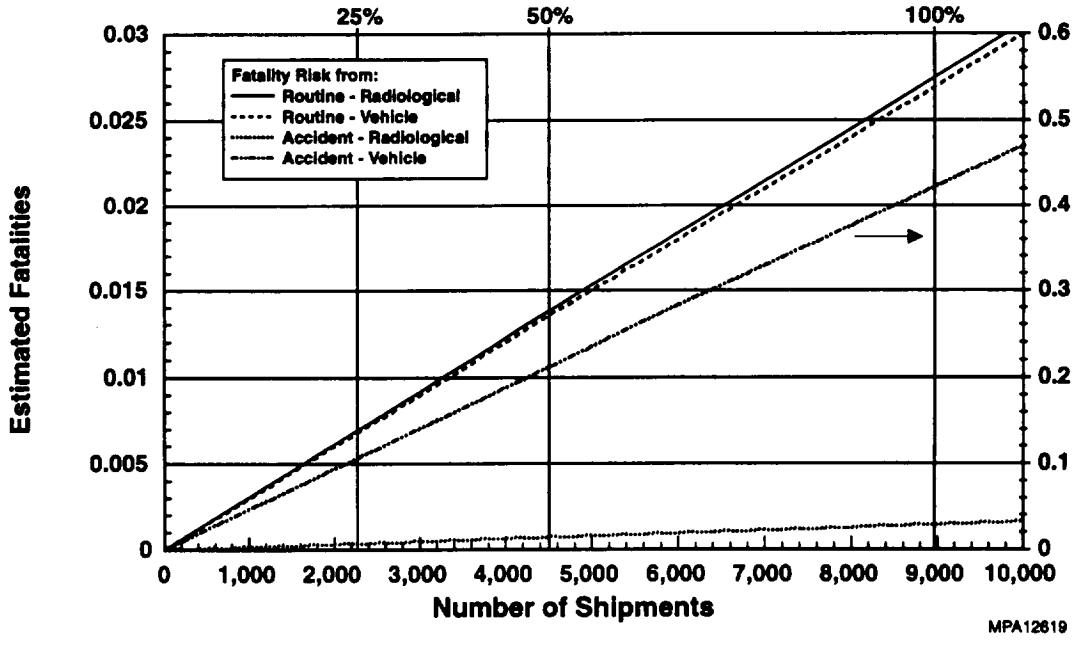

FIGURE K.88 Estimated Rail Transportation Risks for U_3O_8 Shipped from the Conversion Facility to Disposal

TABLE K.6 Example Combinations of Alternatives (Cases) for Which Environmental Impacts Were Evaluated

	Fraction of Inventory		
Case	Use as Uranium Oxide	Use as Uranium Metal	Continued Storage as UF_6 (No Action Alternative)
1	0.25	0.25	0.5
2	0.33	0.33	0.33
3	0.5	0	0.5
4	0	0.5	0.5
5	0.5	0.25	0.25
6	0.25	0.5	0.25
7	0.5	0.5	0

site would be different and the future facilities were assumed to be built at separate sites (except for the continued storage and cylinder preparation activities, which were assumed to occur at the current storage sites; and the conversion and cylinder treatment activities, which would likely occur at the same sites). The potential impacts from continued cylinder storage and cylinder preparation are provided in Appendices D and E, respectively; impacts from the other components are provided in Sections K.1 through K.6.

K.7.1.1 Human Health — Normal Operations

K.7.1.1.1 Radiological Impacts

Involved Workers. The collective radiation dose to involved workers was estimated by summing the radiation dose from each of the components comprising Case 1. The calculation of radiological impacts to involved workers is outlined below. The impacts are first presented for each of the individual components and then summed, as appropriate, to provide an estimate of the total radiological impact.

Continued Cylinder Storage. Potential radiological impacts during continued cylinder storage at the three current storage sites include impacts during storage of 100% of the inventory for a period of 10 years, removal of 50% of the cylinder inventory over a period assumed to be 20 years,

and storage of 50% of the inventory for the remaining 10 years considered during the assessment period (1999 through 2039).

The total dose to involved workers was calculated as follows:

Annual dose to involved workers from storage of the entire cylinder inventory (from Table D.2) = 36 person-rem/yr

Average annual dose from storage of 50% of the entire inventory = 0.5 × 36 person-rem/yr = 18 person-rem/yr

Average annual dose during the cylinder removal period for removal of 50% of the inventory = 0.5 × (36 person-rem/yr + 18 person-rem/yr) = 27 person-rem/yr

The total worker dose from continued cylinder storage of 50% of the inventory was then calculated as:

Total worker dose = 10 years × 36 person-rem/yr + 20 years × 27 person-rem/yr + 10 years × 18 person-rem/yr

Total worker dose = 1,080 person-rem

Cylinder Preparation. For purposes of assessing Case 1, it was assumed that the 50% of the cylinder inventory converted for use would be transported to a conversion site from the three current storage sites and that all of the cylinders transported would require preparation by either placement in overcontainers or transfer to new cylinders. Shipment of 50% of the cylinder inventory over a 20-year period corresponds to annual rates of 709 cylinders per year at the Paducah site, 335 cylinders per year at the Portsmouth site, and 117 cylinders per year at the K-25 site.

The annual collective dose to workers for a range of shipment rates at each site are provided in Appendix E, Figure E.3, for the overcontainer option and in Figure E.4 for the transfer facility option. The doses corresponding to the above shipment rates are as follows:

Annual dose to workers using overcontainer option = 14 person-rem/yr (Paducah) + 6 person-rem/yr (Portsmouth) + 2 person-rem/yr (K-25) = 22 person-rem/yr

Total dose over 20 years using overcontainer option = 22 person-rem/yr × 20 years = 440 person-rem

Annual dose to workers using cylinder transfer option = 35 person-rem/yr (Paducah) + 25 person-rem/yr (Portsmouth) + 20 person-rem/yr (K-25) = 80 person-rem/yr

Total dose over 20 years using cylinder transfer option = 80 person-rem/yr × 20 years = 1,600 person-rem

Total range of worker dose from cylinder preparation = 440 to 1,600 person-rem

Conversion. The doses to workers from conversion for various throughput rates are provided in Figure K.11 for conversion to uranium oxide (UO_2) and in Figure K.17 for conversion to uranium metal. From these data, the estimated collective worker doses for conversion of 25% of the inventory to oxide and 25% to uranium metal are as follows:

Annual dose to workers from conversion of 25% of the inventory to oxide = 22 to 31 person-rem/yr

Total worker dose from conversion to oxide = (22 to 31) person-rem/yr × 20 years = 440 to 620 person-rem

Annual dose to workers from conversion of 25% of the inventory to metal = 18 to 50 person-rem/yr

Total worker dose from conversion to metal = (18 to 50) person-rem/yr × 20 years = 360 to 1,000 person-rem

Cylinder Treatment. The collective dose to workers from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Figure K.23. It was assumed that two treatment facilities would be required, one for each conversion facility. On this basis, the estimated doses to workers are as follows:

Annual dose to workers from treatment of 25% of the cylinder inventory = 6 person-rem/yr

Total worker dose from cylinder treatment = 2 × 6 person-rem/yr × 20 years = 240 person-rem

Manufacture and Use. The doses to workers from manufacture and use for various throughput rates are provided in Figure K.41 for manufacture of uranium oxide (UO_2) shielded casks

and in Figure K.47 for manufacture of uranium metal shielded casks. From these data, the estimated worker doses for manufacture of 25% of the inventory to oxide shielded casks and 25% to uranium metal shielded casks are as follows:

Annual dose to workers from manufacture of 25% of the inventory to oxide casks
= 10 person-rem/yr

Total worker dose from manufacture of oxide casks
= 10 person-rem/yr × 20 years = 200 person-rem

Annual dose to workers from manufacture of 25% of the inventory to metal casks
= 2 person-rem/yr

Total worker dose from manufacture of metal casks
= 2 person-rem/yr × 20 years = 40 person-rem

Total Radiological Impacts to Workers. The total collective radiation dose to involved workers was calculated by summing the collective doses from the individual components. The individual contributions, as well as the total dose, are summarized in Table K.7. In addition, the number of radiation-induced health effects was estimated by multiplying the collective dose by a health risk conversion factor of 4×10^{-4} LCF/person-rem for involved workers. The total LCFs among workers were estimated to range from 1 to 2 over the duration of the program. The radiological impacts to noninvolved workers would be negligible compared to those for involved workers (based on total doses for individual component activities two or more orders of magnitude lower than those for involved workers).

General Public. The collective radiation dose to members of the general public was calculated in a manner similar to that outlined above for workers. However, because the collective dose to members of the public in the vicinity of all sites was found to be well below levels expected to cause adverse health effects for all individual components, a conservative approach was taken to estimate the total impacts. The total impacts to members of the general public were conservatively estimated by summing the maximum dose estimates (100% cases) for each component, as follows:

Maximum collective dose to public from continued cylinder storage (Table D.1)
= 1.1 person-rem

Maximum collective dose to public from cylinder preparation (Table E.1)
= 0.006 person-rem

TABLE K.7 Range of Radiological Doses and Latent Cancer Fatalities among Involved Workers for Case 1: 50% Continued Storage, 25% Use as Oxide, and 25% Use as Metal

Component	Collective Dose (person-rem)
Continued cylinder storage	1,080
Cylinder preparation	440 - 1,600
Oxide conversion	440 - 620
Metal conversion	360 - 1,000
Cylinder treatment	240
Manufacture of oxide casks	200
Manufacture of metal casks	40
Total dose	2,800 - 4,780
Latent cancer fatalities[a]	1 - 2

[a] The number of latent cancer fatalities was calculated using a health risk conversion factor of 4×10^{-4} LCF/person-rem for workers.

Maximum collective dose to public from conversion to oxide (Table F.2)
= 10 person-rem

Maximum collective dose to public from conversion to metal (Table F.2)
= 8 person-rem

Maximum collective dose to public from cylinder treatment (Table F.2)
= 0.008 person-rem

Maximum collective dose to public from manufacture of oxide casks (Table H.1)
= 0.1 person-rem

Maximum collective dose to public from manufacture of metal casks (Table H.1)
= 0.7 person-rem

The maximum total collective dose to the public is estimated to be approximately 20 person-rem, much less than levels expected to cause adverse health effects.

Because individual activities would occur at separate sites and the results of the parametric analyses indicate that impacts decrease with a decrease in the amount processed, the dose to general public MEIs from Case 1 (as well as any of the other combinations analyzed) would be less than the estimates presented for each of the individual components. Therefore, all doses to individual members of the general public would be well below regulatory limits and well below levels expected to cause adverse health effects.

K.7.1.1.2 Chemical Impacts

Chemical impacts from components comprising Case 1 are generally nonadditive because these impacts were estimated for MEIs at each site and future facilities were assumed to be built at separate sites. The two exceptions are (1) continued storage and cylinder preparation activities, which would take place at the current storage sites; and (2) conversion and cylinder treatment activities, which would likely occur at the same site.

Estimated hazard indices for MEIs for all management options are much less than 1 (a hazard index of greater than 1 indicates the potential for health impacts). To provide a conservative estimate of potential hazards from activities occurring at the same sites, the maximum hazard index for both workers and the general public from continued cylinder storage activities for 1999 through 2039 (0.065; Tables D.5 and D.25) was added to the maximum hazard index from cylinder preparation activities (6.1×10^{-6}; Section E.3.1.2). Similarly, the maximum hazard index from conversion options (1.5×10^{-4}; Table F.6) was added to the maximum hazard index from cylinder treatment (7.1×10^{-8}; Table F.6). The results in both cases are still much lower than 1, so adverse chemical impacts from normal operations would not be associated with Case 1 (or any of the other combinations analyzed).

K.7.1.2 Human Health — Accident Conditions

K.7.1.2.1 Radiological and Chemical Impacts

For any combination involving continued cylinder storage and use as oxide and metal, the bounding impacts from accidents involving radiological or chemical releases would be the largest of the impacts estimated for the no action (continued storage) alternative, the use as oxide alternative, or the use as metal alternative. The consequences of bounding accidents for combination alternatives would be the same as the largest consequences of accidents under these alternatives because only a limited amount of material would be at risk of release under accident conditions, regardless of the facility size or throughput. Although the frequencies of some accidents (for example, cylinder-handling accidents) would decrease somewhat as the facility throughput

decreased, the overall frequency category for those accidents would remain the same despite these small changes in frequencies.

K.7.1.2.2 Physical Hazards

Physical hazards to involved and noninvolved workers were estimated by summing the injury and fatality hazards from each of the components comprising the combination, similar to the method described for estimating collective worker radiation dose in Section K.7.1.1.1. For Case 1, the calculations to estimate physical hazards are outlined below.

Continued Cylinder Storage. The numbers of fatalities and injuries during continued cylinder storage at the three current storage sites were estimated by summing the numbers estimated for 10 years of storage of the entire inventory, 20 years for removal of 50% of the cylinder inventory, and 10 additional years for storage of the remaining 50% of the inventory (covering the assessment period 1999 through 2039). The total number of fatalities and injuries to workers was calculated as follows:

Annual fatalities during storage of 100% of the inventory (no action) (from Table D.1)
= 0.11/40 years = 0.0028 fatalities per year

Annual injuries during storage of 100% of the inventory (from Table D.1)
= 143/40 years = 3.6 injuries per year

Annual fatalities during storage of 50% of the inventory
= 0.5 × 0.0028 = 0.0014 fatalities per year

Annual injuries during storage of 50% of the inventory
= 0.5 × 3.6 = 1.8 injuries per year

Average annual fatalities during the removal of 50% of the inventory
= 0.5 × (0.0028 fatalities per year + 0.0014 fatalities per year)
= 0.0021 fatalities per year

Average annual injuries during the removal of 50% of the inventory
= 0.5 × (3.6 injuries per year + 1.8 injuries per year)
= 2.7 injuries per year

The total number of fatalities and injuries from continued storage of 50% of the inventory was calculated as follows:

Total fatalities = 10 years × 0.0028 fatalities per year + 20 years × 0.0021 fatalities per year + 10 years × 0.0014 fatalities per year = 0.08 fatalities

Total injuries = 10 years × 3.6 injuries per year + 20 years × 2.7 injuries per year + 10 years × 1.8 injuries per year = 108 injuries

Cylinder Preparation. For purposes of assessing Case 1, it was assumed that the 50% of the cylinder inventory converted for use would be transported to a conversion site from the three current storage sites and that all of the cylinders transported would require preparation by either placement in overcontainers or transfer to new cylinders. Shipment of 50% of the cylinder inventory over a 20-year period corresponds to annual rates of 709 cylinders per year at the Paducah site, 335 cylinders per year at the Portsmouth site, and 117 cylinders per year at the K-25 site.

The fatalities and injuries for workers conducting overcontainer operations are provided in Appendix E, Figure E.10; the fatalities and injuries for workers conducting transfer operations are provided in Figures E.11 and E.12. These data are estimates of the total fatalities and injuries over the entire 20-year period that cylinder preparation activities were assumed to be ongoing. The estimated number of fatalities and injuries corresponding to shipment of 50% of the inventory at each site are as follows:

Fatalities among workers conducting overcontainer operations = 0.043 (Paducah) + 0.02 (Portsmouth) + 0.007 (K-25) = 0.07 fatalities

Injuries among workers conducting overcontainer operations = 57 (Paducah) + 27 (Portsmouth) + 9 (K-25) = 93 injuries

Fatalities among workers conducting cylinder transfer operations = 0.32 (Paducah) + 0.27 (Portsmouth) + 0.15 (K-25) = 0.74 fatalities

Injuries among workers conducting cylinder transfer operations = 218 (Paducah) + 159 (Portsmouth) + 100 (K-25) = 477 injuries

Total range of fatalities from cylinder preparation option = 0.07 to 0.74 fatalities

Total range of injuries from cylinder preparation option = 93 to 477 injuries

Conversion. The estimated numbers of fatalities and injuries for conversion of various throughput rates are provided in Section K.2.2.3. The estimated numbers of fatalities and injuries from conversion for Case 1 are as follows:

Fatalities among workers from conversion of 25% of the inventory to oxide
= 0.35 to 0.49 fatalities

Injuries among workers from conversion of 25% of the inventory to oxide
= 290 to 430 injuries

Fatalities among workers from conversion of 25% of the inventory to metal
= 0.33 to 0.49 fatalities

Injuries among workers from conversion of 25% of the inventory to metal
= 270 to 450 injuries

Cylinder Treatment. The estimated numbers of fatalities and injuries from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Section K.2.2.3. In the case of conversion to both metal and oxide, two separate conversion facilities with separate cylinder treatment facilities would likely be constructed, so the impacts would be two times the 25% impacts, rather than the impacts for a single 50% capacity treatment facility. The estimated numbers of fatalities and injuries from cylinder treatment for Case 1 are as follows:

Fatalities among workers from treatment of 25% of the cylinder inventory = 0.13 fatalities

Injuries among workers from treatment of 25% of the cylinder inventory = 121 injuries

Total fatalities = 2 × 0.13 = 0.26 fatalities

Total injuries = 2 × 121 = 242 injuries

Manufacture and Use. Fatalities and injuries for manufacture of uranium oxide (UO_2) shielded casks are presented in Figure K.49; values for manufacture of uranium metal shielded casks are presented in Figure K.50. The estimated numbers of fatalities and injuries for Case 1 are as follows:

Fatalities among workers from manufacture of 25% of the inventory to oxide casks
= 0.61 fatalities

Injuries among workers from manufacture of 25% of the inventory to oxide casks
= 490 injuries

Fatalities among workers from manufacture of 25% of the inventory to metal casks
= 0.68 fatalities

Injuries among workers from manufacture of 25% of the inventory to metal casks
= 520 injuries

Total Physical Hazards. The total fatalities and injuries were calculated by summing the values for the individual components and then rounding to the nearest whole number. The individual contributions and total fatalities and injuries are summarized in Table K.8.

K.7.1.3 Transportation

The transportation impacts for normal operations and traffic accident fatalities were determined by the number of shipments required for each combination alternative, assuming a travel distance of 620 miles (1,000 km) per shipment. For Case 1, these impacts would be the sum of the number of shipments if 25% of the inventory was converted for use as oxide and 25% of the inventory was converted for use as metal (no off-site transportation of cylinders would be required

TABLE K.8 Range of On-the-Job Fatalities and Injuries among All Workers for Case 1: 50% Continued Storage, 25% Use as Oxide, and 25% Use as Metal[a]

Component	Fatalities	Injuries
Continued cylinder storage	0.08	110
Cylinder preparation	0.07 – 0.74	93 – 480
Oxide conversion	0.35 – 0.49	290 – 430
Metal conversion	0.33 – 0.49	270 – 450
Cylinder treatment	0.26	240
Manufacture of oxide casks	0.61	490
Manufacture of metal casks	0.68	520
Total	2 – 3	2,000 – 2,700

[a] Represents impacts to involved and noninvolved workers from construction and operation of facilities. Values rounded to two significant figures.

for continued cylinder storage). The impacts of the various combinations examined would be essentially the same for exposures from normal operations because these exposures would generally be expected to result in 1 or fewer adverse health effects among workers and members of the general public combined. As would be expected, traffic accident fatalities for Case 1, which would involve transportation of 50% of the cylinder inventory and the resulting conversion products, are estimated to be about half of those expected under the use as oxide and use as metal alternatives (Table K.9, which follows Section K.7.2 of this appendix).

For any combination involving continued cylinder storage and use as oxide and metal, the bounding impacts for accidents involving releases from cylinders or releases of other materials would be the larger of the impacts estimated for either the use as oxide alternative or the use as metal alternative. The consequences of bounding accidents for combination alternatives would be the same as the largest consequences of these alternatives because the same amount of material would be at risk under accident conditions, regardless of the number of shipments. The overall probability of accidents occurring would decrease in direct proportion to the number of shipments and the distance per shipment; in Case 1, the overall probability would be about half that estimated for the use as oxide alternative.

K.7.1.4 Air Quality

Air quality impacts from construction at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives and combination alternatives examined.

Air quality impacts from operations at the current storage sites for combination alternatives involving varying percentages of continued storage would depend on whether a certain percentage of cylinders was removed from each site or whether cylinders were preferentially removed from one or two of the sites. For 100% continued storage (no action alternative), a potential impact that could occur if cylinder maintenance and painting activities do not reduce cylinder corrosion rates would be exceedance of the HF standard at the K-25 site in about the year 2020 (see Appendix D, Section D.3, for further discussion).

In examining the potential air quality impacts of combination alternatives, the case where cylinders at the Paducah and Portsmouth sites would be preferentially removed for use was assumed as the bounding case, leaving all cylinders in place at the K-25 site. (The number of cylinders stored at the K-25 site constitutes only about 10% of the entire inventory, so that the combination alternatives that consider from 25 to 75% use of the inventory could all have the entire K-25 inventory remaining in place). Therefore, the bounding air quality impacts from operations at the current storage sites for combination alternatives (including Case 1) would be the same as the

impacts from the no action alternative. If the cylinders at K-25 were preferentially removed or part of the inventory was removed, then air quality impacts at the K-25 site would decrease accordingly. Also, if continued maintenance and painting are effective in controlling cylinder corrosion, as expected, concentrations of HF would be kept within regulatory standards at all sites under all combination alternatives.

Pollutant emissions during construction and operation of conversion and manufacturing facilities designed to process the entire inventory would remain within standards. Emissions under the combination alternatives also would remain within standards because emissions were estimated to be within applicable standards for full-scale (100%) facilities and emissions would be somewhat reduced for facilities with lower throughput rates because different sites were assumed for new facilities.

K.7.1.5 Water and Soil

As discussed for air quality impacts, impacts to groundwater at the current storage sites for combination alternatives involving varying percentages of continued storage would depend on whether a certain percentage of cylinders was removed from each site or whether cylinders were preferentially removed from one or two of the sites. For the no action alternative, a potential impact that could occur if cylinder maintenance and painting activities do not reduce cylinder corrosion rates would be that the groundwater uranium concentration at all three sites could exceed 20 µg/L in about the year 2100 or later (see Appendix D, Section D.3, for further discussion). For combination alternatives, the case where cylinders at the Paducah and Portsmouth sites would be preferentially removed for use was assumed as the bounding case, leaving all cylinders in place at the K-25 site. Therefore, the bounding groundwater quality impacts at the current storage sites for combination alternatives could include exceedance of the 20 µg/L guideline level at one or more of the current storage sites at some time after the year 2100. However, if cylinder maintenance and painting are effective in controlling cylinder corrosion, as expected, groundwater uranium concentrations would remain below 20 µg/L at all sites.

Potential surface water, groundwater and soil quality impacts at conversion and manufacturing facilities could be kept within applicable standards or guidelines by following good engineering practices.

K.7.1.6 Socioeconomics

Socioeconomic impacts for each component of the combination alternatives are summarized in Tables K.9 and K.10 (which follow Section K.7.2). Methods of estimating these impacts are discussed in Sections K.7.1.6.1 and K.7.1.6.2.

K.7.1.6.1 Continued Cylinder Storage

Socioeconomic impacts from construction activities at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives and combination alternatives examined.

The socioeconomic analysis evaluated direct income and jobs for the first year of operations. These values may be interpreted as annual averages over the operational periods because annual operations would generally be uniform. Continued storage impacts for combination alternatives need to be normalized to a standard number of years because continued storage would be ongoing for about 40 years (1999 through 2039), whereas use options were assumed to be ongoing for only 20 years (2009 through 2028). For continued storage operations, the totals for direct jobs and direct income were calculated as follows:

Direct jobs during storage (no action), three-site total (from Table D.18)
= 110 jobs per year

Direct income during storage, three-site total (from Table D.18)
= $5.1 million per year

Direct jobs during cylinder removal (action alternatives), three-site total (from Table D.30)
= 120 jobs per year

Direct income during cylinder removal, three-site total (from Table D.30)
= $6 million per year

Average jobs during the removal of 50% of the inventory = 0.5 × (110 jobs per year + 120 jobs per year) = 115 jobs per year

Average income during the removal of 50% of the inventory = 0.5 × ($5.1 million/yr + $6 million per year) = $5.55 million per year

The total jobs and income from continued storage of 50% of the inventory was calculated as follows:

Total jobs = 10 years × 110 jobs per year + 20 years × 115 jobs per year + 10 years × 55 jobs per year = 3,950 job-years

Total income = 10 years × $5.1 million per year + 20 years × $5.55 million per year + 10 years × $2.55 million per year) = $187.5 million

To facilitate comparison with the no action alternative, the total jobs and income were distributed over 40 years, resulting in a value of 99 jobs per year and $4.7 million income per year over 40 years (see Table K.9). To compare with use alternatives, the values should be converted to total jobs, assuming 40 years for no action and combination alternatives involving continued storage, and assuming 20 years for alternatives involving use only.

K.7.1.6.2 Cylinder Preparation, Conversion, and Manufacturing

Parametric socioeconomic impacts for the cylinder preparation, conversion, and manufacturing options were assessed qualitatively (see Sections E.3.5, K.2.5, and K.4.5), based on preliminary cost data for the 100% cases (LLNL 1996) and socioeconomic data for parametric cases provided in the cost analysis report (LLNL 1997b). The estimated direct jobs and direct employment values for combination alternatives calculated using the above-described data are presented in Tables K.9 and K.10.

K.7.1.7 Ecology

The principal differences in ecological impacts between the combination alternatives would be associated with habitat loss. Potential habitat loss at the current storage sites is the sum of habitat loss that would occur under the no action alternative (7 acres [2.8 ha]), which would be applicable for all alternatives because construction would occur prior to 2003) and loss that would occur from cylinder preparation activities. If overcontainers were used, no additional habitat loss would occur. Transfer facilities would range in areal site requirements from about 12 acres (4.9 ha) for a facility to process the inventory at the K-25 site (10% of the entire inventory), to 14 acres (5.7 ha) for a facility to process the inventory at the Portsmouth site (30% of the entire inventory), to 21 acres (8.5 ha) for a facility to process the inventory at the Paducah site (60% of the entire inventory) (see Section E.3.6). For alternatives involving 100% use, the maximum habitat loss at any site would be 28 acres (21 + 7) (11 ha). To estimate habitat loss for alternatives involving 50 to 75% use, it was assumed that all cylinders would be taken from a single facility until the entire inventory at a single site was used. Therefore, maximum habitat loss at any site for a 50% use facility would be estimated at 21 acres (8.5 ha) (Paducah site value) + 7 acres (2.8 ha), or 28 acres (11 ha). Similarly, maximum habitat loss at any site for alternatives involving 75% use would also be 28 acres (11 ha).

Potential habitat loss for conversion facilities was calculated on the basis of data provided in Sections K.2.9.2, K.2.9.3, and K.2.9.4. The habitat losses corresponding to 25%, 50% and 100% capacity uranium oxide (UO_2) conversion facilities would be 16, 19, and 24 acres (6.5, 7.7, and 9.7 ha), respectively. Similarly, the habitat losses corresponding to 25%, 50% and 100% capacity metal conversion facilities would be 17, 21, and 26 acres (6.9, 8.5, and 10.5 ha), respectively. Finally, for 25%, 50%, and 100% cylinder treatment facilities, the habitat losses would be 7, 8, and

9 acres (2.8, 3.2, and 3.6 ha), respectively. Although these parametric values were calculated for specific conversion options (e.g., conversion to UO_2 by the dry process, with anhydrous HF production), the amount of land required for the other conversion technologies would be roughly similar. For combination options involving both oxide and metal conversion, two cylinder treatment facilities would be required, one for each conversion facility. The habitat loss for conversion for Case 1 (25% use as oxide, 25% use as metal) was calculated as follows:

Habitat loss for conversion to oxide = 16 acres (6.5 ha)

Habitat loss for conversion to metal = 17 acres (6.9 ha)

Habitat loss for a treatment facility = 7 acres (2.8 ha)

Habitat loss for each conversion facility = 23 to 24 acres (9.3 to 9.7 ha) (total of 47 acres)

Potential habitat loss for manufacturing facilities was calculated on the basis of data given in Section K.4.9. For an oxide cask manufacturing facility, the land areas corresponding to 25%, 50%, and 100% capacity would be 79, 84, and 90 acres (32, 34, and 36 ha), respectively; the land areas for 25%, 50% and 100% capacity at a metal cask manufacturing facility are assumed to be the same. For Case 1, two 25% capacity manufacturing facilities would be required, so the total land area would be about 79 acres (32 ha) at either manufacturing facility (total of 158 acres).

K.7.1.8 Waste Management

For waste management at the current storage sites, impacts for all combination alternatives would be similar to those estimated for the no action alternative. Although waste generation amounts would vary somewhat on the basis of the numbers of cylinders being stored and maintained, overall impacts to nationwide waste generation would be negligible. Waste generation impacts associated with waste management capabilities at the Portsmouth and K-25 sites would be negligible. Due to large amounts of cylinder painting assumed at the Paducah site in the earlier years of continued storage, impacts to LLMW management at the Paducah site would be moderate for all combination alternatives.

The use as oxide and use as metal alternatives have potential moderate impacts to nationwide LLW generation on the basis of a possible requirement to dispose of CaF_2 and/or MgF_2 as LLW, if the CaF_2 or MgF_2 were considered DOE waste. If such disposal were required, these alternatives could generate a volume of LLW equal to about 10% of the projected DOE complexwide disposal volume. Moderate impacts to nationwide waste management are defined as additional volumes in excess of 10% of the DOE complexwide disposal volume; negligible to low impacts generate less than 10%. Assuming a linear decrease in potential LLW production, combination

alternatives involving 50% or more conversion to oxide or metal could have low to moderate impacts on nationwide LLW waste management.

K.7.1.9 Resource Requirements

Under the combination alternatives, adverse effects on local, regional, or national availability of materials would not be expected.

K.7.1.10 Land Use

Land use corresponds to habitat loss. See Section K.7.1.7 for an explanation of the values calculated for the combination alternatives.

K.7.1.11 Other Areas of Impact

Impacts to cultural resources at the current storage sites would depend on the selected locations for construction activities but are considered unlikely. Cultural resource activities at other facilities would depend on the locations and will be examined in detail at the next stage of the program when facilities are actually sited. Adverse environmental justice impacts for activities occurring under the example combination alternatives are not expected. The occurrence of severe transportation accidents involving a release is unlikely, and accidents occur at random locations along transportation corridors; therefore, significant and disproportionate high and adverse impacts to minority or low-income populations are unlikely.

K.7.2 Summary of Impacts for Example Combination Alternatives

The method used to estimate the impacts for combination alternatives described in Section K.7.1 was used to evaluate the impacts for the example cases listed in Table K.6. The results for the first six cases analyzed are presented in detail in Table K.9. The results for an additional 50% use as oxide, 50% use as metal combination strategy are presented in Table K.10. In general, the impacts for these combination alternatives tend to be very similar to the impacts estimated for the primary alternatives evaluated in the PEIS (as summarized in Chapter 2, Table 2.2).

TABLE K.9 Summary Comparison of Environmental Consequences of Example Combinations of Use as Oxide, Use as Metal, and Continued Storage as UF_6 Alternatives

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Normal Facility Operations[a]						
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among involved workers (1999-2039)	1 to 2 additional LCFs	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among noninvolved workers (1999-2039)	0 additional LCFs from routine site emissions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among members of the public (1999-2039)	0 additional LCFs from routine site emissions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[b]	No (Hazard Index <1)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
General public MEI	No (Hazard Index <1)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Human Health and Safety — Facility Accidents[a]			
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999-2039)	2-3 fatalities; 2,000-2,700 injuries.	2-3 fatalities; 2,100-2,800 injuries	1-2 fatalities; 1,200-1,700 injuries	1-2 fatalities; 1,200-1,800 injuries	3-4 fatalities; 2,200-2,900 injuries	3-4 fatalities; 2,100-2,900 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[c]						
Accident[d]	Corroded cylinder spill, dry conditions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	~ 1 in 10 years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	3-4 potential accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	70	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – public						
Dose to MEI	3 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	1 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to population	0.4 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	77 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	3 in 100,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to workers	2.2 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Workers	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

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TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Facility Accidents[a] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Low Frequency-High Consequence Cylinder Accidents[f]						
Accidents[d]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	~ 1 in 100,000 years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	~ 1 chance in 2,500	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	1,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	300	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – public						
Dose to MEI	15 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	7 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to population	1 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	20 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	8 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to workers	16 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Human Health and Safety — Facility Accidents[a] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f]						
Chemical accident[d]	HF or NH_3 tank rupture	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	HF, NH_3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident location	Conversion site	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	< 1 in 1 million years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 50,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	41,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	1,700	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	30	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	1,100	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	440	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	4	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers[e]	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiological accident[d]	Earthquake damage to storage building at conversion site	Same as Case 1	Same as Case 1	Vehicle-induced fire, 3 full cylinders	Same as Case 1	Same as Case 1
Release	Uranium (UO_2)	Same as Case 1	Same as Case 1	Uranium	Same as Case 1	Same as Case 1
Accident location	Conversion site	Same as Case 1	Same as Case 1	Conversion site	Same as Case 1	Same as Case 1
Estimated frequency	1 in 100,000 years	Same as Case 1	Same as Case 1	1 in 100,000 years	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 5,000	Same as Case 1	Same as Case 1	1 chance in 5,000 (over 20 years)	Same as Case 1	Same as Case 1

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TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Human Health and Safety — Facility Accidents[a] (Cont.)			
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f] (Cont.)						
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	68 mrem	Same as Case 1	Same as Case 1	15 mrem	Same as Case 1	Same as Case 1
Risk of LCF	3 in 100,000	Same as Case 1	Same as Case 1	7 in 1 million	Same as Case 1	Same as Case 1
Total dose to population	5.1 person-rem	Same as Case 1	Same as Case 1	56 person-rem	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	0	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	2,300 mrem	Same as Case 1	Same as Case 1	20 mrem	Same as Case 1	Same as Case 1
Risk of LCF	9 in 10,000	Same as Case 1	Same as Case 1	8 in 1 million	Same as Case 1	Same as Case 1
Total dose to workers	210 person-rem	Same as Case 1	Same as Case 1	8 person-rem	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	0	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 LCFs	Same as Case 1	Same as Case 1	0 LCFs	Same as Case 1	Same as Case 1
Noninvolved workers[e]	0 LCFs	Same as Case 1	Same as Case 1	0 LCFs	Same as Case 1	Same as Case 1
			Human Health and Safety — Transportation[a]			
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Transportation[a] (Cont.)						
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999-2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	2 fatalities	3 fatalities	2 fatalities	2 fatalities	3 fatalities	3 fatalities
Maximum use of rail	1 fatality	1 fatality	1 fatality	1 fatality	1 fatality	1 fatality
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Urban rail accident involving 4 cylinders	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 10,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	4	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – All workers and members of general public						
Total LCFs	60	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability) – Workers and general public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Human Health and Safety — Transportation[a] (Cont.)			
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Urban rail accident involving anhydrous HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Anhydrous HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 30,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	30,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	300	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
Irreversible adverse effects	1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Water and Soil [h]			
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other parameters[i]	No change	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other parameters[i]	Site-dependent; none to moderate impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
			Socioeconomics [j]			
Current Storage Sites						
Continued storage	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 94 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 93 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 93 per year over 40 years, operations
	Income: $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations

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TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Socioeconomics[j] (Cont.)			
Current Storage Sites (Cont.)						
Cylinder preparation	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years operations	**Jobs:** 0-380 peak year, preoperations; 200-320 per year over 20 years, operations	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years, operations	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years, operations	**Jobs:** 0-440 peak year, preoperations; 230-370 per year over 20 years, operations	**Jobs:** 0-440 peak year, preoperations; 230-370 per year over 20 years, operations
	Income: $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-17 million peak year, preoperations; $13-17 million per year over 20 years, operations	**Income:** $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-20 million peak year, preoperations; $14-19 million per year over 20 years, operations	**Income:** $0-20 million peak year, preoperations; $14-19 million per year over 20 years, operations
Other Facilities[g]						
Conversion	**Jobs:** 620-960 peak year, construction; 490-720 per year over 20 years, operations	**Jobs:** 670-1,030 peak year, construction; 500-750 per year over 20 years, operations	**Jobs:** 290-630 peak year, construction; 250-380 per year over 20 years, operations	**Jobs:** 420-470 peak year, construction; 270-400 per year over 20 years, operations	**Jobs:** 660-1,000 peak year, construction; 480-710 per year over 20 years, operations	**Jobs:** 670-1,010 peak year, construction; 540-800 per year over 20 years, operations
	Income: $25-41 million peak year, construction; $29-41 million per year over 20 years, operations	**Income:** $27-44 million peak year, construction; $30-42 million per year over 20 years, operations	**Income:** $14-28 million peak year, construction; $15-22 million per year over 20 years, operations	**Income:** $15-18 million peak year, construction; $16-22 million per year over 20 years, operations	**Income:** $27-45 million peak year, construction; $29-40 million per year over 20 years, operations	**Income:** $26-43 million peak year, construction; $31-44 million per year over 20 years, operations

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Socioeconomics[j] (Cont.)			
Other Facilities[g] (Cont.)						
Long-term storage	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 20 years, operations	**Jobs:** 280 peak year, construction; 490 per year over 20 years, operations	**Jobs:** 130 peak year, construction; 260 per year over 20 years, operations	**Jobs:** 160 peak year, construction; 290 per year over 20 years, operations	**Jobs:** 280 peak year, construction; 480 per year over 20 years, operations	**Jobs:** 290 peak year, construction, 480 per year over 20 years, operations
	Income: $13 million peak year, construction; $30 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $34 million per year over 20 years, operations	**Income:** $5.8 million peak year, construction; $18 million per year over 20 years, operations	**Income:** $7.7 million peak year, construction; $20 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $33 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $33 million per year over 20 years, operations
Disposal	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Ecology			
Current Storage Sites						
Habitat loss	Up to 28 acres; negligible to potential moderate impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Wetlands and threatened or endangered species	None to negligible impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Habitat loss[k]	**Conversion:** Up to 24 acres at a single facility, total of 47 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 79 acres at a single facility, total of 158 acres; potential moderate to large impacts to vegetation and wildlife	**Conversion:** Up to 30 acres at a single facility, total of 52 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 81 acres at a single facility, total of 162 acres; potential moderate to large impacts to vegetation and wildlife	**Conversion:** Up to 27 acres total; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres total; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 29 acres total; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres total; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 27 acres at a single facility, 51 acres total; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres at a single facility, 163 acres total; potential moderate to large impacts to vegetation and wildlife	**Conversion:** Up to 29 acres at a single facility, 52 acres total; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres at a single facility, 163 acres total; potential moderate to large impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (> 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste	Same as Case 1	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste	Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required), potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste	Same as Case 1	Same as Case 1
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Resource Requirements [l]			
All Sites	No effects on local, regional, or national availability of materials are expected	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
			Land Use [k]			
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Conversion	Up to 24 acres at a single facility, total of 47 acres; negligible impacts	Up to 30 acres at a single facility, total of 52 acres; negligible impacts	Up to 27 acres total; negligible impacts	Up to 29 acres total; negligible impacts	Up to 27 acres at a single facility, 51 acres total; negligible impacts	Up to 29 acres at a single facility, 52 acres total; negligible to potential moderate impacts
Manufacturing	Up to 79 acres at a single facility, total of 158 acres; potential moderate impacts	Up to 81 acres at a single facility, total of 162 acres; potential moderate impacts	Up to 84 acres total; potential moderate impacts	Up to 84 acres total; potential moderate impacts	Up to 84 acres at a single facility, 163 acres total; potential moderate impacts	Up to 84 acres at a single facility, 163 acres total; potential moderate impacts
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]	Impacts dependent on location; avoid and mitigate	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur at random locations along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

[a] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[b] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[c] Accidents with probabilities of occurrence greater than 0.01 per year.

[d] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[e] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[f] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[g] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[h] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 μg/L; this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 μg/g.

Footnotes continue on next page

TABLE K.9 (Cont.)

Footnotes (Cont.)

[i] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[j] For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[k] Habitat losses and land-use acreages given as maximum for a single site or facility, conversion facilities would also need to establish protective action distances encompassing 960 acres around the facility.

[l] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

TABLE K.10 Summary of Potential Environmental Consequences of Example 50% Use as Oxide, 50% Use as Metal Combination Alternative

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Normal Facility Operations[a]	
Radiation Exposure	
Involved workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	1 to 2 additional LCFs
Noninvolved workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[b]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[a]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	3–4 fatalities; 2,300–3,100 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[c]	
Accident[d]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	3 potential accidents

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[e]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[e]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[f]	
Accident[d]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – noninvolved workers[e]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Radiation exposure – noninvolved workers[e]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f]	
Chemical accident[d]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000 (over 20 years)
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[e]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident	Earthquake damage to storage building at conversion site
Release	Uranium (UO_2)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000 (over 20 years)

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	68 mrem
Risk of LCF	3 in 100,000
Total dose to population	5 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[e]	
Dose to MEI	2,300 mrem
Risk of LCF	9 in 10,000
Total dose to workers	210 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[a]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	4 fatalities
Maximum use of rail	1 fatality

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Transportation[a] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequeny-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident Risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[g]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)
Water and Soil[h]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[i]	No change
Other Facilities[g]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[i]	Site-dependent; none to moderate impacts
Socioeconomics[j]	
Current Storage Sites	
Continued storage	**Jobs:** 30 peak year, construction; 120 per year over 20 years operations **Income:** $1.4 million peak year, construction; $6 million per year over 20 years operations

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
	Socioeconomics*[j] *(Cont.)
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years operations **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 20 years operations
Other Facilities[g]	
Conversion	**Jobs:** 710–1,100 peak year, construction; 520–770 per year over 20 years operations **Income:** $29–47 million peak year, construction; $31–44 million per year over 20 years operations
Manufacturing	**Jobs:** 300 peak year, construction; 540 per year over 20 years operations **Income:** $14 million peak year, construction; $38 million per year over 20 years operations
	Ecology
Current Storage Sites	
Habitat loss[k]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[g]	
Habitat loss[k]	**Conversion:** Up to 29 acres at a single site; total of 56 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres at a single site; total of 170 acres; potential moderate to large impacts to vegetation and wildlife

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
	Ecology (Cont.)
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate
	Waste Management
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (> 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation
Other Facilities[g]	
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
	Resource Requirements[l]
All Sites	No effects on local, regional, or national availability of materials are expected
	Land Use
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[g]	
Conversion	Up to 29 acres at a single site; total of up to 56 acres; potential moderate impacts
Manufacturing	Up to 84 acres at a single site; total of 170 acres; potential moderate impacts

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Cultural Resources	
Current Storage Sites	Impacts unlikely
Other Facilities[g]	Impacts dependent on location; avoid and mitigate
Environmental Justice	
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse impacts to minority or low-income populations are unlikely

[a] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operation.

[b] Chemical exposures for involved workers during normal operations would depend in part on of facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[c] Accidents with probabilities of occurrence greater than 0.01 per year.

[d] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[e] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[f] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[g] Other facilities are facilities for conversion and manufacturing.

[h] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 μg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 μg/g.

[i] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

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TABLE K.10 (Cont.)

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[j] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[k] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing 960 acres around the facility.

[l] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 μm or less; UF_6 = uranium hexafluoride.

K.8 REFERENCES FOR APPENDIX K

EPA: see U.S. Environmental Protection Agency.

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APPENDIX L:

RESPONSES TO COMMENTS RECEIVED DURING THE SCOPING PROCESS FOR THE PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

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NOTATION (APPENDIX L)

The following is a list of acronyms and abbreviations used in this appendix.

ACRONYMS AND ABBREVIATIONS

General

CEQ	Council on Environmental Quality
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FR	*Federal Register*
HEU	highly enriched uranium
LEU	low-enriched uranium
MOX	mixed oxide (fuel)
NEPA	*National Environmental Policy Act*
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
USEC	United States Enrichment Corporation

Chemicals

UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

APPENDIX L:

RESPONSES TO COMMENTS RECEIVED DURING THE SCOPING PROCESS FOR THE PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

L.1 SCOPING PROCESS

The U.S. Department of Energy (DOE) issued a Notice of Intent (NOI) to prepare a programmatic environmental impact statement (PEIS) for depleted uranium hexafluoride (UF_6) on January 25, 1996, in the *Federal Register* (61 FR 2239). In addition, a letter from the project manager, copies of the NOI, a scoping comment form, and a fact sheet entitled "Overview of the Programmatic Environmental Impact Statement" were mailed to 3,800 individuals. These individuals were identified by personnel at the three DOE sites currently used for storage of depleted UF_6 and through the DOE stakeholder mailing list. Two public scoping meetings were held in the vicinity of each current storage site — Paducah, Kentucky (February 13, 1996); Oak Ridge, Tennessee (February 15, 1996); and Portsmouth, Ohio (February 20, 1996).

Information relevant to both the project and the *National Environmental Policy Act* (NEPA) process was provided through development of an Internet Home Page that includes an overview of the project, fact sheets, NEPA and Council on Environmental Quality (CEQ) regulations, access to an Internet Environmental Law Library, and links to DOE's NEPA Web and CEQ's NEPA Net. Provision for commenting on the scope of the PEIS was provided in the overview presentation on the Home Page. The computer-based overview presentation is available on CD-ROM and was available on computers at the scoping meetings. The public was also provided with a mechanism for commenting directly while viewing the computer program.

Approximately 300 persons attended the scoping meetings. DOE staff were present at information tables to receive comments directly from the attendees. In addition, the public was able to provide comments on the scope of the PEIS by filling out the scoping comment form (hardcopy or via the CD-ROM program); by mailing or faxing comments to the program office; and/or by sending an electronic mail message via the Internet. The majority of the 235 individual comments received during the scoping period were received at the scoping meetings.

The public comments are discussed in detail in the next section. All comments received at the scoping meetings, both written and oral, have been categorized as to subject and made available over the World Wide Web at the following address: http://www.ead.anl.gov/uranium.html.

L.2 ENVIRONMENTAL IMPACT ISSUES IDENTIFIED IN SCOPING

The purpose of the scoping process is to determine the range of actions, alternatives, and significant impacts to be considered in the PEIS. The comments provided by the public during this scoping process were reviewed and organized into several groups on the basis of the issues raised. The majority of comments focused on the range of technical options to be considered by DOE in constructing alternative strategies. The issues and their disposition are summarized below.

L.2.1 Environment

General environmental issues relate to the need to consider a broad range of impacts to human health and safety, water, air, land, wildlife, and socioeconomics. More specific comments relate to the need to consider radioactive decay products, health effects of specific chemicals, and trace elements.

- **Comment**: The PEIS should evaluate in detail a broad range of impacts to water, air, land, wildlife, and socioeconomic resources from all options for storage, use, disposal, or conversion of depleted UF_6.

  Response: The PEIS will cover these technical areas at a level of detail appropriate for the programmatic analysis. Site-specific details related to potential locations for facilities will be provided in follow-on NEPA documents that will be prepared prior to any future siting decisions.

- **Comment**: The PEIS should use the TRIAD model developed by the National Oceanic and Atmosphere Administration for analyzing atmospheric dispersion and releases of depleted UF_6.

  Response: The TRIAD model was evaluated by the project team, who selected a more advanced model called HGSYSTEM for use in the PEIS.

- **Comment**: The PEIS should analyze the "worst-case scenarios" for health impacts to the public and workers from all options for storage, use, disposal, or conversion of depleted UF_6.

  Response: The PEIS will consider various accident scenarios based on preconceptual designs, including reasonably foreseeable low-probability, but potentially high-consequence, events. Accidents evaluated will include those with a probability of occurrence of 1 in 1 million (10^{-6}) to 1 in 10 million (10^{-7}).

- **Comment**: The PEIS should evaluate the risks to the public from unrestricted use of depleted uranium or fluoride materials.

  Response: Due to U.S. Nuclear Regulatory Commission (NRC) radioactive material licensing requirements, among other things, commercial depleted uranium applications with limited public access are envisioned. The PEIS will evaluate the use of depleted uranium as shielding for radioactive materials for which public access is controlled. In the future, it may be possible to get an exemption from the NRC for certain depleted uranium applications. The PEIS will evaluate risks to the general public from conversion of depleted UF_6, including production of hydrogen fluoride, which would be sold.

- **Comment**: The PEIS should compare and contrast health and safety risks from all options for depleted UF_6.

  Response: The PEIS will compare and contrast health and safety risks from representative options that encompass the types of health and safety impacts related to depleted UF_6 management. The range of parameters considered in the PEIS will encompass many specific technologies and commercial processes.

- **Comment**: The PEIS should address the trace elements and contaminants in depleted UF_6 and their potential impacts upon the environment.

  Response: Depleted UF_6 is a very pure material. Decay products of uranium, which are in trace quantities, will be included in the analysis.

- **Comment**: The PEIS should evaluate the cumulative impacts upon the likely locations for all options for depleted UF_6.

  Response: Cumulative impacts for "no action" and for cylinder preparation at the three storage sites will be considered in the PEIS, as appropriate. Cumulative impacts at locations for use, conversion, storage, or disposal will be discussed qualitatively, with references to tiered NEPA reviews. Site-specific analyses of cumulative impacts at specific use, conversion, storage, or disposal locations will be presented in follow-on NEPA analyses prior to any future specific siting decisions for these activities.

- **Comment**: The PEIS should evaluate the impacts upon the DOE waste management system for all depleted UF_6 options.

  Response: The PEIS will address disposal of depleted uranium as an oxide form at a low-level-waste facility. For options involving use or storage of

depleted uranium, waste management will be analyzed for disposal or recycle of empty cylinders or by-products, as appropriate. This discussion will be based, in part, on DOE's *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE/EIS-0200-F).

- **Comment**: The PEIS should evaluate the long-term impacts from the changing chemistry and radioactive decay of uranium under the disposal options.

  Response: The PEIS analysis of disposal will include the decay products of uranium. It will be assumed that these products have a geochemical behavior similar to uranium.

L.2.2 Current Management of Depleted UF_6

Numerous comments were made regarding current management of cylinders at the Paducah site, the Portsmouth site, and the K-25 site on the Oak Ridge Reservation. These comments are summarized as follows:

- **Comment**: The PEIS should explain and evaluate current management of the cylinders at all three locations (Portsmouth, Paducah, and Oak Ridge).

  Response: The PEIS will provide a general discussion of cylinder management at the three sites and will consider the environmental impacts of "no action," which is continued cylinder management at the three sites.

- **Comment**: The PEIS should discuss the risks of current storage of the cylinders at all three locations.

  Response: The risks of current cylinder storage will be included in the PEIS.

L.2.3 Storage

A number of comments were received about alternative storage options, such as using old uranium mines or military installations. These comments are summarized below:

- **Comment**: The PEIS should evaluate a wide range of storage options, including storage in zinc mines in eastern Tennessee, transportation to a central location for consolidation, storage at retired military installations,

stringent monitoring processes, smaller size or different containers, and buildings and low-maintenance storage arrangements.

Response: The PEIS will consider a range of storage options, including storage in a mine, in yards, in buildings, and in vaults. The impacts associated with consolidating all the material at one location compared with dispersing the material at several locations will also be evaluated. The impacts of storage at specific sites, such as a retired military base, will be evaluated in follow-on NEPA analyses conducted prior to any future siting decisions.

- **Comment**: The PEIS should clarify how storage in a mine would work.

  Response: Storage in a mine will be described at the level of a preconceptual design.

- **Comment**: The PEIS should clarify how building storage would work, particularly in terms of ventilation and air controls.

  Response: The PEIS will consider a generic design for building storage. General assumptions about building performance will be made for the purpose of health and safety analysis. Particular designs for climate control and ventilation will be considered in follow-on NEPA analysis conducted prior to a decision on facility design.

- **Comment**: The PEIS should explain how the cylinders will be stored for all options.

  Response: The PEIS will explain cylinder storage for each alternative, as appropriate.

L.2.4 Conversion

A number of suggestions for conversion were made for consideration in the PEIS, which are summarized as follows:

- **Comment**: The PEIS should consider technology-specific options for conversion, such as the Quantum-Catalytic Extraction Process™.

  Response: The PEIS will conduct analyses of representative technologies in determining the impacts of various management strategy alternatives. The conversion technology options analyzed will have a sufficient technical basis to develop meaningful preconceptual designs and estimates of the

environmental data required for the PEIS analysis. After the decision is made on the long-term management strategy, specific technologies and sites will be considered in the second tier of the NEPA review process.

In response to the November 10, 1994, Request for Recommendations, a large number of promising conversion technologies were recommended that are in the early stages of design development or contain key aspects that are proprietary. In general, the proponents of these technologies believe that they offer process improvements and/or cost reductions compared with the more traditional processes. The Quantum-Catalytic Extraction Process™ is included in this category.

- **Comment**: The PEIS should consider other chemical forms for storage, such as metal, tetrafluoride, uranotile, and soddyite.

  Response: The PEIS will consider storage of depleted uranium as UF_6 and as the oxides triuranium octaoxide (U_3O_8) and uranium dioxide (UO_2). The rationale for selection of these chemical forms for analysis will be presented in the PEIS. In general, storage as metal would require substantially less storage space than the other chemical forms under consideration. This advantage must be weighed against disadvantages such as higher conversion cost, lower stability, and the uncertainty of the suitability of the metal form for eventual disposal. Uranium tetrafluoride (UF_4), or greensalt, is an intermediate form in the process of converting UF_6 to metal or converting oxide to UF_6. It is significantly more chemically reactive than uranium oxides, and no use has been identified for UF_4. Conversion into uranium-bearing minerals such as soddyite and uranotile for subsequent storage or disposal would require development of the chemical conversion process as well as examination of the suitability of such forms for storage or disposal.

- **Comment**: The PEIS should evaluate only conversion options at existing facilities, not at new facilities.

  Response: The PEIS is a programmatic-level document and will analyze conversion at representative facilities. The siting issues associated with building and operating conversion facilities at specific locations will be included in follow-on NEPA analyses conducted prior to any future siting decisions. The use of existing facilities would be evaluated when future siting decisions were made after the Record of Decision for this PEIS.

- **Comment**: The PEIS should consider shipping depleted UF_6 to Britain or France for processing.

Response: This PEIS addresses depleted UF_6 located in the continental United States and evaluates the transportation of all uranium products on a per-mile basis using U.S. national statistics. This could be applied to transport of the material to any port in the 48 contiguous states for shipment overseas. A decision as to vendors or processes for conversion of depleted UF_6 would be made after the Record of Decision for this strategic PEIS. At that time, NEPA analysis of international vendors or processes might be appropriate.

L.2.5 Use of Depleted UF_6

Many comments and suggestions were made about the use of depleted UF_6 after conversion, which are summarized as follows:

- **Comment**: The PEIS should consider the recovery (reenrichment) of uranium-235 from depleted UF_6.

  Response: Recovery of uranium-235 is a potential reason for storing depleted uranium. Long-term storage is a management option that would preserve some or all of the inventory of depleted UF_6 for use. The viability of refeeding depleted UF_6 is a function of the isotopic assay of depleted UF_6 and many uncertain factors in the future, such as uranium ore price, separative work cost, and demand. The PEIS will briefly discuss these factors.

- **Comment**: The PEIS should evaluate recycling cylinders as scrap steel.

  Response: The PEIS will address the issue of including empty cylinders in ongoing studies related to DOE's Recycle 2000 initiative for recycle of scrap metals.

- **Comment**: The PEIS should include use of depleted uranium in concrete as aggregate, including use in Hanford reactors.

  Response: Use of depleted uranium oxide in concrete for shielding purposes will be analyzed in the PEIS. The analysis of this technology at specific facilities will be addressed in follow-on NEPA analyses prior to any siting decisions.

- **Comment**: The PEIS should include use of depleted uranium for backfill material in spent nuclear fuel packages.

  Response: The PEIS will evaluate the use of depleted uranium for spent nuclear fuel shielding applications.

- **Comment**: The PEIS should include use of depleted uranium for blending highly enriched uranium (HEU) to produce low-enriched uranium (LEU) or for use in mixed-oxide (MOX) fuels.

  Response: The no action alternative and long-term storage alternatives preserve these options for later use of depleted uranium for blending HEU into LEU or in MOX nuclear fuels (see *Storage and Disposition of Weapons-Usable Fissile Materials, Final Programmatic Environmental Impact Statement*, DOE/EIS-0229, December 1996). The quantity of depleted uranium potentially used for these applications would be very small compared with the representative uses that will be considered in the Depleted UF_6 PEIS.

- **Comment**: The PEIS should evaluate separate uses for depleted uranium and fluorine.

  Response: The PEIS will analyze representative uses for the depleted uranium from depleted UF_6 and will assume that the fluorine from depleted UF_6 has commercial value as anhydrous hydrogen fluoride and would be sold.

- **Comment**: The PEIS should evaluate only feasible and attainable uses.

  Response: The representative options to be evaluated in the PEIS were selected because they are feasible and attainable in a reasonable time frame.

- **Comment**: The extent of uses in the general population and demands for such uses should be analyzed in the PEIS.

  Response: The demand for depleted UF_6 is an economic issue that is outside the scope of the PEIS because the need for management of depleted UF_6 is based on prudent management, not on demand. Such issues as the demand for depleted uranium — including existing data on potential uses, percent of inventory for current or future uses, and optimal form of depleted uranium for use — are discussed in the engineering and cost analysis reports, which will also support the decision on management strategy.

- **Comment**: The PEIS should consider the assay level (e.g., 0.2% uranium-235 compared with 0.4% uranium-235) as a discriminator for uses.

  Response: A homogeneous assay level is being assumed for this programmatic-level analysis. At a later time, when disposition of individual cylinders is decided, assay level will become an important consideration.

L.2.6 Cost

A number of issues were expressed with regard to costs. Some indicated that DOE should not spend a lot of money on the problem of depleted UF_6 management, whereas others indicated that costs and benefits of the options should be considered. Specific comments were grouped into the following major issues:

- **Comment**: The PEIS should present and evaluate costs for all depleted UF_6 management options. Costs should be kept to a minimum by using proven processing procedures, selling by-products, and using competitive bid processes.

  Response: A separate cost analysis report is being prepared, which will be considered in preparing the Record of Decision. The PEIS will discuss costs as they relate to socioeconomic impacts.

- **Comment**: The PEIS should explain the value of the materials in economic terms.

  Response: The value of the materials is being addressed separately in a cost analysis report.

L.2.7 Disposal

The disposal options for depleted UF_6 elicited comments regarding waste definitions and waste disposal options, as follows:

- **Comment**: The PEIS needs to evaluate the impacts of disposal in the event that depleted UF_6 were to be classified as a transuranic waste.

  Response: Depleted UF_6 is a source material. For purposes of the disposal options, it is being assumed that depleted UF_6 will be converted into an oxide and, in oxide form, will be treated as a low-level waste. The PEIS will evaluate the health and environmental impacts of such disposal.

- **Comment**: The PEIS should consider additional options for disposal, such as disposal in sedimentary formations on the ocean floor, vitrification with the molten glass or other techniques, disposal in old missile silos, or returning UF_6 to its original state and to its original source (i.e., uranium mines).

  Response: The PEIS will analyze a set of options that are anticipated to bound most possibilities for disposal. However, some options are subject to

institutional constraints, are speculative in nature, are in an unknown state of technical development, or have exorbitant costs. The PEIS will describe why certain options were considered in less detail or were judged to be unreasonable.

L.2.8 Transportation

It was suggested that barge transportation be considered in the PEIS:

- **Comment**: The PEIS should fully evaluate the transportation impacts from all options for depleted UF_6, especially barge transport (including shipping standards and emergency preparedness).

  Response: Transportation impacts will be discussed generally in the PEIS for representative routes and representative sites. Decisions on the locations of potential conversion, manufacturing, storage, or disposal facilities would be made after the Record of Decision for this PEIS. At that future time, barge transportation might be appropriate and would be analyzed in any accompanying NEPA documentation. This PEIS will include a qualitative discussion of the results of analyses conducted for other NEPA documents that compare barge transport to truck and rail transport, and a statement that future studies or NEPA analyses supporting siting decisions for conversion, manufacturing, storage, or disposal facilities will consider the transport of depleted UF_6 by barge, as appropriate.

L.2.9 Policy

Policy issues are higher level issues that could affect the whole PEIS structure and content. A number of these issues were included in the public comments, as follows:

- **Comment**: The PEIS should explain how its decisions fit within the context of other DOE decisions on materials.

  Response: The PEIS will explain how the programmatic depleted UF_6 decision (how best to manage depleted UF_6 in the future) fits with other related DOE decisions and programs currently under consideration.

- **Comment**: The PEIS should evaluate treatment, storage, and disposal of depleted UF_6 as a waste material.

Response: Depleted UF_6 is a source material. The disposal options considered in the PEIS assume conversion of depleted UF_6 to an oxide, with subsequent disposal. Uranium oxides are generally suitable forms for storage (and disposal). The impacts associated with both storage and disposal of U_3O_8 and UO_2 will be examined.

- **Comment**: The PEIS should explain the time frames for the options and provide some support for those time frames.

  Response: Time frames for the various phases of the options will be discussed in general terms within the PEIS.

- **Comment**: The PEIS should evaluate all depleted UF_6 materials in the United States, both existing stocks and those for the foreseeable future.

  Response: The PEIS will analyze a depleted UF_6 inventory accumulated by DOE and its predecessor agencies at Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. The analysis will cover the period from 1945 through July 1, 1993, at which time the United States Enrichment Corporation (USEC), a government-owned corporation, was created to operate the Paducah and Portsmouth gaseous diffusion plants. Discussions between the Office of Management and Budget, USEC, and DOE are continuing regarding a Memorandum of Agreement, as provided in Section 3109(a)(2) of the USEC Privatization Act. This Memorandum of Agreement will allocate liabilities that arise from USEC's operations prior to privatization among DOE, USEC, the United States Government, and the new private corporation, including those liabilities arising from the disposal of depleted uranium, currently stored as UF_6, that was generated by USEC. The draft PEIS will address DOE's role in the management of this depleted uranium consistent with the terms of the Memorandum of Agreement. Because the new corporation will be responsible for the management of depleted UF_6 that it generates after privatization, DOE's role in the future disposal of this material is uncertain and speculative at this time. DOE will fulfill its NEPA responsibilities, as appropriate, when decisions are made in the future regarding the disposition of depleted UF_6 generated by the private corporation.

- **Comment**: DOE should include the NRC, the U.S. Environmental Protection Agency (EPA), and the Nevada Test Site in the discussions of disposal options for depleted UF_6.

  Response: Other federal agencies, including NRC and EPA, will be consulted during the PEIS comment process. The Nevada Test Site, a DOE site, will be asked for comments.

- **Comment**: The PEIS should analyze options for privatizing all facilities considered in the options for depleted UF_6.

  Response: The privatization of facilities will be considered qualitatively in the PEIS.

- **Comment**: DOE needs to identify the sources of funds that will be used for this program.

  Response: The issue of program funding is outside the scope of this NEPA analysis, which addresses impacts to the natural and human environment.

L.2.10 Other Issues

Other issues are not easily categorized and therefore have been placed at the end of the discussion of topics brought up during public scoping. These issues are summarized as follows:

- **Comment**: The PEIS should consider what other nations such as Japan and France have done with regard to depleted UF_6.

  Response: Part of the engineering development for options considered technologies in other countries.

- **Comment**: The PEIS should fully explain the need for taking any actions for depleted UF_6.

  Response: The PEIS will explain the purpose and need for the action.

- **Comment**: The PEIS should have a smaller list of alternatives so that the decisions and impacts can be clearly understood.

  Response: The PEIS will attempt to minimize the list of options and alternatives in order to clearly lay out the environmental effects for the decision makers and the public.

APPENDIX M:

CONTRACTOR DISCLOSURE STATEMENT

APPENDIX M:

CONTRACTOR DISCLOSURE STATEMENT

Argonne National Laboratory (ANL) is the contractor assisting DOE in preparing the PEIS for depleted UF_6. DOE is responsible for reviewing and evaluating the information and determining the appropriateness and adequacy of incorporating any data, analyses, or results in the PEIS. DOE determines the scope and content of the PEIS and supporting documents and will furnish direction to ANL, as appropriate, in preparing these documents.

The Council on Environmental Quality's Regulations (40 CFR 1506.5(c)), which have been adopted by the U.S. Department of Energy (10 CFR Part 1021), require contractors who will prepare an Environmental Impact Statement to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for the purposes of this disclosure is defined in the March 23, 1981, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 *Federal Register* 18026-18028 at Questions 17a and 17b. Financial or other interest in the outcome of the project includes "any financial benefit such as promise of future construction or design work on the project, as well as indirect benefits the consultant is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients"), 46 *Federal Register* 18026-18038 at 10831.

In accordance with these regulations, Argonne National Laboratory hereby certifies that it has no financial or other interest in the outcome of the project.

Certified by:

Anthony J Dvorak

Signature

Anthony J. Dvorak

Name

Director, Environmental Assessment Division

Title

September 6, 1996

Date

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APPENDIX N:

PUBLIC LAW 105-204

Public Law 105–204
105th Congress

An Act

To require the Secretary of Energy to submit to Congress a plan to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to treat and recycle depleted uranium hexafluoride.

July 21, 1998
[S. 2316]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. UNITED STATES ENRICHMENT CORPORATION.

President.

Ohio.

(a) PLAN.—The Secretary of Energy shall prepare, and the President shall include in the budget request for fiscal year 2000, a plan and proposed legislation to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to commence construction of, not later than January 31, 2004, and to operate, an onsite facility at each of the gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio, to treat and recycle depleted uranium hexafluoride consistent with the National Environmental Policy Act.

(b) LIMITATION.—Notwithstanding the privatization of the United States Enrichment Corporation and notwithstanding any other provision of law (including the repeal of chapters 22 through 26 of the Atomic Energy Act of 1954 (42 U.S.C. 2297 et seq.) made by section 3116(a)(1) of the United States Enrichment Corporation Privatization Act (104 Stat. 1321–349), no amounts described in subsection (a) shall be withdrawn from the United States Enrichment Corporation Fund established by section 1308 of the Atomic Energy Act of 1954 (42 U.S.C. 2297b–7) or the Working Capital Account established under section 1316 of the Atomic Energy Act of 1954 (42 U.S.C. 2297b–15) until the date that is 1 year after the date on which the President submits to Congress the budget request for fiscal year 2000.

APPENDIX O:

SUMMARY OF THE ENGINEERING ANALYSIS REPORT*

*Please note that this entire Appendix O has been added after the public comment period.

UCRL-ID-124080

Depleted Uranium Hexafluoride Management Program

Summary of the ENGINEERING ANALYSIS REPORT for the Long-term Management of Depleted Uranium Hexafluoride

Prepared for the Department of Energy by
Lawrence Livermore National Laboratory

September 1997

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DISCLAIMER

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Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

Summary of the ENGINEERING ANALYSIS REPORT for the Long-Term Management of Depleted Uranium Hexafluoride

Note: This summary condenses and simplifies a number of technical issues and ideas. To obtain a fuller understanding of particular issues and ideas, the reader is urged to consult the complete *Engineering Analysis Report.*

1. Introduction

The Department of Energy is reviewing ideas for the long-term management and use of its depleted uranium hexafluoride.

The Department of Energy (DOE) owns about 560,000 metric tons (over a billion pounds) of depleted uranium hexafluoride (UF_6). This material is contained in steel cylinders located in storage yards near Paducah, Kentucky, and Portsmouth, Ohio, and at the East Tennessee Technology Park (formerly the K-25 Site) in Oak Ridge, Tennessee.

Uranium hexafluoride (UF_6) is a compound of one part uranium to six parts fluorine. At room temperature, it is a white solid similar to rock salt. It is usually measured in metric tons (MT). One MT equals about 2200 pounds.

On November 10, 1994, DOE issued a Request for Recommendations and an Advance Notice of Intent in the *Federal Register* (59 FR 56324 and 56325) to initiate the consideration of alternative strategies for the long-term management and use of depleted UF_6. The first part of the Depleted UF_6 Management Program consists of engineering, cost, and environmental impact studies. Part one will conclude with the selection of a long-term management plan, or strategy. Part two will carry out the selected strategy.

1.1 Background—What Is Depleted Uranium Hexafluoride?

Uranium is made up of several different types of atoms. One of these, uranium-235 (U-235), can be made to split apart and release a large amount of energy. As found in nature, uranium contains only a very small amount of U-235. In order for uranium to produce significant amounts of energy, the percentage of U-235 must be increased. For example, uranium fuel for powerplants usually contains between three and five percent U-235, while natural uranium contains only about 0.71 percent U-235. Uranium with more than 0.71 percent U-235 is called "enriched" uranium.

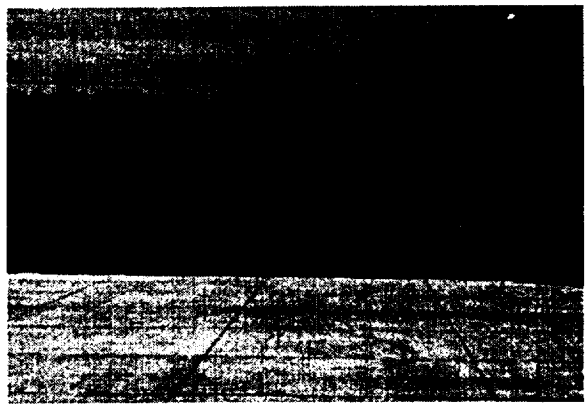
The enrichment process used in the United States is gaseous diffusion. It was first used on a large scale in the 1940s as part of the Manhattan Project in Oak Ridge, Tennessee. Later, plants were also built at Paducah, Kentucky, and Portsmouth, Ohio. On July 1, 1993, DOE leased these two plants to the United States Enrichment Corporation, as required by the Energy Policy Act of 1992. Oak Ridge had stopped enriching uranium in 1985.

The first step in gaseous diffusion is to heat solid natural UF_6 until it becomes a gas. The UF_6 gas is repeatedly separated into two streams. Gradually, one stream gains U-235, while the other loses U-235. When the U-235 in this second stream has been reduced to between 0.2 and 0.4 percent, the depleted UF_6 is removed from processing and placed in storage. Between 1945 and July 1, 1993, about 560,000 MT of depleted UF_6 was stored at the three gaseous diffusion plant sites.

Why is there so much depleted UF_6? For every pound of enriched uranium, between eight and nine pounds of depleted uranium are produced.

DOE's depleted UF_6 is stored in a partial vacuum inside steel cylinders. Most cylinders are about twelve feet long and 48 inches in diameter and hold between 9 and 12 MT of solid depleted UF_6. In all, there are 46,422 cylinders:

28,351 at Paducah
13,388 at Portsmouth
4,683 at Oak Ridge.



Depleted UF_6 is stored in cylinder yards like this one at Portsmouth.

1.2 Selecting a Management Strategy

The current management strategy is to continue safe storage of the depleted UF_6 cylinders in the existing storage yards. Activities in this strategy include inspection, handling, monitoring, and maintenance, as needed, to keep the cylinders in good condition. Other possible management strategies could involve use of the depleted uranium, long-term storage, disposal, or some combination of these. A complete management strategy may include a number of different activities. Examples are transportation or conversion of the depleted UF_6 to another chemical form, such as an oxide or metal.

The *Draft Programmatic Environmental Impact Statement* (Draft PEIS) looks at alternative strategies for the long-term management of depleted UF_6. They include the current management strategy (the "No Action alternative"), two alternatives for long-term storage, two alternatives for use, and one for disposal. DOE's preferred alternative is to use 100 percent of the depleted uranium, either as uranium oxide or uranium metal, or a combination of both. The fluorine in the depleted UF_6 would also be used.

The *Engineering Analysis Report* contains the technical data on which the Draft PEIS and the cost analysis are based. The PEIS, the *Cost Analysis Report*, and the *Engineering Analysis Report* will help DOE select a management strategy. The Record of Decision is expected in 1998.

2. The Engineering Analysis Project

Data from the engineering analysis will help DOE compare the environmental impacts and costs of management strategy alternatives.

In November 1994, DOE asked members of the public, industry, and other government agencies to submit recommendations for the use or long-term management of depleted UF_6. Fifty-seven replies were received and reviewed by independent technical experts. The results were published in the *Technology Assessment Report* in June 1995. Most of the recommendations were judged to be feasible, or capable of being carried out now or in the near future. These ideas and technologies were analyzed in more detail.

The main part of the Engineering Analysis Project developed engineering data for the feasible technology options. The data include general layouts for facilities, descriptions of processes, and analysis of hazards.

2.1 Work Breakdown Structure

A work breakdown structure shows the work that will need to be done on a project, moving from a general level to more and more detailed levels. It provides an orderly way to analyze and compare complex management strategies. Figure 1 shows the first three levels of the work breakdown structure for depleted UF_6 management.

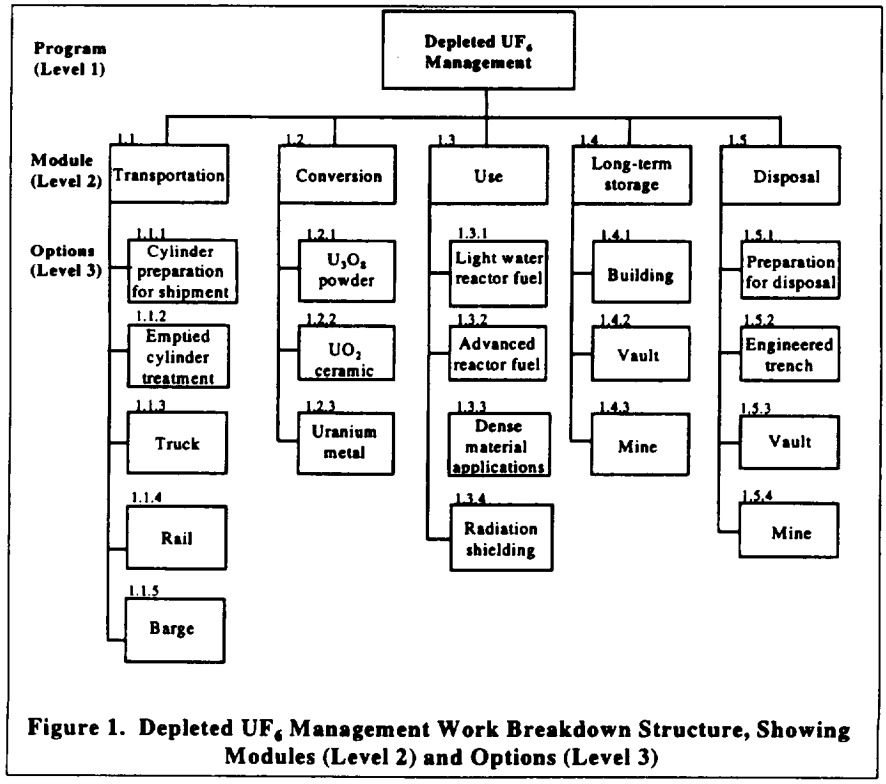


Figure 1. Depleted UF_6 Management Work Breakdown Structure, Showing Modules (Level 2) and Options (Level 3)

The recommendations received early in the Engineering Analysis Project fell into several general categories. These general categories are called modules because they are the most basic building blocks for management strategies (see Level 2 in Figure 1). The modules are transportation, conversion, use, long-term storage, and disposal. Most management strategy alternatives combine two or more of these five modules. For example, conversion of the depleted UF_6 to another chemical form is involved in the use and disposal alternatives and in one of the long-term storage alternatives. Transportation of materials occurs in all strategies except the No Action alternative.

In each module, there are various options (Level 3 in Figure 1), or different ways of doing things. For example, in the long-term storage module there are three different options for the type of facility in which the depleted uranium could be stored: building, vault, and mine.

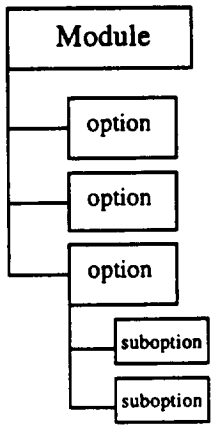


Figure 2. Modules are broken down into options. Options are broken down into suboptions.

The next level of detail after options is called suboptions. For example, the long-term storage facility types are further broken down by the forms of depleted uranium which might be stored in each. Figure 2 shows the general relationship among modules, options, and suboptions.

The *Engineering Analysis Report* focuses on technology options and suboptions. Data for the options and suboptions can be combined to provide overall data for alternatives. To get a better idea of how options and suboptions were linked together to form management strategy alternatives, see Figure 3, which appears at the end of this Summary.

2.2 Methodology

The *Engineering Analysis Report* contains 13 Engineering Data Input Reports, covering the specific options and suboptions named in the unshaded boxes in Table 1. These are the options and suboptions which were analyzed in depth. Options and suboptions which were analyzed in less detail are discussed in Chapter 4 of the *Engineering Analysis Report.*

Each Data Input Report includes layouts for facilities, descriptions of processes, estimates of wastes and emissions, estimates of resources and workers needed, hazard assessments, accident scenarios, and transportation information. The data are estimates based on an early stage of design. More detailed data for specific technologies will be developed in the second part of the Program.

Table 1. Options and Suboptions for the Various Modules

(Note: shaded boxes are principal options and suboptions analyzed in less detail)

Transportation Module		Conversion Module		Use Module		Long-Term Storage Module		Disposal Module	
Options	Suboptions	Options	Suboptions	Options	Suboptions	Options	Suboptions	Options	Suboptions
Cylinder preparation for shipment	• Current cylinders • Over-container • Transfer facility	U_3O_8 powder	• Dry process with AHF* • Dry process with HF neutralization	Light water reactor fuel	• Re-enrichment	Building	• UF_6 • U_3O_8 • UO_2	Preparation for disposal	• U_3O_8 cemented • UO_2 cemented • U_3O_8 bulk • UO_2 bulk
Emptied cylinder treatment	• Cylinder treatment facility	UO_2 ceramic	• Dry process with AHF* • Dry process with HF neutralization • Wet process (gelation) with AHF*	Advanced reactor fuel	• Breeder and other fast reactors			Engineered trench	• U_3O_8 cemented • UO_2 cemented • U_3O_8 bulk • UO_2 bulk
Truck	• UF_6 in current or new cylinders or over-container • Depleted uranium conversion products • Metal or oxide shields • By-products, chemicals, and wastes			Dense material applications	• Existing applications: munitions, armor, counter-weights, ballasts • New applications	Vault	• U_3O_8 • UO_2		
Rail		U metal	• Batch reduction					Vault	• U_3O_8 cemented • UO_2 cemented • U_3O_8 bulk • UO_2 bulk
Barge	• UF_6 in current or new cylinders or over-container		• Continuous reduction	Radiation shielding	• UO_2 • U metal	Mine	• UF_6 • U_3O_8 • UO_2	Mine	• U_3O_8 cemented • UO_2 cemented • U_3O_8 bulk • UO_2 bulk

* Anhydrous hydrogen fluoride (HF)

Examples of assumptions used in the engineering analysis:

- Total time for project: 20 years.
- Processing rate: 28,000 MT (60 million pounds) of depleted UF_6 per year.
- Each of the different forms of depleted uranium would always have the same bulk density and the same type of packaging for transportation.
- Facilities are newly built on previously unused sites.

To make it easier to compare the different options and suboptions, data were based on certain common assumptions.

Estimates based on different processing rates (50 percent and 25 percent of the assumed rate) were made for several technologies and are included in Chapter 8 of the *Engineering Analysis Report.*

Each Engineering Data Input Report includes its own analysis of reasonably foreseeable accidents involving radiological or hazardous materials. There is also an accident analysis in Chapter 7 which discusses two particular types of accidents: (1) accidents associated with depleted UF_6 cylinder handling and storage and (2) accidents which would have significant hazardous and/or radiological material releases but have a very low probability. In general, the higher the consequences of an accident, the less frequently such an accident is likely to occur. The accidents discussed in Chapter 7 are what are called "incredible" accidents, which means that their likelihood of occurrence is between once in one million years and once in ten million years.

The *Engineering Analysis Report* also includes discussions of license, permit, and regulatory requirements and changes in regulations for the transportation of depleted UF_6 cylinders.

3. Summary of Options Analyzed in Depth

Feasible technologies for which data could be developed were analyzed in depth.

Options which were judged to be feasible in the *Technology Assessment Report* were analyzed in depth. These are general types of technologies, but they have enough technical basis to allow engineers to develop the data needed for estimates of environmental impacts and costs. Additional options, most of which are at an earlier stage of development, were also considered. These are described in the *Engineering Analysis Report* but are analyzed in less detail.

This section describes the technology options and suboptions which were analyzed in depth. They are grouped into the five modules in the work breakdown structure. The modules are printed in boldface type and the options are underlined. Table 1 gives an overall summary of the information.

3.1 Transportation Module

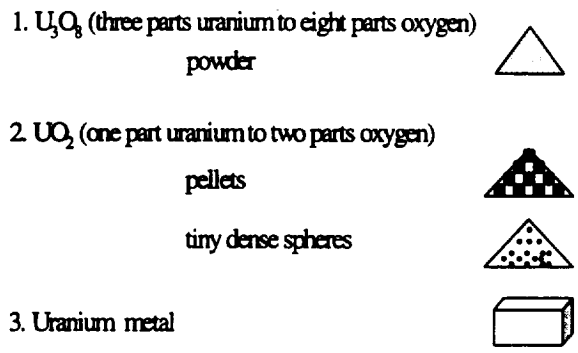
All of the Engineering Data Input Reports include a discussion of transportation of materials by both truck and rail. Materials which would be transported would include depleted UF_6, depleted uranium in other chemical forms (after conversion), manufactured products for use, and other materials such as by-products and wastes.

Two transportation options, preparation of depleted UF_6 cylinders for shipment and treatment of emptied cylinders, are analyzed in their own individual Data Input Reports.

Cylinder Preparation for Shipment. All alternatives in the Draft PEIS, except for the No Action alternative, assume that depleted UF_6 cylinders will be moved from their current locations. Transportation of cylinders is regulated by the Department of Transportation (DOT). These regulations involve (1) the amount of depleted UF_6 inside the cylinder, (2) the pressure inside the cylinder, and (3) the condition of the cylinder, especially the thickness of the steel walls. Some cylinders meet the DOT requirements and would require minimal preparation; however, some would require additional work to meet DOT regulations.

There are two suboptions for preparing these nonconforming cylinders. In the overcontainer suboption, the cylinder would be placed inside a container which meets DOT regulations. In the transfer facility suboption, the depleted UF_6 would be transferred to a new cylinder. Using the overcontainer would require less handling and produce less waste. It would also avoid the construction of a special facility. A transfer facility would be expected to have greater impacts, but it could be used in developing an alternative for long-term storage of depleted UF_6 in new cylinders.

Emptied Cylinder Treatment. In most of the management strategies, the depleted UF_6 would be taken out of the cylinders and converted to another chemical form. Any depleted UF_6 left in the emptied cylinder (called the "heel") would be washed out with water. After the water evaporates, the mixture of depleted uranium and fluorine would be converted to solid uranium oxide and hydrogen fluoride



UF_6 Conversion Products

(HF) gas. Hydrogen fluoride gas is corrosive. To neutralize it, or make it harmless, lime would be added, forming calcium fluoride (CaF_2). The analysis assumes that the cleaned, emptied cylinders will be stored as scrap metal.

3.2 Conversion Module

Most management strategy alternatives require converting the depleted UF_6 to another chemical form. Three other chemical forms of depleted uranium are analyzed in depth: triuranium octaoxide (U_3O_8) powder, uranium dioxide (UO_2) ceramic, and uranium metal. The oxides are compounds of uranium and oxygen. Because the oxides are very stable and slow to dissolve in water, they are presently the preferred forms for long-term storage and disposal. Very dense depleted UO_2 and depleted uranium metal are preferred for use in shielding for spent nuclear fuel because they are good at absorbing the kind of radiation called gamma rays. Depleted uranium metal is preferred for most dense material applications, which need high density and mass.

Conversion starts by heating solid depleted UF_6 to produce a gas. All the conversion processes being analyzed in depth produce large quantities of hydrogen fluoride (HF). Uranium hexafluoride and HF are the most significant chemical hazards to the environment and workers during conversion. The designs for the conversion process buildings and the HF storage buildings use reinforced concrete for added safety. Temperatures in the HF storage buildings would be kept between 45° and 55° Fahrenheit. This would prevent the HF from becoming a gas that a worker might inhale in case of a spill.

The conversion facilities would be expected to operate about 7000 hours per year. They would have enough outdoor storage for one month's supply of full depleted UF_6 cylinders. There would also be enough indoor storage space for three months' supply of nearly empty cylinders. This would allow time for short-lived radioactive products in the heel to decay before the cylinders are treated or shipped off site. The facilities would include storage for one month's production of the new depleted uranium form and one month's production of HF.

<u>U_3O_8 Option.</u> Two suboptions are analyzed for converting depleted UF_6 to depleted U_3O_8. (The conversion of UF_6 to an oxide is referred to as "defluorination" because fluorine atoms are removed.) Both suboptions use a two-step process in which depleted UF_6 reacts with steam at high temperatures. This is called a "dry" process, as opposed to "wet" processes, in which the main reactions occur in water. The process produces depleted U_3O_8 in fluffy powder form and concentrated HF, which is about 70 percent HF and about 30 percent water. After the depleted U_3O_8 is compacted, it would have a bulk or packing density of about 3 grams per cubic centimeter (about 1 3/4 ounces per cubic inch).

The first U_3O_8 suboption uses distillation to reduce the water content in the concentrated HF to one percent or less. The resulting HF vapor is called anhydrous HF (AHF), meaning that it has very little water. It is expected that the uranium content will be low enough that the AHF can be sold for use. The second U_3O_8 suboption would neutralize the HF to produce CaF_2 for sale or disposal.

UO_2 Option. Uranium dioxide in the ceramic form is very dense. Depending on the shape and size of its particles, the UO_2 will generally be two to three times denser than compacted U_3O_8 powder. The denser product would require less space for storage or disposal. The denser form could also be used in depleted uranium concrete for radiation shielding.

There are three suboptions for converting depleted UF_6 to depleted UO_2. Two of them use a dry process (similar to the one described above for U_3O_8) to make UO_2 powder. The UO_2 powder is pressed into pellets about 2 centimeters (3/4 inch) in diameter. To increase their density, the pellets are then heated at about 1700° centigrade (about 3092° Fahrenheit). The furnaces are expected to be larger than those currently used in nuclear fuel manufacturing plants. One of the dry process suboptions provides an AHF by-product and the other neutralizes the HF.

The third technology suboption is based on a "wet" process which produces dense depleted UO_2 in the form of very small spheres of a millimeter (about 1/20 inches) or less in diameter. These tiny particles can be packed very close. The process, called "gelation," dissolves U_3O_8 in an acid. Various chemicals are added and the solution is fed through nozzles which break it into small droplets. These droplets are then decomposed into jelly-like spheres of depleted uranium oxide. These are further processed and finally heated at high temperatures. Gelation has yet to be proven as an industrial process; therefore, the technological uncertainties with the wet process are greater than with the more developed dry processes.

Uranium Metal Option. The analysis considers two suboptions, a batch process and a continuous process, for converting depleted UF_6 to depleted uranium metal. Both processes start by combining depleted UF_6 with hydrogen to make depleted uranium tetrafluoride (UF_4) and AHF. In the second step, magnesium (Mg) is used to remove the fluorine from the UF_4 (known as "reduction"). Because it uses a metal, Mg, and takes place at high temperatures, this process is called "metallothermic reduction."

The batch process is the standard industrial process. A mixture of depleted UF_4 and Mg metal is heated in a sealed steel container until it forms liquid depleted uranium metal and a magnesium fluoride (MgF_2) by-product. The denser uranium metal settles to the bottom and the MgF_2 collects on top. After the container has cooled, the solid depleted uranium metal and MgF_2 are removed and separated from each other. The by-product contains some uranium. Without further treatment, it would have to be disposed of as a radioactive low-level waste. The design for the batch process includes a step for removing uranium from the MgF_2. It is assumed that, after this step, the MgF_2 could be disposed of as a nonradioactive, nonhazardous solid waste.

The other suboption analyzed in depth is the continuous process, which is currently being developed. In this process, depleted UF_4 and Mg are continuously fed into a heated container. The dense liquid uranium metal settles to the bottom and is removed. The liquid MgF_2 forms a middle layer and is separately removed. The liquid Mg floats on the top.

The continuous process has three possible advantages over the batch process: (1) a higher processing rate, (2) a lower level of uranium in the by-product, and (3) a liquid depleted uranium product which could be directly formed into an end product. The early design assumes that the amount of uranium in the by-product will be small enough that a decontamination step would be unnecessary. Based on the design, the continuous process would have a lower cost than the batch process. However, since the continuous process is still being developed, the technological uncertainties are greater.

3.3 Use Module

The use option analyzed in depth is to make depleted uranium into a shielding material to put around spent nuclear fuel. The fuel in nuclear powerplants has to be replaced every so often. The used-up, or spent, nuclear fuel (SNF) is still radioactive and must be shielded. The *Engineering Analysis Report* analyzes two suboptions for use as radiation shielding, but this is only one of several possible uses for depleted uranium. Other uses include fuel for light (regular) water reactors or advanced reactors and dense material applications. Section 4.3 discusses use options which were analyzed in less detail. The two radiation shielding suboptions analyzed in depth are examples of possible uses.

Radiation Shielding Option - UO_2 Suboption. This suboption would use depleted uranium in the form of UO_2 pellets. These dense pellets can be used instead of gravel to make concrete shielding for SNF storage containers. Depleted uranium concrete, also known as DUCRETE™, provides shielding with less weight and bulk than regular concrete. It might also be usable in overcontainers for SNF disposal, but this use has yet to be developed.

In the designs for storage containers, the depleted uranium concrete is enclosed inside stainless steel. The shielding manufacturer receives partly finished steel shells and other parts and puts the containers together in one building. In another building, where radiological materials can be handled, depleted UO_2 pellets from a conversion plant are combined with sand, cement, and water, and the depleted uranium concrete is poured between the stainless steel shells. After the cement hardens, the container is completed.

Radiation Shielding Option - Uranium Metal Suboption. This suboption would manufacture depleted uranium metal into shields for use inside a multi-purpose unit system. A multi-purpose unit is a container that would provide confinement of SNF during storage, transportation, and disposal.

In this design, the manufacturer receives depleted uranium metal (or alloy), partly completed stainless steel or metal alloy shells, and other pieces to enclose the uranium metal. The containers are put together in one building. In a separate building, where radiological materials can be handled, the depleted uranium metal is melted and poured between the steel or alloy shells. After the depleted uranium metal cools, the container is completed.

3.4 Long-Term Storage Module

Long-term storage means that the depleted uranium could be used at some later date. Three long-term storage options are analyzed in depth: (1) storage in a building, (2) storage in a below ground vault, and (3) storage in a mine. The suboptions are the chemical forms in which the depleted uranium is stored. Three forms are considered for storage in buildings or mines: UF_6, U_3O_8, and UO_2. Two forms are considered for storage in vaults: U_3O_8 and UO_2. These chemical forms have very different bulk densities. A denser product takes up less space and could therefore cost less to store. This analysis assumes that the tiny, dense UO_2 spheres produced by the gelation process would need the least storage space and U_3O_8 powder would need the most storage space.

The building option uses metal framed buildings for storage. The below ground vault would be made of reinforced concrete with a steel roof supported by trusses. Storage in a mine would use underground tunnels.

3.5 Disposal Module

The engineering analysis for this module considers three options for disposal: (1) disposal in an engineered trench, (2) disposal in a below ground vault, and (3) disposal in a mine. The engineered trench is an 8-meter (26-foot) deep trench covered with a sloping cap of closely packed clay and other barriers. This option would work best in drier areas.

A form which is stable and slow to dissolve is preferred for disposal. Therefore, the chemical forms analyzed for disposal are the oxides, U_3O_8 and UO_2. In addition, the depleted uranium oxide powder or pellets may either be mixed with cement before disposal or disposed of in bulk form inside drums. Altogether, there are four waste form suboptions: (1) cemented U_3O_8, (2) cemented UO_2, (3) bulk U_3O_8, and (4) bulk UO_2. Each disposal facility option is analyzed for all four waste forms.

The analysis covers a wide range of conditions, including variations in the climate and geology of possible disposal locations and variations in the amount of disposal space needed. Cemented U_3O_8 requires the most space because U_3O_8 is less dense than UO_2 and because the cement adds to the mass. The form requiring the least space for disposal is bulk UO_2.

All the disposal facility designs include a waste form facility (preparation for disposal option). This is where the depleted uranium oxide is received from the conversion plant. For cemented waste forms, preparation would include mixing the oxide with cement, repackaging it in new or recycled drums, and allowing it to harden. Bulk waste forms would require less preparation.

4. Summary of Principal Options and Technologies Analyzed in Less Detail

Technologies analyzed in less detail in this part of the Program are preserved for the second part of the Program.

Most of the options considered in the engineering analysis were replies to DOE's Request for Recommendations. The technologies discussed in Section 3 are general types, but they have enough technical basis to allow engineers to develop data which can be used to estimate environmental impacts and costs. A number of other technologies were also recommended. These options are promising but are analyzed in less detail for one or more of the following reasons: they are in earlier stages of design or development; they would take more time than the 20-year schedule assumed in this analysis; they are proprietary; they involve uses of depleted uranium which are already in practice.

Technologies analyzed in less detail during the first part of the Depleted Uranium Hexafluoride Program are still available for consideration for the next part of the Program. These technologies are briefly described below. The options and suboptions analyzed in depth are general enough that the estimates made could cover a variety of specific technologies.

4.1 Transportation Module

Transport by barge was considered. However, at this time the locations for most activities are unknown and the possibility of using barge transportation is uncertain. All three gaseous diffusion plant sites mainly use ground transportation. Except for the East Tennessee Technology Park, facilities for using barges would have to be developed.

4.2 Conversion Module

Many good ideas for conversion technologies were submitted. In general, they are in the early stages of design or development. Some of them are also proprietary. When more fully developed, these processes might offer such advantages as more flexibility, fewer processing steps, reduced environmental impacts, lower costs, and higher profits.

Uranium Oxide Suboptions. A number of responses recommended using the well-known dry process for converting UF_6 to an oxide with an AHF by-product. There were also several recommendations for newer technologies with important features. One example uses a wet process to convert depleted UF_6 to an intermediate compound which is then heated and converted to depleted U_3O_8. Anhydrous hydrogen fluoride is directly produced. Another technology uses a liquid metal such as iron to speed up the decomposition of depleted UF_6. Afterwards, uranium oxides and AHF are formed in a single step.

Two general processes were recommended which have a by-product other than AHF. One makes a depleted uranium oxide and a solid aluminum and fluoride compound which is used in the

production of aluminum metal. The other technology uses depleted UF_6 as a source of fluorine for making hydrofluorocarbons. Hydrofluorocarbons can be used instead of chlorofluorocarbons, which are believed to reduce ozone in the atmosphere.

Uranium Metal Suboptions. As discussed earlier, the more familiar processes for producing depleted uranium metal also produce large amounts of MgF_2 waste. A different type of technology called plasma dissociation avoids the MgF_2 waste stream. In this one-step process, a gas such as argon is heated to more than 5000° centigrade or 9032° Fahrenheit, using electrical energy. At these very high temperatures, depleted UF_6 is broken down into uranium and fluorine atoms. After the gas cools, the fluorine atoms react with added hydrogen to produce AHF, and the uranium atoms combine with each other to form depleted uranium metal.

This process would avoid the uncertainties about the disposal of MgF_2. It would also bring in more money from the sale of AHF, because all the fluorine in the depleted UF_6 is recovered. This process is in the early stage of development.

Several other recommendations contained improved ideas for removing uranium from MgF_2. These recommendations also had suggestions for the recovery and possible use of by-products (for example, converting the MgF_2 to AHF). These advanced treatment technologies could reduce waste and be more economical.

4.3 Use Module

Three use options are analyzed in less detail. These are (1) use as fuel for a light (regular) water power reactor, (2) use as fuel for an advanced power reactor, and (3) use in dense material applications. A number of people recommended these uses. The fuel options are analyzed in less detail because they would take a long time to use up significant amounts of depleted UF_6. The long-term storage options discussed in the *Engineering Analysis Report* and the preferred alternative in the Draft PEIS would allow these, and other, uses to be reconsidered in the future. The environmental impacts of existing or new dense material applications are expected to be similar to those of the uranium metal radiation shielding option which is analyzed in depth.

Light Water Reactor Fuel Option. The main suboption for this use would involve re-enriching the depleted UF_6, that is, increasing the percentage of U-235. The technologies that are used for enriching natural uranium could also be used to enrich depleted uranium. If all the U-235 in DOE's depleted UF_6 were recovered, it could provide fuel for the equivalent of about 100 power reactors operating for 10 years apiece. Re-enriching depleted uranium would save natural uranium resources and avoid the impacts of uranium mining and milling. However, only a small amount of the depleted uranium would actually be converted into enriched uranium. Most of the depleted uranium (over 90 percent) would remain after processing, and would still require management.

It is uncertain when re-enrichment would be economical. Continued storage preserves the possibility for the future, particularly for depleted uranium which has more than 0.3 percent U-235.

Another possible use of depleted uranium in light water reactors could involve converting the depleted UF_6 to UO_2. The depleted UO_2 could then be mixed with plutonium oxide to produce mixed oxide fuel. However, this suboption would use up only a very small amount of the depleted UF_6.

Advanced Reactor Fuel Option. One reason why DOE considered the depleted UF_6 a valuable resource was its potential use in advanced reactors of the future. One such type of reactor, called a fast breeder reactor, actually produces additional fuel. Used in an advanced reactor, the depleted uranium could provide hundreds of years of electrical power at the present U.S. production rate. However, this option would require a change in national policy, which is based on a once-through fuel cycle. In addition, since the advanced reactors are very fuel efficient, they would use up only a small amount of depleted uranium.

Dense Material Applications Option. Dense material applications include some ways in which depleted uranium metal is already being used, such as armor-piercing munitions, vehicle armor, ballasts in aircraft, and weights for stabilizing machinery. Other new uses were suggested in responses to the Request for Recommendations. These include energy storage flywheels (heavy metal wheels that store energy and make shafts rotate evenly), drill collars to keep oil well drill shafts centered, and explosives for the petroleum industry to open up the earth around natural gas and oil wells. Future dense material applications are uncertain at this time. The long-term storage options discussed in the *Engineering Analysis Report* and the preferred alternative in the Draft PEIS would allow these, and other, uses to be considered in the future.

4.4 Long-Term Storage Module

Storage as depleted uranium metal and storage as depleted uranium tetrafluoride (UF_4) were considered but analyzed in less detail. Uranium metal bars would require much less space than oxides or UF_6, but it costs much more to convert depleted UF_6 to metal than to U_3O_8. In addition, there are safety issues with storage as metal. Unless it is protected, bulk uranium metal slowly corrodes. In air, the metal flakes can catch fire and release energy rapidly. The reaction between moisture and uranium metal creates hydrogen, which could explode if it collected in closed storage containers. For these reasons, storage as metal would require special packaging and more supervision.

Depleted uranium in the form of UF_4 was considered for long-term storage or disposal but was analyzed in less detail. Conversion to UF_4 is fairly simple and inexpensive, but another conversion step would probably be required before the material could be used. Depleted UF_4 is less chemically reactive than depleted UF_6 but more reactive than the oxides and it would take up about the same amount of storage or disposal space as depleted U_3O_8. Other forms are more generally recommended for disposal.

4.5 Disposal Module

Disposal as depleted UF_6, depleted uranium metal, and depleted UF_4 were considered but analyzed in less detail. Regulations restrict the chemical forms that can be used for disposal. Reactive waste forms such as the fluorides and metal are specifically excluded by the Nevada Test Site and Hanford and by DOE Orders.

The *Engineering Analysis Report* analyzes bulk and cemented waste forms in detail. Another possible suboption is vitrification, in which depleted uranium oxide would be enclosed in glass. The basic technology is developed (for disposal of high-level radioactive waste), but other types of waste preparation are generally preferred for depleted uranium. Vitrified waste would require more space for disposal. In addition, a vitrification facility would be more complicated and costly to build and operate than a cementing facility.

5. Roadmap for Integration of Engineering Data Input Reports into Long-Term Management Strategy Alternatives

Figure 3 shows how complete management strategy alternatives can be put together from the options and suboptions analyzed in the *Engineering Analysis Report*. Depleted UF_6 stored in the cylinder yards at Paducah, Portsmouth, and Oak Ridge (the current management strategy) is shown at the left of the figure. Moving from left to right are the transportation, conversion, use, long-term storage, and disposal modules (work breakdown structure Level 2).

The options and suboptions which are analyzed in depth are shown as blocks below the module names. The arrows on the chart indicate the flow of material for the various management strategies. Offsite transportation may be required between one option or suboption and another. This is shown by the small boxes marked "T." Activities such as construction of facilities, transportation of other materials and by-products, and transportation and disposal of wastes are also included in the assessments of the management strategies.

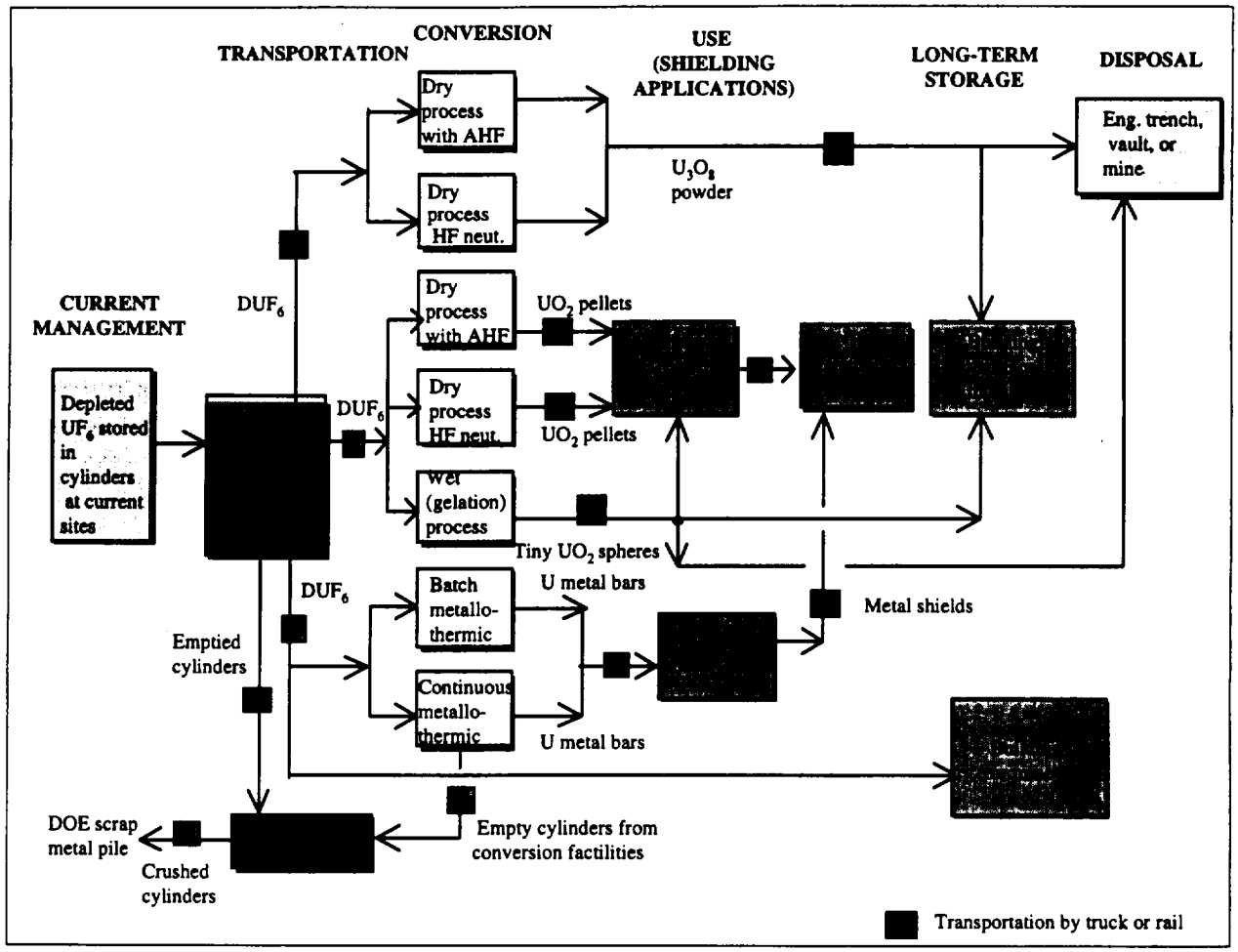


Figure 3. Flowchart for Developing Management Strategy Alternatives from Options and Suboptions

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DEPLETED UF_6

Final

Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride

Volume 3 Responses to Public Comments

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, Maryland 20874

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DOE/EIS-0269

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FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

Volume 3: Responses to Public Comments

April 1999

U.S. Department of Energy
Office of Nuclear Energy, Science and Technology

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1 OVERVIEW OF PUBLIC PARTICIPATION AND COMMENT PROCESS

On December 24, 1997, the Department of Energy (DOE) published a Notice of Availability (63 FR 7771) in the *Federal Register* for the *Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE/EIS-0269). In accordance with the Council on Environmental Quality (CEQ) and DOE National Environmental Policy Act (NEPA) regulations, the notice invited interested agencies, organizations, and the general public to provide oral and written comments on the Draft PEIS.

This volume of the Final PEIS contains the comments and DOE's responses to comments received during the comment period. Chapter 2 contains photocopies of written submissions received by DOE on the Draft PEIS; DOE's responses to those comments are listed in Chapter 3. Chapter 4 provides the oral comments received at the public hearings and DOE's responses. Chapter 5 provides indices to comments and responses arranged by commentor name and by comment number.

1.1 TECHNOLOGY ASSESSMENT

On November 10, 1994, DOE published a Request for Recommendations (59 FR 56324) and an Advance Notice of Intent (59 FR 56325) in the *Federal Register* to prepare a PEIS for alternative strategies for the long-term management and use of depleted uranium hexafluoride (UF_6). The Request for Recommendations asked interested persons, industry and government agencies to submit suggestions for potential uses for the depleted UF_6 as well as technologies that could facilitate the long-term management of this material.

By publishing the Request for Recommendations, DOE offered a unique opportunity for the public to become involved in the Depleted Uranium Hexafluoride Management Program and provide input early in the decision-making process. In keeping with the DOE's intent to foster candid information exchange and ongoing two-way communication with stakeholders, two sets of information exchange forums/workshops were held at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio: one in November/December 1994, after the release of the Request for Recommendations/Advance Notice of Intent, and one in July 1995, at the conclusion of the Technology Assessment phase of the Program. The purpose of these sessions was to explain the Depleted Uranium Hexafluoride Management Program and the Technology Assessment component, provide updates, solicit questions and comments, and foster awareness of the various opportunities for public participation.

A 60-day public comment period was announced; however, all responses, including those submitted after the end of the comment period, were evaluated. In all, 57 responses containing

approximately 70 recommendations were received and evaluated, including five options under consideration by DOE. The *Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride* (UCLR-AR-120372, June 30, 1995) provides a summary of the responses to the Request for Recommendations, the verbatim assessments of the Independent Technical Reviewers, and a summary of the evaluation results. The feasibility analysis in the report was used by DOE in developing alternative strategies for the long-term management of depleted UF_6.

1.2 SCOPING

The DOE published a Notice of Intent (61 FR 2239) to prepare a PEIS in the *Federal Register* on January 25, 1996. The notice invited interested agencies, organizations, and the general public to provide oral and written comments to determine the scope of the PEIS. After publication of the Notice of Intent, stakeholders were sent a letter announcing the schedule for the scoping meetings, a copy of the Notice of Intent, a comment form, and a fact sheet titled "Proposed Scope of Environmental Issues."

Rather than the traditional hearing format, a more interactive workshop format was used for the scoping meetings which were held in February 1996 near the three DOE storage sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee.

During the 60-day public scoping period, comments were submitted in a variety of ways: through comment forms available at meetings and in mailings, by making an oral comment to a Program representative at a meeting, by mailing or faxing DOE, by calling the toll-free information line, by sending an e-mail or by using the CD ROM program at the meetings. All comments received were entered into a database and were considered in determining the scope of the PEIS.

A summary report, consisting of a compilation of the comments from the scoping period and their disposition/responses, is included in Appendix L to the PEIS. The issues raised during the scoping period were used in developing the details of the draft outline PEIS.

1.3 DRAFT PEIS HEARINGS

During the 120-day public comment period for the Draft PEIS, DOE held four public hearings to discuss issues and to receive oral and written comments. The hearings were held near the three DOE storage sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee; as well as in Washington, D.C. The Draft PEIS was made available to the public at the hearings, through mailings, the Depleted UF_6 website, and DOE public reading rooms.

The hearings on the Draft PEIS were an important component of the Program's continuing efforts to provide the public with opportunities to participate in DOE's decision-making process. In keeping with DOE's intent to foster candid information exchange and ongoing two-way communication with the public, an informal, interactive meeting format was chosen. An independent facilitator conducted the hearings that included an information exchange session and a question and answer period. As demonstrated during the scoping phase of the Program, interactive sessions were particularly effective for soliciting comments and gaining participation from the public.

To facilitate public involvement, there were a variety of ways to submit comments on the Draft PEIS. Written comments were accepted by mail, fax, Internet and e-mail. In addition, a toll-free telephone line was available. These methods augmented comments received from the public at the four public hearings. As during the scoping meetings, the public was able to submit both written and oral comments at the Draft PEIS hearings. Court reporters and note takers collected the oral comments offered by the public at each of the hearings. Chapter 4 contains the oral comments from each hearing with DOE's response to those comments.

1.4 COMMENTS ON THE DRAFT PEIS

DOE received approximately 600 comments contained within approximately 90 submissions on the Draft PEIS. The comments addressed a wide range of issues, encompassing technical, environmental, local, economic, and DOE policies. Comments were received from individuals, Federal and State agencies, local governments, foreign entities, and non-government organizations such as businesses, environmental and public interest groups.

Chapter 2 of this document (Volume III) contains photocopies of written submissions received by DOE on the Draft PEIS. Each document was assigned a commentor number. For those documents containing comments, each individual comment was delineated and assigned a unique identification number. This ensured that the comment tracking system tracked each comment, not just the document itself. It also provided DOE with greater detail as to the number of comments submitted in addition to the number of documents received.

After comments were delineated and numbered, each comment was assigned to one of five general categories based on the nature of the comment. In addition, key words were assigned within each category. The use of general categories and keywords facilitated the development of responses to comments and provided DOE with information concerning major issues raised by commentors. DOE's responses to comments are provided in Chapter 3. Where applicable, the responses identify specific chapters, sections, or appendices in the Final PEIS that address the issue(s) raised in the comments.

1.5 MAJOR ISSUES RAISED BY COMMENTORS

As discussed in the previous section, the use of general categories and keywords identified major issues raised by commentors. These issues are presented below with DOE's general response to these comments. The approximate percentage of commentors that addressed each major issue is provided and indicates the importance of that issue to those stakeholders who submitted comments.

Comment

Approximately 45% of the commentors raised the issue of the suitability of the Paducah site for continued cylinder storage and conversion actions due to its proximity to several fault zones, particularly the New Madrid Fault. The largest recorded earthquake in the region (magnitude of 7.3 on the Richter scale) occurred in 1812 and was centered in the New Madrid fault zone; the epicenter was 60 miles southwest of the Paducah site.

General Response

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Of the three storage sites, an earthquake which could cause more than slight damage is considered credible (though highly unlikely) only for the Paducah site.

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports (SARs) for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs were issued in February 1997 by the DOE's management and operating contractor, and were subsequently reviewed and approved by DOE in March 1997.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the safety analysis reports. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the safety analysis reports are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment

Approximately 45% of the commentors expressed doubt about any widespread uses for the depleted UF_6.

General Response

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. Potential depleted uranium uses include radiation-shielding applications. Uses for the fluorine products exist now in the aluminum, chemical, steel, and glass industries.

The DOE provided its initial plan for the conversion of depleted uranium hexafluoride, as required by Public Law 105-204, to Congress on March 12, 1999. In addition, the Department issued a "Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations" on March 4, 1999. Responses to the request for expressions of interest will provide information to develop the Department's detailed procurement strategy for an integrated approach to the management of its depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued in 1999.

DOE plans to continue its support for the development of government applications for depleted uranium products. The two representative use options described in Section 2.2 and Appendix H of the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate.

Comment

Approximately 40% of the commentors favored rapid conversion of the depleted UF_6 materials instead of storage. Of those, approximately 85% favored conversion to U_3O_8 for either storage or ultimate disposition.

General Response

Based on the comments received on the Draft PEIS, DOE has modified its preferred alternative for the final PEIS (see PEIS, Section 2.5). DOE's revised preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. This would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use.

Comment

Approximately 25% of the commentors requested the PEIS to address site-specific impacts for any proposed facility.

General Response

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2 of the PEIS). However, as a programmatic EIS, it does not propose any site-specific projects. Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities is included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, additional NEPA reviews for any site-specific proposals would be prepared identifying the environmental impacts of site-specific projects and a range of alternative actions, including a "no action" alternative.

Comment

Approximately 45% of the commentors raised questions and concerns about the safety and adequacy of current management of the cylinders at the three DOE locations. Many of these concerns stemmed from cylinder inspection data showing that corrosion has occurred on numerous cylinders in the 50 years or so since cylinder storage at the three sites began.

General Response

DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading of cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion, and regular inspection and surveillance of the cylinder and storage yard conditions.

Comment

Approximately 15% of the commentors opposed any unrestricted uses of the converted UF_6 products and questioned the process for radioactive release limits of such products as hydrogen fluoride (HF) or calcium flouride (CaF_2).

General Response

As described in Section 2.2 and Appendix H of the PEIS, the two use options evaluated in the PEIS, use as depleted uranium oxide and use as depleted uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks. Use of depleted uranium products, HF, and CaF_2 would be subject to DOE and/or NRC review and approval, depending on the specific use.

The ultimate decision concerning HF or CaF_2 production will depend on the conversion process selected, the residual uranium concentrations, market demand, and both public acceptance and regulatory considerations. In response to this uncertainty, the potential environmental impacts of options for both production and sale of HF, and production and sale or disposal of CaF_2 are considered throughout the PEIS.

Comment

Approximately 5% of the commentors favored conversion to uranium metal, followed by long-term storage, use, or disposal.

General Response

The PEIS analyzes two options for radiation shielding applications using depleted uranium. The uranium metal option would result in a spent nuclear fuel disposal package, primarily as part of a Multi-Purpose Unit (MPU).

The reasons that long-term storage and disposal options for uranium metal were considered but not analyzed in detail are provided in Sections 2.3.3 and 2.3.4 of the PEIS. Disadvantages associated with long-term storage or disposal of uranium metal include higher conversion cost, lower chemical stability than uranium oxides, and regulatory restrictions on the disposal of the metal form.

Comment

Approximately 5% of the commentors provided information and raised questions about the health effects of depleted uranium exposures.

General Response

The analyses of potential health impacts conducted for the PEIS addressed both the chemical and the radioactive toxicity of uranium as several different compounds: UF_6, UO_2F_2, UO_2, U_3O_8, UF_4, and uranium metal. For normal operations, the chemical toxicity was addressed

by comparing potential exposure amounts with the U.S. Environmental Protection Agency's reference dose for uranium. For accidents, the chemical toxicity was addressed by comparing potential intakes with: 1) the intake of 30 mg given as the threshold for potential irreversible kidney damage under U.S. Nuclear Regulatory Commission (NRC) guidance for certification of gaseous diffusion plants (NRC 1994a; the full citation is provided in Chapter 8 of the PEIS); and 2) the intake of 10 mg, which NRC publications give as the threshold for potential adverse chemical effects (generally temporary, reversible effects occur in the range from 10 to 30 mg of intake). The methodology for chemical toxicity analyses for uranium exposure is summarized in Sections 4.3.1.2.2 and 4.3.2 of the PEIS and discussed in greater detail in Sections C.5.1.2 and C.5.2.1.1. The methodology for radiological toxicity analyses is summarized in Sections 4.3.1.1.2 and 4.3.2 and discussed in greater detail in Sections C.4.1 and C.4.2. Chemical toxicity was assessed for each alternative, and the results of the accident analyses show that the largest potential impacts from accidental uranium releases would be chemical impacts. Please see text in Section 2.4.2.2 of the PEIS, which states "chemical effects (kidney damage) occur at lower exposure levels than radiological effects," and elaborates on the numbers of workers and members of the general public estimated to experience these adverse chemical effects under the various accident scenarios analyzed.

1.6 CHANGES MADE TO THE DRAFT PEIS

DOE has revised the Draft PEIS in response to the comments received. In general, the responses to comments provided in Chapters 3 and 4 of this volume indicate whether or not a change was made to the text of the PEIS in response to the comment and the nature of the change. The revisions to the PEIS generally consisted of the following types: (1) editorial revisions, consisting mostly of corrections of typographical errors; (2) consistency revisions, in which inconsistencies between sections or tables were corrected; (3) clarifications, in which additional information was provided to clarify or provide further details about information provided; and (4) additions to the PEIS of information in response to changes in the overall scope of the PEIS analysis. The most significant revisions to the PEIS are summarized below.

Revision of the Preferred Alternative. After careful consideration of the comments received, DOE revised the preferred alternative for the PEIS. The revised preferred alternative, as described in detail in Section 2.5 of the PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that can not be put to immediate use. Under the revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal product become available. The impacts of the revised preferred alternative are discussed in Sections 2.5, 5.7 and 6.3.7 of the PEIS.

Discussion of Potential Life-Cycle Impacts. In response to commentors' requests for life-cycle impact analysis, a new section has been added to the PEIS (Section 5.9) that discusses the

issues related to potential impacts of the long-term (beyond the year 2039) management of materials containing depleted uranium under all alternatives. However, because of the uncertainties associated with the events that would occur far into the future and with the regulatory atmosphere at that time, the discussion is limited to issues that would need to be considered and the options that would be available for managing the material beyond the year 2039.

Consideration of USEC-Generated Cylinders. In May and June of 1998, management responsibility for approximately 11,400 depleted UF_6 cylinders (approximately 137,000 metric tons) was transferred from the United States Enrichment Corporation (USEC) to DOE by the signing of two Memoranda of Agreement. The Memorandum of Agreement between DOE and USEC relating to depleted uranium generated prior to the privatization date was signed in May 1998 (DOE and USEC 1998a; the full citation is provided in Chapter 8 of the PEIS). It transferred management responsibility for approximately 9,400 cylinders (about 6,600 cylinders stored at Paducah and about 2,800 stored at Portsmouth) from USEC to DOE. A second Memorandum of Agreement between DOE and USEC relating to depleted uranium, signed in June 1998, transfers a total of about 2,000 depleted UF_6 cylinders from USEC to DOE between 1999 and 2004 (DOE and USEC 1998b). (The locations of these cylinders are not specified in this second agreement.)

To account for uncertainties related to the management of depleted UF_6 generated by USEC in the future, the analysis in the PEIS was expanded to consider management of up to 15,000 USEC-generated cylinders (approximately 180,000 metric tons). For the purposes of analysis, it was assumed that 12,000 of the USEC-generated cylinders would be managed at Paducah and 3,000 would be managed at Portsmouth. Chapter 6 has been added to the PEIS, and Chapter 2 and the Summary have been revised so the PEIS includes the impacts associated with the management of these additional USEC-generated cylinders.

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2 COMMENT DOCUMENTS

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2.2 COMMENT DOCUMENTS

This section contains photocopies of written submissions received by DOE on the Draft PEIS. For those submissions containing comments, the comments are delineated with unique identification numbers. DOE's responses to those comments are listed in Chapter 3.

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COMMENTOR NO. 1: HOLLINGER, WADE
OAK RIDGE, TENNESSEE

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site, http://www.sal.sal.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail depleted_uf6@ecmail.gmt.saic.com

Comments

Make a reasonable risk based, economical decision, hire a team of lawyers and set on with getting rid of the stuff! Just take it for granted someone is going to sue DOE because they want you to make it so that it was never here in the first place (impossible) and put your lawyers to work, by the time it gets out of court you'll have the stuff gone. MAKE THE DECISION AND DO IT! I'm tired of supporting all you do nothing bureaucrats! A NEPA review and going out to the public was not necessary for this. You know what has to be

1-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form. Done

Name Wade Hollinger (optional)

Organization _____

Address 117 Westwood Lane (optional)

City Oak Ridge State TN Zip 37830

Phone number _____ (optional)

E-mail address _____ (optional)

☐ Please add my name to the Depleted UF_6 mailing list.

☐ Please take my name off the Depleted UF_6 mailing list.

DO IT!

DEPLETED UF6

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Fuel Cycle
19901 Germantown Road • Germantown, MD 20874 • 301/903-4721

1407

COMMENTOR NO. 2: RAGAN, GUY
LAS VEGAS, NEVADA

Name: Guy Ragan

Date Sent: 1/6/98

Document Ref.: PEIS: S.4 SUMMARY AND COMPARISON OF IMPACTS FOR ALTERNATIVEMANAGEMENT STRATEGIES

----- COMMENT -----

What is the basis for the consequences stated? In other words, if the no-action alternative creates 110 jobs over 40 years, that is as compared to what? Compare it to continuation of the present situation? But continuation of the present situation is not an option. The PEIS states its impacts relative to an inconceivable baseline. According to DOE's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, "the no-action alternative provides an environmental baseline against which impacts of the proposed action (and alternatives) can be compared." Therefore, the consequences should be stated as deviations from the no action alternative. For example, as compared to the No Action alternative, for operations, Long-Term Storage creates 10 jobs per year over 20 years. Then there are 110 federal jobs from 20 to 40 years. For construction, no jobs are created relative to No Action. Comparisons like this should be made explicit by stating all consequences as deviations from the No Action alternative. This comment applies to all types of enviromental consequences, not just socioeconomic impacts.

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COMMENTOR NO. 3: ELLISON, PHILLIP
IDAHO FALLS, IDAHO

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments

I briefly Reviewed the UF_6 Draft PEIS. It appears to be a well developed and documented effort. One area that you may wish to improve is the hazardous analyses of the HF and NH3 tank farms. Other events including tornado induced missles may wish to be addressed. These events may have been covered but I was unable to locate data on the Results of Analyses

Phil Ellison

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name Phillip Ellison (optional)
Organization INEEL
Address P.O. Box 1625 (optional)
City Idaho Falls State ID Zip 83415
Phone number 208-526-5883 (optional)
E-mail address pge@inel.gov (optional)

☑ Please add my name to the Depleted UF_6 mailing list
☐ Please take my name off the Depleted UF_6 mailing list.

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

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1408

COMMENTOR NO. 4: DYER, ROBERT
HARRIMAN, TENNESSEE

DYER ENTERPRISES
301 Old Suddath Road • Harriman, TN 37748 • (423) 882-2623
bdyer@hotmail.com
January 12, 1998

Mr. Charles E. Bradley, Jr
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Friends and Former Associates,

I was happy to see that you are getting better at meeting schedules, only six months late in getting out the two volume Draft PEIS for the alternative strategies for the future of the few cylinders of depleted that are stored around.

I have spent some time reading it and thinking about the way it is presented, both from the my own point of view as one who knows what the stuff is and also from the point of view of one whose only knowledge of depleted UF_6 is from these writings. As you can see by my comments, I think you missed your opportunity to inform the unknowing and get them on your side once you make the long term management strategy.

I am interested in your reaction to my comments, and maybe we can work together to improve the document.

Bob "Captain Fuddy Duddy" Dyer
Robert Dyer

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

YER ENTERPRISES
301 OLD SUDDATH ROAD • HARRIMAN, TN 37748 (423) 882-2623

January 12,1999

Comments as a Result of Reviewing the PEIS for
Alternative Strategies for the
Long-Term Management and Use of
Depleted Uranium Hexafluoride

As a result of several days of pouring through the two volumes of the referenced document, I have the following comments and suggestions to make. I believe that I am qualified to review the work because I have had 53 years of experience in the operation and design of the gaseous diffusion process in Oak Ridge while working 35 years for the operating contractor followed by 15 years for DOE . I have seen the depleted cylinders at all three of the plants, I actually filled some of them in Oak Ridge, I know the chemistry and physical properties of UF_6, I was on the committee to investigate the cause and effect of the wall failures of the two Portsmouth cylinders, and I am a voting member of the ANSI N14.1, *Uranium Hexafluoride - Packaging for Transport* standards committee that establishes cylinder design and fabrication criteria. Twice, I have presented my training course "Fundamentals of Gaseous Diffusion Plant Operations" to members of the Argonne National Laboratory staff who have prepared this report.

I will start with some general comments and proceed to some specific ones.

4-1 (Con't.)

UF_6 Storage Cylinder Description

Let me quote some of the words in the box on Page S-1 in Volume 1. "*Sufficient information must be included in the EIS for reviewers to evaluate the relative merits of each alternative.*"

It seems to me that you have to describe the problem in order for reviewers to see the merits of any of the possible solutions, including continued long term storage. In this case, the problem is what to do with the large quantity of depleted uranium hexafluoride that has accumulated at the gaseous diffusion plants in Oak Ridge, TN, Paducah KY, and Portsmouth, OH. I think you have to accept the fact that UF_6 is not a commodity that is familiar to the general public, especially those living

4-2

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

in the vicinity of the plants. Therefore, the description of depleted UF_6 in the storage cylinders on page S-2 is grossly understated "*Depleted UF6 is stored as a solid at all three sites in steel cylinders. Each cylinder holds approximately 10 to 14 tons (9 to 12 metric tons) of material.*"

The next mention of stored cylinders of UF_6 that I found was on page B1 in Volume 2. "*Depleted UF_6 has been stored in steel cylinders in outdoor yards at the three DOE storage sites since the 1950s. Most cylinders have either a 10- or 4- tons (9- or 12- metric tons) capacity and a nominal wall thickness of 5/16 in. (0.79 cm or 312.5 mil).*" It is a little more correct, in stating the cylinder capacity as 10 or 14 tons but is still oversimplified:

I, as a reviewer, know the details of the design criteria and methods of fabrication for the storage cylinders, and know that the UF_6 is being safely stored at the plants. I do not think the smidgen of information you have included will sufficiently inform and convince the farmer working the fields next to the plant, or the housewife in Wakefield, Ohio, or the new tenant in one of the K-25 buildings that they have nothing to worry about. These people should not forced to imagine what is in those somewhat rusted cylinders they see stored in the yards. I think you should at least use some of the pictures and descriptions of the cylinders from the ORO 651 series of documents. I can give you copies of ORO 651 Rev 5 and ORO 651 Rev 6, but you will have to buy the successor document USEC 651 Rev 7 from the USEC for which they charge $5.00. Also, and more importantly, you should point out that there is an American National Standard, ANSI N 14.1, *Uranium Hexafluoride - Packaging for Transport* which governs the quality of the material in and fabrication of these cylinders. You should be sure to point out that the cylinder has only one valve for filling and emptying. This valve is located at the 12 o'clock position on one of the ends.

4-2 (Con't.)

Assuming you expand your description of the cylinders, then you need to tell the people what is in them. You need to tell them that the ^{235}U isotope concentration has been reduced from the naturally occuring 0.711% to 0.2 - 0.3 % resulting in a proportional increase the concentration of ^{238}U.

You need to tell them that UF_6 is a chemical compound that has one atom of uranium combined with six atoms of fluorine. It can be either a solid, a liquid or a gas depending on its temperature. In the storage yards it is a solid in the bottom of the cylinders and a gas at subatmospheric pressure in the top. If a cylinder is heated, the solid will melt to a boiling

COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

liquid at 147°F. You need to tell them that it is a greater chemical hazard than a radioactive one.

You need to tell them how UF_6 reacts with the iron on the inner surfaces of the steel cylinder to form a corrosion inhibiting, protective surface layer of iron fluoride. This protective coating insures the UF_6 inside the cylinder will not react with and corrode the cylinder wall, i.e. if you protect the outside of the cylinder, and prevent it from rusting away, the UF_6 can stay in storage in the cylinders forever.

4-2 (Con't.)

Cylinder Fill Limits

There are long standing specific requirements that have been used to determine the quantity of UF_6 that can be safely stored in an approved design cylinder. The fundamental concepts of the approach to assuring the safety of the many cylinders of depleted UF_6 stored at Paducah, Portsmouth, and Oak Ridge are ***certified minimum volume*** and ***5% ullage***, in particular, my comment concerns the UF_6 fill-limit and heating temperature limit for 48G cylinders, although the same rationale applies to the other sizes of UF_6 cylinders.

The crucial concept is the ***certified minimum volume*** of the cylinder. UF_6 cylinders are fabricated in strict accordance with the drawings and criteria in the American National Standards Institute standard ANSI N14.1, ***Uranium Hexafluoride - Packaging for Transport***. One of the code requirements is that upon final fabrication, in order to determine its exact internal volume, the cylinder will be completely filled with 60°F water and weighed on a scale accurate to 0.1%. The actual water weight obtained is recorded for the individual cylinder certification data and stamped on the cylinder nameplate to conclusively demonstrate that the requirement has been met. For a cylinder to be acceptable, the quotient of the certified full cylinder water weight divided by 62.37(the weight in pounds of 1 ft^3 of water at 60°F) shall not be less than the published minimum volume. For a 48G cylinder, the minimum volume is 139 ft^3, equivalent to a water weight of 8669 lbs. Using this method of measurement, the actual internal volume of a cylinder can be determined and if it is not greater than the ***minimum volume***, the cylinder is destroyed.

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

The density, or weight of a cubic foot of UF_6 has to be known in order to use the ***certified minimum volume*** to determine a safe-fill quantity of UF_6 for the cylinder. During the first 20 years of the atomic age, much research work was done to determine the physical properties of UF_6. R. DeWitt of the Goodyear Atomic Corporation made an extensive literature search and compiled the results in a document, GAT 280, ***Uranium Hexafluoride: A Survey of the Physico-Chemical Properties January 29,1960.*** Data from this source has been used to produce Figures 1 and 2. Solid UF_6 undergoes a significant expansion as it is heated and melts from a solid to a liquid. This is illustrated in Figure 1, Density of Solid UF_6, and Figure 2, Density of Liquid UF_6 235 - 300°F.

Knowing that all cylinders are larger than the ***certified minimum volume*** allows the establishment of a safe UF_6 fill limit for them. This weight is obtained by using the density of liquid UF_6 at the 250°F design temperature of the cylinder and determining how much of this 250°F liquid UF_6 will fill 95% of the cylinder's ***certified minimum volume***. Because all cylinder volumes are certified to be greater than the minimum, this guarantees that there will be at least 5% of the ***certified minimum cylinder volume*** as ullage(space above the liquid in the cylinder) when the full cylinder is heated to its design temperature of 250°F, and thus there will be no possibility of hydraulic forces developing in the liquid to cause cylinder rupture.

4-3 (Con't.)

From ANSI N14.1, the minimum volume for a 48G cylinder is 139 ft^3 and from Figure 2, the density of liquid UF_6 at 250°F is 203.7 lbs/ft^3. For a 48G cylinder the calculation of the fill limit is:

95%(139 ft^3) (203.3lbs/ft^3 of UF_6) = 26840 lbs of UF_6

COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

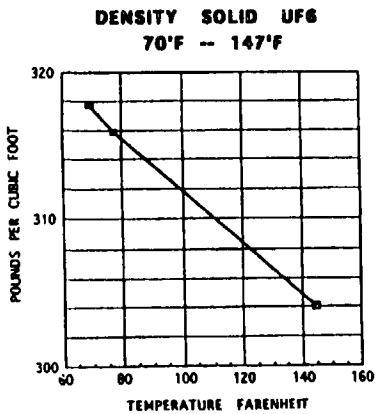

Figure 1

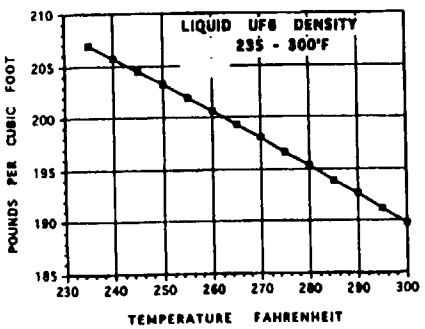

Figure 2

4-3 (Con't.)

COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

Keep in mind that because all cylinders are required to prove that they have greater than a minimum volume, there will always be at least, if not more than, a 5% ullage to prevent hydraulic rupture at the design temperature. At lower than design temperatures, because the density of liquid UF_6 expressed in lbs/ft³ increases as the temperature is lowered to the freeze point of147°F, the percentage of the cylinder volume occupied by gaseous UF_6 will increase and be larger than 5%. For example, prior to going to the storage yards, after all the air was evacuated from inside them, the depleted UF_6 cylinders were filled to the fill limit with liquid UF_6 at a temperature of 160°F with a density of 224 lbs/ft³. The ullage in this case is at least 14%. There can be no hydraulic rupture as long as gas in the ullage provides a cushion.

This fill-limit calculation assures safety if the cylinder is heated to the design temperature and before any material is removed from it. In diffusion plant practice, the cylinder is never heated above 100°F. As UF_6 gas is withdrawn, there is a smaller mass of liquid UF_6 in the cylinder so the ullage increases. Any volatile impurities that may have been in the cylinder will be expelled when feeding is first started so the pressure of the system will correspond to the vapor pressure of UF_6 for the temperature.

When the cylinder is filled with liquid UF_6 to its proper fill limit, and has cooled to room temperature, based on the data in Figure 1, showing the density at 68°F to be 317.8 lbs/ft³, the solid UF_6 will occupy 26,840 lbs/317.8 lbs/ft³ = 84.45 ft³/139 ft³ = 61% of the ***certified minimum volume***. The remaining 39% of the volume will be filled with UF_6 gas at subatmospheric pressure or vacuum.

4-3 (Con't.)

Minimum Cylinder Wall Thickness

The 0.25" minimum wall thickness specified in ANSI N14.1 and the ORO 651 series for the 48G, 48H, 48 HX, 48 O, and 48 OM cylinders is for a pressure vessel rated at 100 PSIG. However, this pressure is only achieved if the cylinder of solid is heated 147°F to liquefy the UF_6 and the heating of the liquid continued until the temperature of the liquid is increased to 200°F, as is done in gaseous diffusion plant operations requiring rapid emptying of the cylinder's contents. However, if by strict administrative control, the cylinder is only heated to a skin temperature of 133°F, 14°F below the liquefaction temperature, the UF_6 gas pressure in the cylinder will be atmospheric pressure(14.7 psia), and the UF_6 can be changed directly from solid to gas without going through the liquid phase

4-4

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

in order to remove it from the cylinder at a slow rate. (This is the way the French feed their diffusion plant, and is what you have heard referred to as "cold feeding". *4-4 (Con't.)*

Radiation Emanating from a Depleted Cylinder of UF_6

There is another aspect of the filled cylinders that I do not think has been adequately covered. There should be a statement concerning how many, or few, curies or sieverts of radiation emminates from one cylinder. Depleted UF_6 is by definition ^{238}U. The handbooks show ^{238}U to have a half life of 4.47 billion years (about as long as the earth has been around). The thorium and protactinium daughter products have melting points in the range of 1650-1850°F. This means that any daughter products that may be in a cylinder of normal assay UF_6 being fed into the cascade will not be vaporized and expelled from the cylinder with the UF_6 gas at 200°F. In essence, since no uranium daughter products are fed to the cascade, the only ones in depleted UF_6 are the ones that have grown in the past 50 years. With ^{238}U's half life, there can't be more than a handfull!

I know from experience that it is very difficult to measure any gamma radiation when scanning the outer surface of a full cylinder in storage with a radiation meter. However, after a cylinder has been heated, liquefied, emptied, and cooled, the scan will show a small amount of gamma radiation on the bottom of the cylinder. Keep in mind that the purpose for which the diffusion plants were built was to prepare uranium for fission, either in a weapon or a nuclear reactor. The diffusion process removes 70% of the fissionable isotope found in naturally occurring uranium. The stored depleted uranium has never been used as fuel in a nuclear reactor where fission products occur in great abundance. There are very few gamma emitting fission products in the depleted UF_6. The gamma radiation in the depleted uranium is coming from uranium decay daughter products. These non-volatile daughter product form extremely slowly throughout the cake of solid UF_6 as uranium decays. They are homogeneously mixed with the solid UF_6 resulting in their gamma rays being shielded by the uranium atoms. Because the daughters are chemically different than UF_6, they will not vaporize and be removed from the cylinder as a gas. They concentrate in an ever diminishing pool of liquid until they are all that is left on the bottom. In this location, their radiation is directed downward away from people working with the cylinders. If you sit on top of a cylinder, your butt is at least four feet from the emitters. *4-5*

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

I make no pretense of being a Health Physicist, so I find it hard to understand how you can estimate the exposures that people will get, if you don't state the intensity of the radiation at the source. Just one of many examples, Table D.1 page D-6 states as an impact during Storage(1999 - 2039), the *total collective dose to population within 50 miles (3 sites)* will be 0.38 person-rems. How can you be accurate to two decimal points when you don't know how much radiation, if any, is coming from a cylinder of depleted UF_6? Here is an area where you could do a lot of good in taking the hocus pocus out of Health Physics and educating the public about radiation and its effects! Don't let them learn it from the Simpsons on the anti-nuke Fox Network! *4-5 (Con't.)*

Specific Comments VOLUME 1

- Table S.3 Page S-46 What are the quantities of uranium compounds and HF considered to be released from a "*Corroded cylinder spill, dry conditions*," and "*Corroded cylinder spill, wet conditions*"? Without these numbers, it is difficult to understand the postulated consequences. The rest of the table has the same problem of not stating how much UF_6 or HF or UO_2 is released in the accidents *4-6*
- .PAGE 1-1 SECTION 1.1 BACKGROUND INFORMATION The statement is made: "*At atmospheric pressure, UF_6 is a solid material below a temperature of 134°F and a gas at temperatures above 134°F (additional information about the characteristics of the chemical UF_6 is provided in Appendix A).*" When I go to the Appendix A, I was amazed at the paucity of information presented not only for UF_6 but also for the other uranium compounds and HF. I thought at least, I would find the phase diagram of UF_6 that clearly shows the inaccuracy of the above statement but, alas, it wasn't there! UF_6 can be a gas below 134°F as well as above 134°F, and a solid all the way up to 147°F. *4-7*
- PAGE 3-50 TABLE 3.13 FOOTNOTE c The footnote states "*Radiation dose could result from drinking 365 L of K-25 site water(0.3 mrem/yr) and ingesting the maximally contaminated fish (1.6 mrem/yr)* " Do you have to drink all 96.5 gallons(365 L) of water and eat the fish at one sitting? If you do, this is nonsense and serves no purpose. If you don't, what is the time period? *4-8*

COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

- PAGE 4-14 DEFINITIONS *"Involved Worker - Might be exposed to direct gamma radiation emitted from radioactivematerials such as depleted UF_6 or other uranium compounds"* Here again, the question has to be asked, "How much radiation does depleted UF_6 or other uranium compounds emit/unit quantity of the substance?" Is the UF_6 still in the cylinder? Do you take credit for the shielding of the uranium in the UF_6 in the cylinder? The way this is written does absolutely nothing to allay the fears of the uninformed. — 4-9
- PAGE 8-18 DEFINITION OF TRANSURANIC WASTE The word "transuranic" means "beyond uranium" i.e. elements that have a greater than the 92 atomic weight of uranium. like plutonium, neptunium, americium, etc. They probably do have half-lives greater than 20 years. Plutonium is deliberately made in nuclear reactors and extracted from spent reactor fuel. In the late '70s, a very small quantity of uranium recovered from spent reactor fuel was refined, converted to UF_6, and fed into the diffusion plant complex. They do not exist in sufficient quantity in depleted UF_6 to be a problem. Here again is a place where you could do good in educating. — 4-10

Volume 2

- PAGE A-2 TABLE A-1 It seems incredulous that the particle and bulk density of UF_6 are each 4.6 g/cm³, and neither one of them is the generally accepted 5.1 g/cm³ at 68°F. — 4-11
- IBID. A.1.2 I think you should mention that uranyl fluoride picks up water of hydration from humid air and in doing so changes color from brilliant orange to yellow. If a cylinder should break open in the storage yard, this color change would probably be observed. — 4-12
- PAGE A-4 A.2.1 UF_6 is essentially inert to copper, witness all the copper tubing instrument lines in the plants. Also don't forget Teflon that was developed specially for the Manhattan Project. — 4-13
- PAGE B-7 4TH FULL PARAGRAPH, LAST SENTENCE *"It was assumed that uranium would be released as solid uranyl fluoride (UO_2F_2),which would be deposited on the ground."* You should do more than say it lays on the ground. Uranyl fluoride (UO_2F_2) has a characteristic of being very soluble in water, so as soon as it rains, its will go into solution which, because of the HF, will be acidic and be neutralized by the cement or limestone construction materials of the storage yard. The resulting calcium salts will — 4-14

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

probably be insoluble in water and lay where they have been formed.

- PAGE C-3 C.2.1 CONTINUED CYLINDER STORAGE 1ST PARAGRAPH 3RD SENTENCE *"Because of their age, potential direct contact with the ground, and skirted ends, many of the cylinders show signs of corrosion."* Unless you include the ORO 651 series of documents, how is the reviewer to know what you are talking about when you suddenly introduce "skirted ends"? — 4-15
- PAGE E-20 FIGURE E.1 The design of the Horizontal "Clamshell" Overcontainer looks interesting, and since you will have to use it at all three plant sites, while you are at it, why don't you design to be a 100 PSIG pressure vessel and use the steam heated autoclaves that you have at the plants to empty the defective cylinders? Otherwise you have to come up with an autoclave designed for hot air heating which will require different than your presently approved safety systems to avoid gross overheating with hot air. — 4-16
- PAGE E-21 E.2.2 CYLINDER TRANSFER You will have some damaged cylinders at all three sites, and if you can't get a DOT permit to ship them off the plant site, how would one of these expensive cylinder transfer facilities at each site be of value to the enterprise? — 4-17
- PAGE F-3 SITE LAYOUT FOR A CONVERSION FACILITY Why do you store the full cylinders outside, and build the biggest building on the site for the empties to be under cover? — 4-18
- PAGE F-11 1ST PARAGRAPH Why wash the empty cylinders with water when a nitric acid solution would do a better cleaning job? The used solution could also be evaporated to dryness for disposal. — 4-19
- PAGE F-13 F.2.3 CONVERSION TO METAL. 3RD PARAGRAPH, 4TH SENTENCE *"The more dense molten uranium/iron would settle to the bottom of the reactor where it would be continuously withdrawn"* What kind of material are you going to use for the reactor and liquid uranium/iron draw off piping? I have always been told that liquid uranium at 2100°F, and uranium alloys at lower temperatures are the universal solvents. Nothing, even yttrium lined equipment will contain them for very long. — 4-20

  If you go with the Fe/U alloy just to lower the molten metal temperature, how good a radiation shield will your alloy be as compared to pure uranium?
- PAGE F-14 IMPACTS OF OPTIONS The amount of HF produced from any of the conversion options should be expressed because it is the big safety hazard. The design rate of 2300 48G cylinders of UF_6 a year equates to 6.3*26,840 lbs or169,100 lbs UF_6 a day. Using a molecular — 4-21

COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

weight of 352 for UF_6, these 6.3 cylinders contain 480 lb/mols of UF_6. Each lb/mol of UF_6 that reacts with water will create six lb/mols of HF. Thus 480 lb/mols * 6 = 2880 lb/mols HF/day. Using a molecular weight of 20 for HF, this equates to 57,000 lbs or 6600 gallons of anhydrous HF/day produced. Remembering that HF boils at 60°F, this is a lot of HF to handle day in and day out in plastic pipes and tanks. You are buying a much bigger safety problem than I think you are portraying in these tomes. You should know that a drop of this liquid will burn a hole through your unprotected hand and the fumes can kill as happened at Kerr McGhee in Gore OK! *4-21 (Con't.)*

- PAGE F-23 TABLE F.7 In the Conversion to U_3O_8 section, the last accident is a U_3O_8 drum spilling its contents onto the floor after an accident with a forklift. These drums contain 1600 lbs of U_3O_8 powders, and you are asking the reviewer to believe that the spill quantity will only be 63 <u>milligrams</u>! This tends to lose your creditability for the whole study! Later on in the Table, you show a 2400 lb drum of UO_2 in a similar accident only spilling 25 <u>milligrams</u>, but you have an extremely unlikely 3, UF_6 cylinders bursting from some kind of fire and dumping 24,000 lbs in 30 minutes. I believe you lose integrity when you ignore the historical fact that this cylinder rupture scenario has not occurred, or even come close, in the past 50 years of cylinder storage. On the other hand, you seem to completely accept speculation about future accidents in plants that have not been built. It sure looks like you are trying to make people think this UF_6 stuff is the most hazardous thing there ever was? *4-22*
- PAGE F-29 CYLINDER TREATMENT FACILITY EXTREMELY UNLIKELY ACCIDENTS Why is the amount released in an earthquake where 50% of the stored drums are breached only 1.9 lbs, whereas in a Tornado that pierces only one drum of U_3O_8 the quantity released is 69 lbs? You need to cross check all these tables you publish. I am sure that I have not found all the inconsistencies. *4-23*
- IBID. The 3.4 lbs of HF released when the evaporator tank fails and the pool of HF evaporates into the building is just plain wrong. I can tell that none of you ever worked at Fernald! If the temperature is above 60°F, 3.4 lbs of anhydrous HF will become 61 standard cubic feet of extremely toxic and obnoxious gas.
- PAGE G-16 SECTION G.2.2 I don't find recognition of the cylinder sweating problem in any of the inside storage options. During the winter, the 10 or 14 ton cake of UF_6 in each cylinder cools approaching the temperature of the coldest day. When spring comes and the warm *4-24*

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COMMENTOR NO. 4: DYER, ROBERT (CONT'D.)
HARRIMAN, TENNESSEE

humid days return, the outer surface of the cylinders becomes a condenser for the water in the air, not unlike the sweating on your evening rum and coke glass. Unless you air condition the buildings, vaults, and mines, the cylinder wall corrosion will continue especially in the spring. *4-24 (Con't.)*

- PAGE H-16 TABLE H-5 Why is that the drop of a single 2400 lb drum of UO_2 only releases $7.3X10^{-7}$ pounds (3.3 mg) of UO_2 in this accident whereas the same accident in Table G.6 page G-26 releases $1.1X10^{-4}$ lbs (50 mg)of UO_2? Once again, what you got don't make no sense! *4-25*
- PAGE J-28 SECTION J.3.4.3 CYLINDER TREATMENT FACILITY I question the assumption that emptied UF_6 cylinders will retain a 22 lb heel. Why not use dry air to purge the UF_6 gas from the emptied cylinder in the autoclave and let these purge gases go directly to your conversion apparatus. If you do this you should get your heels to be around 10 ppm UF_6. However, even if you do this, you will still have to wash the cylinders to get the daughter products out *4-26*

COMMENTOR NO. 5: DENTON, MARK S., DR.
OAK RIDGE, TENNESSEE

Depleted Uranium Hexafluor. Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments

I am writing concerning the Draft PEIS Summary, Vol I and Vol II. Thankyou for the opportunity to provide comments. I have been having this problem (w/ lack of fee in the the higher priority sites with the Gaseous Tanks and Metal Wells Storage Tanks at ORNL) since 1992 at Oak Ridge (K-25, PGDP and PORTS.

Please add me to your mailing list as individual below.

Thankyou again

/s/ Mark S. Denton, M.D., CCT CHAM, RSO

5-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form

Name Dr. Mark S. Denton (optional) ☒ Please add my name to the Depleted UF_6 mailing list.

Organization Manufacturing Technologies Network (MTN) ☐ Please take my name off the Depleted UF_6 mailing list

Address P.O. Box 5701 (optional)

City Oak Ridge State TN Zip 37831

Phone number (423) 574-0777 (optional)

E-mail address (423) 457-3352 (optional)

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

S14 1

COMMENTOR NO. 6: WEIGEL, RUDY
OAK RIDGE, TENNESSEE

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- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments

NO COMMENT AT THIS TIME. THE PUBLIC MTG SHOULD ELICIT VARIOUS COMMENTS WHICH EITHER WILL ENHANCE OR DISTRACT FROM THE DECISION MAKING PROCESS.

QUESTION – I DIDN'T THINK "ECONOMICS" WAS A CONSIDERATION OF THE NEPA PROCESS. IF IT'S NOT, WHY IS IT PRESENTED IN THE PEIS?? IT'S BEING PRESENTED COULD ADVERSELY INFLUENCE ULTIMATE DECISIONS FOR THE PROJECT – PEOPLE WILL LOOK @ THE $$ INSTEAD OF THE BEST PROJECT OPTION

6-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form

Name RUDY WEIGEL (optional) ☐ Please add my name to the Depleted UF_6 mailing list

Organization STAKEHOLDER ☒ Please take my name off the Depleted UF_6 mailing list

Address 107 TIDEWATER LN (optional)

City OAK RIDGE State TN Zip 37830

Phone number (423) 481-8108 (optional)

E-mail address N/A (optional)

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COMMENTOR NO. 7: PEELLE, BOB
OAK RIDGE, TENNESSEE

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- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments

In discussing possible future uses of depleted uranium, you prominently mention radiation shielding. True for x-rays and gamma rays, and sometimes true for electrons. Never true for neutrons! (fast or slow. [I was associated with some simple minded experiments 40 yr ago that made the point dramatically.] The neutrons produce fissions, and the (subcritical) multiplication ruins the shield.

Uranium pellets would ruin concrete blocks, if many neutrons are around. So for any application including around an accelerator, an analysis would have to be made.

So, qualify the statements to apply only to x-ray or γ-ray shields.

7-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name Bob Peelle (optional)
Organization self in this case
Address 130 Oklahoma Ave (optional)
City Oak Ridge State TN Zip 37830
Phone number 423 683 8974 (optional)
E-mail address 76533226@compuserve.com (optional)

☐ Please add my name to the Depleted UF_6 mailing list
☐ Please take my name off the Depleted UF_6 mailing list

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

1416

COMMENTOR NO. 8: PLANSKY, LEE, DR.
IDAHO FALLS, IDAHO

Name: Dr Lee Plansky

Date Sent: 1/28/98

Document Ref.: PEIS: APPENDIX I: ENVIRONMENTAL IMPACTS OF OPTIONS FOR DISPOSAL OF OXIDE

----- COMMENT -----

A re: Disposal Options U- minerals are deposited in reducing environments. It would seem that you would chose a *grout* that would tend to be chemically neutral or also reducing, perhaps a glass or synroc. The oxidizing environment implied in the present scenario (cement grouts, implies rapidly rusting metal drum, and oxidation of U to U ++++++ (+6, or +5) and we mobilize what we don't want to. 8-1

B. The PEIS downplays the importance of U-toxicity as a metal. Refer to any simple MDSDS on U METAL and you and the public will all be shocked. 8-2

C. The way I understand it, the new proposed 20 micrograms/liter EPA MCL on U-238 is inviolable. Depleted uranium material would be disposed of as low-level radioactive waste. The disposal options assessed in the PEIS were defined on the basis of the chemical form of the uranium and the type of disposal facility. The following disposal options were considered: Disposal as U3O8. Depleted uranium could be disposed of as U3O8, either ungrouted (bulk) or grouted U3O8, following conversion. The disp al facilities considered included shallow earthen structures, belowground vaults, and an underground mine. Disposal as UO2. Similar to U3O8, depleted uranium could be disposed of as UO2 following conversion, either in ungrouted or grouted form. The disposal facilities considered were the same as those considered U3O8: shallow earthen structures, belowground vaults, and an underground mine. 8-3

COMMENTOR NO. 9: MILITARY TOXICS PROJECT LEWISTON, MAINE

MILITARY TOXICS PROJECT

National Office
411 Main Street, 2nd Floor
Lewiston ME 04240

phone (207)783-3081
fax (207)783-3088
e-mail mtp@igc.apc.org

February 4, 1998

Charles E. Bradley, Jr.
U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, MD 20874

Dear Mr. Bradley

Secretary Pena recently held a press conference in Washington D.C. to tout his Openness Initiative. We hope that this willingness to be open includes efforts to be more inclusive in DoE's outreach to impacted, or potentially impacted communities.

Specifically of concern to the Military Toxics Project and the Indigenous Environmental Network is the **Draft Programmatic Environmental Impact Statement For Alternative Strategies For The Long-Term Management And Use Of Depleted Uranium Hexafluoride.**

We believe that all of the strategies that proposed have serious environmental justice concerns and potential impacts to communities that you have not adequately reached with the draft PEIS. We also believe that the meetings that the DoE has held in the past, as well as the ones that are beginning on February 19, 1998 in Paducah, are not properly reaching people who are or may be impacted by decisions that your agency will be making regarding the long-term plan for the use of this dangerous material. 9-1

Keeping with the spirit and intent of President Clinton's Executive Order on Environmental Justice, and Secretary Pena's Openess Initiative, we feel that it would be reasonable to request that the DoE initiate roundtable meetings, much like the Federal Facilities Restoration Dialogue meetings. We beleive that it is necessary and just to bring in grassroots leaders from community, labor and environmental justice groups to further discuss the implications of strategies that have been proposed. 9-2

We further request that the comment period be extended to six months to give these folks the opportunity to meet with you, in addition to the hearings that are taken place now, as well as the opportunity to obtain expert technical advice regarding the impact of the various different strategies. 9-3

Please respond to our request in writing. We will be happy to suggest participants for a roundtable discussion.

Sincerely,

Cathy Lemar
Cathy Lemar, Director
Military Toxics Project

Tom Goldtooth, Director
Indigenous Environmental Network

Dan Fahey
Swords To Plowshares

cc: Energy Secretary Federico Pena

MTP is a project of the Tides Center

recycled paper

1417

COMMENTOR NO. 10:

[Comment letter submitted but since withdrawn.]

COMMENTOR NO. 11: ADKISSON, RON
OKLAHOMA CITY, OKLAHOMA

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*.

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments One long-term alternative which has not been considered to date for long-term storage of the converted uranium (i.e., UO2, U3O8, etc.) is the placement in a uranium mill tailings impoundment for long-term retrievable storage. Mill tailings impoundments are designed for 1,000 year stability and the long-term care and maintenance is legally the responsibility of the Department of Energy. Quivira Mining Company's mill tailings site in New Mexico, for example, is presently licensed to dispose of 5,000,000 tons of byproduct materials even though the structural stability of the site was designed for an additional 43,000,000 tons.

The primary advantages of using a mill tailings site are (1) the inventory would be consolidated and isolated from the environment; (2) placement in a tailings impoundment would be relatively simple and with minimum personnel exposure; (3) it would remain in the custody of the US Government for long-term monitoring and care; and, (4) it could be retrieved at any time in the future should the need arise.

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name Ron Adkisson (optional)
Organization Rio Algom Mining Corp.
Address 6 3 C 5 Waterford Blvd. #325 (optional)
City Oklahoma City State OK Zip 73118
Phone number 405-842-1773 (optional)
E-mail address _____ (optional)

☐ Please add my name to the Depleted UF_6 mailing list.
☐ Please take my name off the Depleted UF_6 mailing list.

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

11-1

COMMENTOR NO. 12: BALDING, ANDREW
KEVIL, KENTUCKY

Name: Andrew K Balding

----- COMMENT -----

Appendix D, pg. 5, 1st Para. - The assumption that any further breaches would be a result of handling damage vs. corrosion is very valid, however the follow on assumption that this breach or damage would go undetected for 4 years is not a valid assumption. The same detailed Inspection of a cylinder is required each and every time it is handled as it is Quadrennially or Annually, the Inspections in fact almost identical, the same procedures and checklists are used regardless of the type of inspection or frequency. Any damage that might occur under the current regimented and proceduralized handling activities whether during painting, cylinder relocation to improved storage, or just normal storage yard operations, would be immediately noted and dealt with at the occurrence. Therefore there would be no release and no "Environmental Impact" whatsoever, furthermore the one handling damage induced breach (the Paducah cracked cylinder) was caused by handling damage in 1987; since that time this Site has handled thousands of cylinders without breaching a cylinder due to handling damage, the current Project alone has handled over 30,000 cylinder relocations since 1992 without causing damage to a cylinder sufficient to cause a breach. The facts do not support the conclusions of the predicted number of cylinder breaches portrayed in the "No Action Alternative": the estimate of 444 at Paducah over the next 40 years with only one under old handling practices (even disregarding that those practices have been improved) is sensationalistic.

12-1

COMMENTOR NO. 13: YGDRASIL INSTITUTE GEORGETOWN, KENTUCKY

Ygdrasil Institute
PO Box 131
Georgetown, KY 40324
502-868-9074

February 21, 1998

Charles E. Bradley, Jr.
US Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, MD 20874

Dear Mr. Bradley:

We are writing to you to request that you extend by six months the period for comment on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*. The material in the draft is very technical and complex, and many people concerned with the management of the hexafluoride have only recently received copies of it. 13-1

We should also like to recommend that people in the affected communities be invited to roundtable meetings like those for the Federal Facilities Restoration Dialogue. The affected communities should include those likely to be at risk if transportation of uranium hexafluoride on a large scale takes place. 13-2

Sincerely,

Mary B. Davis

Mary B. Davis, PhD
Director

cc: Energy Secretary, Frederico Pena

In Norse mythology, Ygdrasil is the world tree.
Ygdrasil Institute is a project of Earth Island Institute

1419

COMMENTOR NO. 14: WHITEHEAD, CORINNE BENTON, KENTUCKY

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*.

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@csmail.gmt.saic.com

Comments

WE URGE DOE TO DETERMINE ALL LEAKING CYLINDERS AT PGDP. TRANSFER THE CONTENTS OF LEAKING CYLINDERS INTO HEAVY GUAGE 48Y CONTAINERS. STORE IN A EARTHQUAKE PROOF CONCRETE STRUCTURE OFF THE FLOOR SO THEY CAN BE MONITORED FOR LEAKS. NO MAJOR EFFORTS TO TRANSFER CONTENTS AND WASH OUT CONTAINERS IN A PROCESS TO CHANGE TO URANIUM OXIDE SHOULD BE AT THE PADUCAH FACILITY. DOE HAS KNOWN DETAILS OF SEVERE SEISMIC POTENTIAL SINCE THE LATE 1970'S AND HAS TAKEN LITTLE OR NO ACTION TO PROTECT THE WORKERS OR THE COMMUNITY. NEGLIGENCE IS NOT AN "ACT OF GOD" IF ACUTE DAMAGE IS DONE TO THE FACILITY OR THE COMMUNITY DURING SEISMIC EVENTS. WE URGE A COMPREHENSIVE ENVIRONMENTAL IMPACT STUDY BE MADE ITS FULL REPORT TO THE PUBLIC. WE URGE ATTENTION TO DAMAGE AND HAZARD REDUCTION RE: THE EARTHQUAKE POTENTIAL UTILIZING NATIONAL & INTERNATIONAL EARTHQUAKE ENGINEERING AND SEISMIC SCIENTISTS, WHO ARE RESPECTED IN THEIR FIELD. WE EXPLORE THE USE OF DEPLETED URANIUM IN MILITARY EQUIPMENT

14-1

14-2

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name CORINNE WHITEHEAD (optional)
Organization COALITION FOR HEALTH CONCERN
Address 1021 U S 641 NORTH (optional)
City BENTON State KY Zip 42025
Phone number 502-527-1217 (optional)
E-mail address _____ (optional)

☒ Please add my name to the Depleted UF_6 mailing list.
☐ Please take my name off the Depleted UF_6 mailing list.

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

COMMENTOR NO. 15: JACOBS ENGINEERING GROUP, INC. PADUCAH, KENTUCKY

JACOBS ENGINEERING GROUP INC.
Paducah Site

DOCUMENT REVIEW RECORD

Document Title: *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*

Control Number: _____ WBS Code: _____

Reviewers: L. Lee Hamblin

Review for: Editorial ☐ Peer ☐ Regulatory ☒ Technical ☐ QCC

Review Requested by: _____ Date: _____

	Concurrence in Comment Incorporation
REVIEWER'S SIGNATURE	REVIEWER'S SIGNATURE
DATE 2/23/98	DATE
☐ Approved (only if no comments)	☐ Approved
☒ Not Approved	
☐ Not Reviewed (indicate reason(s) for not reviewing below)	

Cmnt No.	Page and Location [Revised Location]	Comment	Comment Disposition
1.	Page S-1; Para. 2; Sent. 4; and Page S-4; Sect. S.1.2; Sent. 2	Text states: "Additional NEPA analyses, as appropriate, will be prepared once a long-term management strategy has been selected..." "This PEIS examines the environmental consequences of alternative strategies of long-term storage, use, and disposal of the depleted UF_6 inventory." This document does not appear to analyze completely the use and disposal of the depleted UF_6 inventory when it defers the analysis of future siting, design, and construction to possible separate NEPA analyses (as appropriate) in the future when, in effect, they appear to be "connected actions" and/or "cumulative actions" and should be evaluated thoroughly in this PEIS.	

15-1

1420

JACOBS ENGINEERING GROUP INC.
Paducah Site

DOCUMENT REVIEW RECORD

Document Title: *Proposed Remedial Action Plan for Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*

Date: February 13, 1998

Cmnt No.	Page and Location [Revised Location]	Comment	Comment Disposition
2.	Page S-42; Sect. S.4.13; Sent. 1	Text states: "All depleted UF_6 management alternatives would result in environmental impacts that, even when combined with other activities that could occur at the three current storage sites, would be expected to be relatively minor." This statement does not adequately address cumulative impacts from all alternatives considered in this draft PEIS. This statement conflicts with the statement on page 4-27 that states: "The cumulative impact analysis was conducted by examining those impacts resulting from depleted UF_6 management activities that would occur at the three current storage sites (Paducah, Portsmouth, and K-25). The impacts from these activities - including continued cylinder storage and cylinder preparation - were then added to the impacts of other past, present, and reasonable foreseeable future actions at these sites to assess potential cumulative UF_6 impacts." What past, present, and reasonable foreseeable future actions at these sites (specifically) were assessed, and where is the methodology discussing such assessment?	
3.	Page 3-12; Sect. 3.3.6.3; Sent. 1	Text states. "No wetlands were identified on the Paducah site by the National Wetlands Inventory (ANL 1991a)." This may be a true statement; however, jurisdictional wetlands were delineated by a wetlands survey performed in 1995 and confirmed by the U.S. Army Corps of Engineers in 1996 in some of the drainage ditches on the Paducah site. So the text stated above may be true, but it is inaccurate as far as the current wetland scenario on the Paducah site. Is it possible old information has been quoted?	

15-2

15-3

COMMENTOR NO. 15: JACOBS ENGINEERING GROUP, INC. (CONT'D.)
PADUCAH, KENTUCKY

JACOBS ENGINEERING GROUP INC.
Paducah Site

DOCUMENT REVIEW RECORD

Document Title: *Proposed Remedial Action Plan for Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*

Date: February 13, 1998

Cmnt. No.	Page and Location [Revised Location]	Comments	Comment Disposition	
4.	General	Cumulative impacts are not analyzed thoroughly throughout this document. The storage and management scenarios are well known and scoped; however, the unknowns (siting, design, and construction) are described in enough detail (with enough siting criteria described) to narrow the likely locations at which of these facilities possibly will be sited and constructed to be evaluated for cumulative impacts in this document. These "Phase II actions" appear to be "connected actions" and should be analyzed in this PEIS. Phase II is described as "... implementation of the strategy selected."(page S-5, 1st paragraph, 1st sentence). It would be difficult to implement efficiently a strategy of this magnitude that has "connected actions" that are not fully described, planned, and evaluated in this document.		15-4
5.	Pages S-2, S-18, S-55, S-66, S-78, and S-94	No cumulative impacts discussions were included for each of these alternative discussions even though Figure 4.1 on page 4-7 shows "Areas of Potential Impact Evaluated in the PEIS for Each Alternative." The "Cumulative Impacts " box appears in the center at the bottom of this figure.		15-5
6.	Page S-104; Sect. S.8; Sent. 4	Text states: "No non-DOE actions have been identified that would have potential cumulative impacts at the three sites." How was this conclusion reached? What "non-DOE" entities were contacted and what past, present, and reasonably foreseeable actions were analyzed that considered these "non-DOE" entities' actions? Were local governments, municipalities, regional planning agencies, federal agencies, state agencies, local industries, and other non-DOE entities directly communicated with in this PEIS? Are they referenced in this document?		15-6
7.	Appendix E; Page E-72, Sect. E.3.12; Bullet 2	Text states: "The impacts would be negligible." What methodology and analysis deem these impacts to be "negligible?" Where is a cumulative impacts analysis performed to make this decision?		15-7

14721

COMMENTOR NO. 15: JACOBS ENGINEERING GROUP, INC. (CONT'D.)
PADUCAH, KENTUCKY

JACOBS ENGINEERING GROUP INC.
Paducah Site

DOCUMENT REVIEW RECORD

Document Title: *Proposed Remedial Action Plan for Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*

Date: February 13, 1998

Cmnt. No.	Page and Location [Revised Location]	Comments	Comment Disposition	
8.	Appendix F; Page F-72; Sect. F.3.10; Para. 1; Last sent.	Text states: "These impacts, although considered, were not analyzed in detail for one or more of the following reasons: ..." How can the "The impacts would be negligible" be an accurate statement if the impacts were not analyzed in detail? Were these impacts analyzed for cumulative impacts? If so, where? Also consider the rationale for the 1st and 2nd bullets.		15-8
9.	Appendix G, H, I; Page G 63, H 34, I-72; Sect. G 3.10, H 3.10, I 3.10; Para. 1; Last Sent.	Text states: See number 8 above. Same comment here.		
10.	Appendix J; Page J-39; Sect. J.3.8; Para. 1; Last sent.	Text states: See number 7 above. No cumulative impacts analysis was seen for these determinations. These actions should be analyzed in this document not in "connected actions" via a later NEPA document.		15-7
11.	Appendix J; Page J-39; Sect. J.3.8; Para. 1; Last sent.	Text states: see number 8 above. No cumulative impacts analyses were seen for these determinations. These actions should be analyzed in this document not in a later NEPA document where "connected actions" are proposed for analysis ("as appropriate"). How is the public going to connect effectively these actions back to this PEIS when the identification and technology analyses for siting, design, and construction are going to be performed in distinctly separate NEPA documents that will be generated at some undefined future dates?		15-8
12.	General	How were the magnitude and significance of cumulative effects determined for the proposed action? What methodology was used to make this determination? Will it be included in an appendix for public review and or comments? What other methods were used to analyze cumulative effects?		15-9
13.	General	Do the cumulative effects of any of the alternatives and the proposed plan exceed the carrying capacity of any resources, ecosystems, or human communities?		15-10

COMMENTOR NO. 15: JACOBS ENGINEERING GROUP, INC. (CONT'D.)
PADUCAH, KENTUCKY

JACOBS ENGINEERING GROUP INC.
Paducah Site

DOCUMENT REVIEW RECORD

Document Title: *Proposed Remedial Action Plan for Solid Waste Management Unit 81 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*

Date: February 13, 1998

Comt No.	Page and Location (Revised Location)	Comment	Comment Disposition	
14.	General	Throughout the PEIS, at the Paducah site, Bayou Creek is referenced as "Big Bayou Creek." This is in error, as the 1978 USGS topographic map for Heath, KY, shows the creek as Bayou Creek not Big Bayou Creek.		15-11
15.	General	Is there any correlation between this PEIS and the "Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel," DOE/EIS-0251, Nov., 1996, specifically with concern to interim consolidated storage of spent nuclear material at some location such as Yucca Mountain or another site?		15-12
16.	General	The preferred alternative is not one of the alternatives described and compared in the body of this PEIS but is a combination of alternatives 4 and 5. Why wasn't there another alternative (say # 7) that described and compared the use of the entire UF$_6$ inventory as the preferred alternative? It seems a little difficult to the reader to see that the preferred alternative isn't one of the decribed and compared alternatives in the body of the PEIS. In combining alternatives 4 and 5, were additive, countervailing, and synergistic effects evaluated? If so, where is this covered in the PEIS?		15-13
17.	Pages 5-109, 5-111, 5-113; Tables 5.12, 5.13, and 5.14	Tables are titled: "Maximum Cumulative Impacts of Depleted UF$_6$ Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the ..." The reader does not agree that these tables should be titled "Maximum Cumulative Impacts ..." because cumulative impacts have not been analyzed in detail and appear to be based on a limited cumulative impacts methodology and evaluation. In addition, the "Impact Categories" are incomplete and do not include other potential impact areas.		15-14
18.	General	Has this action been correlated with the Vortec Vitrification proposed action for the Paducah Site?		15-15

14422

COMMENTOR NO. 16: ANONYMOUS
PADUCAH, KENTUCKY

7

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF$_6$ World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@ocmail.gnet.saic.com

Comments

USE CYLINDER DROP TEST RESULTS, CRASH TESTS AND MAKE IT PUBLIC TO REASSURE THE PUBLIC. PUT IT IN THE PEIS. DO PR & CAPITALIZE ON IT. WE'VE DROPPED PAH CYLINDERS AT PADUCAH FROM THE PAH CRANE USE. PUT ON SECOND SKIN FOR BREACHES - SEND TO PADUCAH AND FEGO OUT.

⇨ DATA TO SHOW NOTHING BAD WILL HAPPEN

16-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name PADUCAH CYLINDER HANDLER (optional)

Organization _____

Address _____ (optional)

City _____ State ____ Zip ____

Phone number _____ (optional)

E-mail address _____ (optional)

☐ Please add my name to the Depleted UF$_6$ mailing list.

☐ Please take my name off the Depleted UF$_6$ mailing list.

Depleted Uranium Hexafluoride Management Program · Charles E. Bradley, Jr.
Department of Energy · Office of Nuclear Energy, Science and Technology · Office of Facilities
19901 Germantown Road · Germantown, MD 20874 · 301/903-4781

COMMENTOR NO. 17: ROBISON, WILLIAM A.
COOKEVILLE, TENNESSEE

Depleted Uranium Hexafluoride Management Program

Mail this form

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
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- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site, http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@ccmail.gmt.saic.com

Comments

We have no comments at this time, but will remain involved in the public scoping process 17-1

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name William A. Robison (optional)
Organization U.S. Fish & Wildlife Service
Address 446 Neal Street (optional)
City Cookeville State TN Zip 38501
Phone number 931-528-6481 (optional)
E-mail address _____ (optional)

☒ Please add my name to the Depleted UF_6 mailing list
☐ Please take my name off the Depleted UF_6 mailing list

UF_6

Depleted Uranium Hexafluoride Management Program · Charles E. Bradley, Jr.
Department of Energy · Office of Nuclear Energy, Science and Technology · Office of Facilities
19901 Germantown Road · Germantown, MD 20874 · 301/903-4781

1423

COMMENTOR NO. 18: JANASKIE, MARK
OAK RIDGE, TENNESSEE

Question/Information Request Card

If you have questions that were not addressed or need additional information, please fill out this form and bring it to the registration table. DOE will address your concern to extent possible.

Name: MARK JANASKIE
Address: 151 LAFAYETTE DRIVE, SUITE 210 | OAK RIDGE 37830
Phone: 482-0400 Fax: 482-7690
E-mail: MJanaskie@DPRA.com

DEPLETED

Question/Request: Is there a [redacted] considered by DOE to measure the corrosion rates, and if [redacted] the corrosion rate is slow or benign, [redacted] is there a chance that DOE will do no coating and simply wait until the [redacted] conversion (2006+)? If the corrosion rate is slow [redacted] could DOE consider the risk to cylinders low, and thus simply wait until conversion begins. 18-1

Is this one of DOE's current options?

COMMENTOR NO. 19: PARROTT, ROBERT C. OAK RIDGE, TENNESSEE

Question/Information Request Card

If you have questions that were not addressed or need additional information, please fill out this form and bring it to the registration table. DOE will address your concern to extent possible.

Name: Robert C. Parrott
Address: 151 Lafayette Drive, Suite 210
Phone: (423) 482-0400 Fax: (423) 482-7690
E-mail: cparrott@dpra.com

DEPLETED

Question/Request: 1) What does DOE plan to do with the cylinders after conversion occurs? Disposal as [illegible] decon & sales as scrap or reuse? 2) Does DOE have a [illegible] technology to convert the DUF6? Is it realistic that DOE can convert the material by 2028? 3) The current painting program seems inadequate to control corrosion. Does DOE plan to increase the rate of coating? 4) How will DOE decide whether to transport cylinders in overpacks or transfer the contents to new cylinders?

19-1
19-2
19-3
19-4

1424

COMMENTOR NO. 20: RADCLIFFE, DONALD W. ADDRESS UNKNOWN

TO: depleted UF6 at SAIC_BM2
Subject: Unable to comment on DUF6

When I tried to send a commet through the e-mail link on the website, AOL could not deliver to that address. My comment on the PEIS is:

The cost of enrichment services is much lower and thus the viability of refeeding the DUF6 at higher assays is much improved at some locations outside the U.S. The PEIS should address the issues of overseas shipping and disposal.

20-1

Donald W. Radcliffe
Nuclear Fuel Consultant

COMMENTOR NO. 21: UNITED STATES DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C.

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

In Reply Refer to:
ER 97/732

MAR 5 1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NF-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Mr. Bradley:

The Department of the Interior has reviewed the draft " Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride" and offers the following comments:

The Paducah site's proximity to the Reelfoot Rift and New Madrid fault zones would seem to indicate that an earthquake caused accident could be considerably greater at Paducah than at either the Portsmouth site or the Oak Ridge site. This area has experienced seismic activity within the last two to three months. This should be factored into the analysis. 21-1

§ 1.3 Under Proposed action-Contaminants leaking into groundwater may not be detected for several hundred years. The rate of movement of contaminants in groundwater is variable. Because of the long period of time during which the radiation would still be potentially harmful, monitoring of ground-water contamination should continue as long as a risk exists and should cover a large enough area to capture the full geographic extent of possible contamination. The McNairy-Nacatoch aquifer is a very important source of drinking and domestic water for a number of towns in Missouri and Arkansas. Monitoring should be extensive enough to capture any incidence of contamination in these important water sources following a contamination event. 21-2

§ 4.5-It is important to note that the Paducah site should be considered a "wet site." A disposal facility failure in this wet environment would impact the ground-water system with uranium concentrations in groundwater greater than 20 mg/l. within 1,000 years after the failure. 21-3

The Paducah site is also vulnerable to changes in the biological and chemical composition of surface water caused by ground-water discharges into surface water streams. If contamination from such a discharge were to occur, it could affect the ecological stability of the surface water environment. 21-4

1425

COMMENTOR NO. 21: UNITED STATES DEPARTMENT OF THE INTERIOR (CONT'D.)
WASHINGTON, D.C.

There is not sufficient information presented in the PEIS to permit an analysis or assessment of the validity of the models; therefore, we cannot confirm that the worst-case accident or other scenarios are reasonable simulations. 21-5

Most of the strategies for disposing of the inventory of uranium would require construction of processing plants to convert UF6 to other chemical forms, however, locations of these plants are not identified. The use of generic data for the proposed plant seems to be a weak link in the analysis because of uncertainty about site location and lack of specific data. Therefore, we cannot confirm the validity of the potential environmental impacts that might be caused by this conversion process. 21-6

The units for measuring contaminant concentrations are reported differently in different parts of the document (e.g., mg/g, ug/mg, etc.). The same is true of hydraulic conductivity (cm/s, ft/d). Consistent units of measure should be used throughout the PEIS. 21-7

On page 3-28, the assertion that the high thallium concentrations may be caused by a problem in the laboratory analysis should be confirmed or denied, and explained if levels are confirmed to be as high as suggested. 21-8

Sincerely,

Willie R. Taylor

Willie R. Taylor
Director, Office of Environmental Policy
and Compliance

COMMENTOR NO. 22: LAWRENCE LIVERMORE NATIONAL LABORATORY
LIVERMORE, CALIFORNIA

Lawrence Livermore National Laboratory

March 3, 1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Mr. Bradley,

Lawrence Livermore National Laboratory has no substantive comments to make on the content of the December 1997 Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the long-term Management and use of Depleted Uranium Hexafluoride. We wish to receive a copy of the Final PEIS when available. 22-1

Should you have any questions, please direct them to Ken Zahn (L-627), phone 510-422-2140 or Internet address: zahn1@llnl.gov.

Sincerely,

Kenneth C. Zahn, Group Leader
Environmental Evaluations Group
Environmental Protection Department

cc: EEG file L-627
Zahn., K., L-627
Galles, H., L-626
Jackson, C.S., L-633

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1426

COMMENTOR NO. 23: ECO-PAK SPECIALTY PACKAGING, DIVISION OF CBC
ELIZABETHTON, TENNESSEE

ESP Eco-Pak Specialty Packaging Division of CBC
Intermediate Bulk Containers for Chemicals & Liquids
UF_6 and UO_2 Packaging

125 Iodent Way, Suite A
Elizabethton, TN 37643-0154
Tel: 423-543-4211 • 800-221-2465 • Fax: 423 543 6007
E-mail: info@ecopak.com

February 25, 1998

Mr. Charles E. (Ched) Bradley
Program Manager, Facilities Office, ONEST
19901 Germantown Rd.
Germantown, MD 20874

Dear Mr. Bradley:

It was a pleasure to meet you, last night, at the DOE public meeting in Oak Ridge. Heather and I both feel that the preferred program to convert the stockpiled UF6 to uranium oxide and uranium metal for future use is the most worthwhile alternative.

Eco-Pak Specialty Packaging is very interested in assisting in the transport of this material to the future conversion facilities. I am enclosing a brochure on both Eco-Pak Specialty Packaging (ESP) and our parent company, The Columbiana Boiler Company (CBC).

ESP is a division of The Columbiana Boiler Company (CBC) and part of the Columbiana network of companies, which encompasses more than 100 employees and 200,000 square feet of manufacturing area. ESP and CBC offer the knowledge and manufacturing experience of both the UF6 cylinders (30B & 48" series) and the UF6 cylinder overpacks. Additionally, ESP has experience in packaging for the transportation of uranium oxide materials, plutonium products, and waste products. ESP has a comprehensive quality assurance program in place, which is approved by the U.S. Nuclear Regulatory Commission under Quality Assurance Program Approval for Radioactive Material Packages No. 0179, Revision 6. NCI has on staff a core group of project engineers with a wide range of experience, a strong management team, regulation specialists, a certified core of welders, AWS Certified Welding Inspectors also certified in accordance with ASNT-TC-1A for nondestructive inspection, and excellent production personnel. 23-1

I hope some of this information helps in the decision making for this project. I look forward to working and meeting with you, again.

If you have any questions about our company or need any further information regarding our capabilities, please contact myself or Heather Little at (800) 221-2465

Best regards,

William M. Arnold
President

WMA/hl
Enclosure

COMMENTOR NO. 24: SWORDS TO PLOWSHARES
SAN FRANCISCO, CALIFORNIA

Swords To Plowshares
a veterans' rights organization

5 Market Street, 3rd Floor
San Francisco, CA 94103

Telephone (415) 247-8777
Fax (415) 227-0848

March 11, 1998

Charles E. Bradley, Jr.
US Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, MD 20874

Dear Mr Bradley:

Enclosed is a copy of the Depleted Uranium Case Narrative about the health and environmental consequences of depleted uranium munitions. I hope that you will carefully review the information presented here as part of your effort to determine the fate of uranium hexaflouride stockpiles.

24-1

Depleted uranium should be stored in safe containers away from humans, water supplies, and the food chain. The use of depleted uranium in ammunition is an unwise use for chemically toxic and radioactive waste.

If I can be of further assistance, please do not hesitate to contact me.

Respectfully,

Dan Fahey

14427

COMMENTOR NO. 24: SWORDS TO PLOWSHARES (CONT'D.)
SAN FRANCISCO, CALIFORNIA

Swords To Plowshares
a veterans' rights organization

995 Market Street, 3rd Floor
San Francisco, CA 94103

Telephone (415) 247-8777
Fax (415) 227-0848

DEPLETED URANIUM CASE NARRATIVE
QUOTES SHEET

I. Pre-Desert Storm Reports:

1974: "In combat situations involving the widespread use of DU munitions, the potential for inhalation, ingestion, or implantation of DU compounds may be locally significant."
Medical and Environmental Evaluation of Depleted Uranium; Ad Hoc Working Group on Depleted Uranium of the Joint Technical Coordinating Group for Munitions Effectiveness; April, 1974; p. ix.

1974: "The use of DU in certain RDT&E [Research, Development, Training and Evaluation] and combat activities results in the redistribution of uranium in the environment, thereby providing a potential for adverse effects. Adherence to safety procedures and use of protective clothing minimize the potential for human exposure during RDT&E activities."
Medical and Environmental Evaluation of Depleted Uranium; April, 1974; p. viii.

July, 1990: "Aerosol DU exposures to soldiers on the battlefield could be significant with potential radiological and toxicological effects."
Kinetic Energy Penetrator Environmental and Health Considerations; Science Applications International Corporation (SAIC); July 1990. Vol. 1, 4-5.

July, 1990: "Under combat conditions, the MEI's [most exposed individuals] are probably the ground troops that re-enter a battlefield following the exchange of armor-piercing munitions, either on foot or motorized transports."
Kinetic Energy Penetrator Environmental and Health Considerations; SAIC; July 1990, Vol. 2, 3-4.

July, 1990: "We are simply highlighting the potential for levels of [DU] exposure to military personnel during combat that would be unacceptable during peacetime operations."
Kinetic Energy Penetrator Environmental and Health Considerations; SAIC; July 1990; Vol. 1, 4-5.

July, 1990: "Following combat, however, the condition of the battlefield, and the long-term health risks to natives and combat veterans may become issues in the acceptability of the continued use of DU kinetic energy penetrators for military applications."
Kinetic Energy Penetrator Environmental and Health Considerations; SAIC; July 1990, Vol. 2, 3-4.

July, 1990: "Depleted uranium: low level alpha radiation emitter which is linked to cancer when exposures are internal, [and] chemical toxicity causing kidney damage."
Kinetic Energy Penetrator Environmental and Health Considerations; SAIC; July 1990; Vol. 1, 2-2.

July, 1990: "Assuming US regulatory standards and health physics practices are followed, it is likely that some form of remedial action will be required in a DU post-combat environment."
Kinetic Energy Penetrator Environmental and Health Considerations; SAIC; July 1990; Vol. 1, 4-6.

October, 1990: "Bioassay procedures will be performed when radioactive materials are used in such a manner that they could be inhaled, ingested, or absorbed into the body."
Preventative Medicine; US Army Regulation 40-5; October 15, 1990; Chapter 9, 9-6 a(2).

September, 1990: "If ingestion or inhalation of radioactive materials is suspected, bioassays should be performed."
Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions and Armor Which Contain Depleted Uranium; TB 9-1300-278; Headquarters, Department of the Army, September, 1990; p. 7-3.

II. Post-Desert Storm Reports:

March, 1991: "There has been and continues to be a concern regarding the impact of dU on the environment. Therefore, if no one makes a case for the effectiveness of dU on the battlefield, dU rounds may become politically unacceptable and thus, be deleted from the arsenal . . . I believe we should keep this sensitive issue at mind when after action reports are written."
"The Effectiveness of Depleted Uranium Penetrators;" Los Alamos National Laboratory memorandum; Lt Col M V Ziehm; March 1, 1991.

March, 1991: "As Explosive Ordnance Disposal (EOD), ground combat units, and the civil populations of Saudi Arabia, Kuwait, and Iraq come increasingly into contact with DU ordnance, we must prepare to deal with the potential problems. Toxic war souvenirs, political furor, and post conflict clean-up (host nation agreement) are only some of the issues that must be addressed."
"Depleted Uranium (DU) Ammunition;" Lt. Col. Gregory Lyle; Defense Nuclear Agency; March, 1991.

1995: "When DU is indicted as a causative agent for Desert Storm illness, the Army must have sufficient data to separate fiction from reality. Without forethought and data, the financial implications of long-term disability payments and health-care costs would be excessive."
Health and Environmental Consequences of Depleted Uranium Use in the US Army: Technical Report; US Army Environmental Policy Institute (AEPI); June, 1995; p. 4.

1996: "US service personnel also could have been exposed to DU if they inhaled or ingested DU dust particles during incidental contact with vehicles destroyed by DU munitions, or if they lived or worked in areas contaminated with DU dust from accidental munitions fires. Thus, unnecessary exposure of many individuals could have occurred."
Presidential Advisory Committee on Gulf War Veterans' Illnesses Final Report; December, 1996; p. 99.

1993: "Army officials believe that DU protective methods can be ignored during battle and other life-threatening situations because DU-related health risks are greatly outweighed by the risks of combat."
Operation Desert Storm: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination; US General Accounting Office; GAO/NSIAD-93-90; January, 1993; p. 4.

1995: "Combat in Desert Storm has shown us that all soldiers anytime during battle may come across depleted uranium and depleted uranium contamination."
Development of Depleted Uranium Support Package: Tier I - General Audience; US Army Chemical School; October, 1995; p. 25.

1995: "The person most likely to be contaminated is breathing without protection when DU munitions hit and penetrate his AHA [DU armored] M1 tank and the DU aerosolizes into the tank turret. He will inhale large amounts of DU dust. Next is the person in an AHA M1 tank hit and penetrated by non-DU munitions. The DU in the armor would aerosolize into the turret. Other persons include crew members in Bradleys struck by DU ammunition. Last are individuals moving

COMMENTOR NO. 24: SWORDS TO PLOWSHARES (CONT'D.)
SAN FRANCISCO, CALIFORNIA

Statement of Jerry Wheat
Gulf War Veteran
4/7 Cav, 3rd Armored Division
March 2, 1998

My name is Jerry Wheat, and I served in the Army from 1987 until 1991 as a cavalry scout. During the Gulf War, I was assigned to the 3rd Armored Division in Germany and was sent to the Gulf on December 24, 1990. We were deployed near the Iraqi border, where we practiced manuvers before the invasion in February 1991. I left the Gulf in March 1991.

Our unit was engaged in heavy fighting on February 26, 1991. I was injured in a friendly fire incident involing depleted uranium ammunition. Our Bradley Fighting Vehicle was struck twice by DU rounds fired by US tanks, and I was awarded a Purple Heart for my shrapnel wounds.

In October 1991, I became ill. I began having abdominal pains that would drop me to the floor, and I could barely eat. This went on for several weeks even though I was seeing a doctor at an Air Force hospital in Albuquerque, NM. I left the military shortly after falling ill, and I could no longer seek medical care from the military. I contemplated suicide because there were no answers and there was no treatment. At that time, I was not informed nor was I aware of the fact I could go to the Department of Veterans Affairs for medical care. The pain is still with me today.

Later on, I visited the VA in Albuquerque, and I was told that the illnesses are not real, but that it is psychological -- that it is in my head. After seven years, the VA won't say if my physical ailments are related to DU exposure.

In March 1992, my father, an industrial hygenist technician at Los Alamos Laboratory, called me and informed me that the shrapnel taken from my gear and skin were radioactive. This was a tremendous surprise to me, since the Army never bothered to tell me I was hit with radioactive and toxic ammunition.

I am now part of a VA medical review following the health of veterans exposed to DU. This program only follows a handful of those with known heavy doses of DU exposure. By 1993, I had lost 60 pounds, and the VA has yet to explain this to me.

I am speaking out today because so many people are affected by Gulf War illnesses. Our government should stop using depleted uranium. If it won't do that, then the least it can do is provide training and health care for those exposed to the toxic waste.

Remember, this sad legacy of government mistakes is not new. About 50 years ago, veterans were used as human test subjects for atomic bomb blasts. Then the government tested LSD drugs on others. Then there was the use of Agent Orange more than 30 years ago.

The government should conduct more research into the health effects of DU. The government should admit that many, many more were exposed to DU dust and begin to provide health care as soon as possible -- before it is too late. Thank you.

1428

COMMENTOR NO. 24: SWORDS TO PLOWSHARES (CONT'D.)
SAN FRANCISCO, CALIFORNIA

Swords to Plowshares, Inc.
National Gulf War Resource Center, Inc.
Military Toxics Project, Inc.

Case Narrative

Depleted Uranium (DU) Exposures

Case Narratives are reports of what we know today about specific events that took place during the Persian Gulf War. This particular case narrative focuses on exposures to depleted uranium (DU). This is an interim report, not a final report. We hope that you will read this and contact us with any new information that would help us better understand the events reported here. With your help, we will be able to report more accurately on depleted uranium exposures during the Persian Gulf War. Please contact our offices to report any new information by calling:

(202) 628-2700, ext. 162
National Gulf War Resource Center, Inc.

(207) 783-5091
Military Toxics Project

(415) 247-8777
Swords to Plowshares

Last Update:
March 2, 1998

Author:
Dan Fahey

1429

COMMENTOR NO. 25: QUAPP, WILLIAM J., P.E.
IDAHO FALLS, IDAHO

Comments on the
DOE NE PEIS on the Management of
Depleted Uranium Hexafluoride

Prepared by: William J. Quapp, PE
Starmet Corporation,
2300 No. Yellowstone Hwy
Idaho Falls, ID 83401

Phone: 208-535-9001
Fax: 208-535-9070
Email: wjq@srv.net

March 10, 1998

I. INTRODUCTION AND BACKGROUND

Good afternoon, my name is William Quapp, from Starmet Corporation. I have been actively involved in evaluating the management issues associated with depleted uranium hexafluoride since May 1993. At that time and until June 1996, I was employed at the Idaho National Engineering Laboratory. My investigations were performed for DOE Environmental Management Program (EM50). Over these three years, we identified various management options and costs of their deployment. One of the major things we learned is that the management of the depleted uranium inventory must be considered as a system in context with other DOE materials and waste management responsibilities. While the depleted uranium hexafluoride can be processed and useful fluorine byproducts extracted for the recycle value, the residual uranium material – oxide or metal – must be managed as a radioactive material. The fluorine product value will not pay for the total conversion and byproduct management costs. Consequently, DOE must either plan on disposal of the residual uranium materials or identify products that can consume the material and be manufactured at reasonable costs. Additionally, there must be customers for those products. The alternative to products and customers is to manage the depleted uranium as waste.

25-1

The INEL program developed and patented one technology – *DUCRETE Shielding: A Depleted Uranium Concrete* -- which has been considered in the DOE PEIS as a potential use for depleted uranium. However, as will be pointed out later, because of the radioactive nature of depleted uranium, certain policies with respect to eventual disposal must be put in place to remove obstacles and encourage the use of depleted uranium in products.

25-2

As has been shown in studies supported by DOE EM, the current quantity of depleted uranium reasonably matches the required quantity if some of the storage applications were to be implemented. No other economic use has been identified that uses large quantities of material.

COMMENTOR NO. 25: QUAPP, WILLIAM J., P.E. (CONT'D.)
IDAHO FALLS, IDAHO

My remarks today will provide a summary of the INEL findings and provide my recommendations for DOE policies and actions needed to support the depleted uranium recycle applications envisioned in the PEIS for the preferred alternative.

2. DISPOSAL AS WASTE

The INEL studies addressed this issue in a parametric sense using published costs of conversion of UF_6 to oxide and the then current cost of disposal at the Nevada Test Site and Hanford. The studies showed that the potential cost range was somewhere between $3 to $11 billion assuming that either the Nevada Test Site or Hanford could accept the material and dispose of it in shallow land burial. Parameters considered included 1.) disposal as a compacted oxide and as stabilized oxide, 2.) disposal site locations and costs, and 3.) disposal as LLW versus Mixed LLW (RCRA controlled material).

25-3

3. RECYCLE USES

We evaluated recycle uses with the recognition that the depleted uranium is a radioactive material and must be controlled, used, and ultimately disposed of in appropriate nuclear waste repositories. We did not consider uses that would allow unrestricted use and disposal.

25-4

After evaluating numerous concepts (nuclear shielding, flywheels, drill rods, blast shielding, etc.), we concluded nuclear shielding was the only viable use for depleted uranium since it was a controlled nuclear material and will be slightly radioactive forever. Additionally, because of the lower cost of competitive materials, depleted uranium was not an economic alternative for most other applications. Depleted uranium metal makes economic sense when the benefit of its very high density enables a solution that is otherwise not possible with traditional materials (steel, lead, concrete, etc.).

Depleted uranium has been used as metallic shielding in the past for various shipping casks and as shielding for radiation sources. In these applications, depleted uranium was selected because of its higher efficiency for gamma attenuation would allow cask weight limitations and/or size constraints to be met.

We found that one of the biggest impediments to the use of depleted uranium as metal in storage cask shielding applications is the high cost of converting from UF_6 to uranium metal. In a survey performed for DOE by Technics Corporation, the cost was identified to be about $11.70 per kg-U ($5.30 per lb-U) for conversion of UF_6 to metal and casting into a shape. Any forming or machining was additional and was priced at $4.40 to $22 per kg-U. Some cost reductions could be forecast through larger conversion facilities but these would not be expected to be sufficient to dramatically reduce the costs below those cited. Consequently, since casks could be made with conventional materials at lower total cost, we believed that there was no economic application for depleted uranium metal in storage casks.

25-5

This economic reality spawned the invention of DUCRETE Concrete as a potentially economic alternative for using depleted uranium and avoiding the near term investment in disposal. This concept, while not directly cost competitive with conventional concrete, is much cheaper than

14 30

COMMENTOR NO. 25: QUAPP, WILLIAM J., P.E. (CONT'D.)
IDAHO FALLS, IDAHO

using depleted uranium metal and has some performance values that can make it economically competitive to traditional materials on a life cycle cost basis. And, by recycling the material, DOE can avoid declaring the material waste.

4. DUCRETE SPENT FUEL AND HIGH-LEVEL WASTE STORAGE CASKS

1.) DUCRETE Concrete is a technically viable material for spent fuel and high-level waste dry storage casks. Smaller, lighter weight, and more versatile casks can be designed and fabricated. DUCRETE casks can be factory fabricated and shipped to the user facility and re-shipped to the interim storage site or the geologic repository as required.
2.) DUCRETE Storage casks can be developed and deployed at DOE sites, commercial utility sites, the DOE Interim Spent Fuel Storage Site, and for shielding in Yucca Mountain. However, there is no industry incentive to independently finance DUCRETE cask demonstrations. Consequently, DOE must support such demonstration.
3.) DUCRETE Casks are competitive with traditional concrete IF DOE pays for conversion of the UF_6 into the depleted uranium aggregate (UF_6 to UO_2 to aggregate). DUCRETE concrete is not a competitive cask material if the cost for conversion from UF_6 to aggregate must be born by the cask fabricator.
4.) DUCRETE Casks will be acceptable to utilities and other users IF DOE agrees to accept them at end of life in a DOE disposal facility such as the NTS or the Spent Fuel Geologic Repository. Without a predefined disposal option, no commercial utility will accept ownership.
5.) DUCRETE concrete is a stable chemical form of material that meets the disposal criteria of the Nevada Test Site as-is. No further processing would be required for disposal.
6.) When used as shielding in casks or other radioactive material containers, DUCRETE concrete is managed by organizations already licensed to hold nuclear materials. Thus, the institutional control required for handling of depleted uranium is in place.

25-5 (Con't.)

4. TIMELY ACTIONS REQUIRED

Driven by the need for spent fuel storage in the country, many fuel storage actions are underway by both DOE OCRWM and utility organizations. Since a cask demonstration and licensing program could take up to 4 years, if DOE NE is to be successful in its goal to recycle the depleted uranium into nuclear storage products, prompt funding of demonstration cask projects need to be undertaken. If prompt initiation of such programs is not undertaken, the window of opportunity for the deployment of depleted uranium in spent fuel storage casks will have passed. To take advantages of the unique characteristics of DUCRETE cask systems, the cask design must be compatible with other transportation systems being developed. This necessitates early integration of cask design with other parts of the transportation systems.

25-6

5. POLICIES THAT DOE SHOULD ESTABLISH TO ENCOURAGE DEPLETED URANIUM RECYCLING

1. Any product manufactured from depleted uranium after the PEIS ROD should be accepted at the NTS or other DOE site for disposal, provided that,

25-7

COMMENTOR NO. 25: QUAPP, WILLIAM J., P.E. (CONT'D.)
IDAHO FALLS, IDAHO

a) All depleted uranium products submitted to DOE for future disposal be in a chemical and physical which form meets the current Waste Acceptance Criteria at that DOE disposal site, or,
b) DOE shall retain title to the depleted uranium material and, at end of product life, DOE will accept the product for disposal at the NTS provided that the depleted uranium product meets the NTS Waste Acceptance Criteria. *25-7 (Con't.)*

1. The Nuclear Waste Policy Act should be modified to allow disposal of depleted uranium casks or other depleted uranium materials in empty drift space between or other locations within the geologic repository. Presently, the Act restricts disposal of all materials other than spent fuel or high level waste. *25-8*
2. Empty depleted uranium storage casks in sound physical condition should be accepted at the NTS for re-use and at no cost to the owner. DUCRETE spent fuel or high-level waste casks would be very suitable as high integrity containers for the subsequent disposal of various Greater-than-Class C wastes from reactor decommissioning. DOE has responsibility for receiving such future wastes. *25-9*

6. OTHER DOE ACTIONS THAT WILL FACILITATE THE RECYCLE OF DEPLETED URANIUM

1. DOE should stimulate the demonstration of low cost UF_6 conversion technologies to lower the cost of management. Low cost processes to convert the UF_6 to metal or to an oxide are needed to reduce the management cost to DOE and to support any recycle objective. *25-10*
2. DOE should support the development and licensing of DUCRETE storage casks and mandate their use on DOE storage projects where the total system life cycle cost can be shown to be advantageous to DOE. *25-11*
3. DOE can consider the provision of DUCRETE storage casks to utilities for interim storage of spent fuel as partial compensation for being unable to receive spent fuel as required by law. *25-12*
4. DOE should objectively evaluate the use of DUCRETE shielded storage casks for shielding the spent fuel and high level waste packages in the geologic repository as an alternative to operating the repository as a remote handled facility for the 125 year period during emplacement and post-closure monitoring. *25-13*

7. CONCLUSIONS

Fifty years of nuclear activities in the US have left a large inventory of material with both unique and undesirable characteristics. To minimize the future cost of management in an environmentally and economically responsible manner, a system solution is needed to assure that the beneficial attributes of depleted uranium are recognized and used while the negative impacts of being a nuclear material are minimized. *25-14*

During the studies I managed for the DOE, we defined such a system solution where DUCRETE casks were used for spent fuel storage at reactor sites, at the interim storage facility, and for disposal containers in the geologic repository. That concept still appears to me to be the most environmentally responsible solution achievable at the least cost to the US taxpayers.

1431

COMMENTOR NO. 26: DIETZ, LEONARD A.
NISKAYUNA, NEW YORK

Leonard A. Dietz
1124 Mohegan Road
Niskayuna, NY 12309-1315

March 12, 1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Subject: Comments requested on "Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride"

Dear Mr. Bradley:

Remediation of the depleted uranium (DU) storage problem is an important and urgent task of Herculean proportions. My choice of the six options presented is No. 2: **Long-Term Storage as UF_6**—storage of UF_6 cylinders in yards, buildings, or a mine at a consolidated site. This choice has the least potential to pollute the environment with more DU. I suggest that each cylinder of DU hexafluoride should be placed in a permanent overcontainer filled with one atmosphere pressure of an inert gas such as argon to retard corrosion by preventing water vapor and oxygen from entering the containers. The overcontainers should be sealed hermetically and designed to last for 100 years or more. *26-1*

I believe that at this time we as a nation do not possess sufficient wisdom or foresight needed to decide on the final disposition of this enormous stockpile of waste uranium. It would be prudent to wait a few decades more before deciding on a final course of action.

Under no circumstance should DU be allowed in commercially-manufactured consumer goods or be made available to the general public as has been hinted at in a New York Times article by Mathew Wald.[1] He mentions industrial use of DU flywheels to store energy and use as a substitute for lead weights. Elsewhere it has been suggested that DU should be used as ballast in the keels of sailboats. Imagine a long-forgotten sailboat sunk in a storm and unretrievable, its hulk polluting a deep freshwater lake with uranium that slowly becomes soluble and pollutes the water. I became even more convinced that DU should be banned from commercial use when I saw an advertisement for a new driver golf club that contains a sphere of DU metal in its head so that a golf ball can be driven farther. These suggested commercial uses of DU are irresponsible and reckless, and will be dangerous to public health if they are implemented. The average person knows nothing about the technical aspects of uranium or radioactivity and is totally unprepared to deal with this radioactive and pyrophoric material that is highly toxic both chemically and radiologically.[2] Uranium in any chemical form presents significant dangers to health and safety, if it is not handled with scrupulous care. *26-2*

Beginning on the next page, detailed reasons are given why I chose the second alternative.

I would appreciate it very much if you would please add my name to the Depleted UF_6 mailing list. Thank you.

Sincerely,

Leonard A. Dietz

[1] M. L. Wald, "Danger From Uranium Waste Grows as Government Considers Its Fate," NY Times, March 25, 1997
[2] *Handbook of Chemistry and Physics*, The Chemical Rubber Co., 75th ed., 1994-95, Boca Raton, FL 33431, p. 4-32

COMMENTOR NO. 27: DUPONT NAFION® PRODUCTS FAYETTEVILLE, NORTH CAROLINA

DuPont Nafion® Products
P.O. Drawer 2
Fayetteville, NC 28302
Tel (910) 678 1329
Fax (910) 678 1765

DuPont Nafion® Products

March 17, 1998

Mr. Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program Office of Facilities
Office of Nuclear Energy, Science and Technology
Department of Energy
Germantown, MD 20874-1290

Dear Mr. Bradley,

We are interested in the Depleted Uranium Hexafluoride Management Program and the safe disposal of this material. Our major interest is in the utilization of the fluorine contained in the depleted uranium hexafluoride.

A number of proposals for the chemical conversion of the UF_6 have been made. At present, the conversion of UF_6 into elemental fluorine and uranium metal proposed by BNFL Inc. appears to be the most promising scheme. The preparation of high value fluorine (F_2) makes the most economic sense. We have had and continue to have discussions with BNFL Inc. about this process and our uses for the fluorine product. Although we do not anticipate any interest in the uranium coproduct this may also be its most desirable form for ultimate use or disposal by others.

27-1

We will continue our discussions and contacts with BNFL Inc. and the Department of Energy. Please do not hesitate to contact us if we be of any help to you in your work on the Depleted Uranium Hexafluoride Management Program.

Sincerely yours,

Paul R. Resnick

Paul R. Resnick
DuPont Fellow
(910) 678-1607 (910) 678-1498 FAX

Robert A. Boyajian
Senior Engineering Associate
(609) 540-3649 (609) 540-3078 FAX

14432

Printed on Recycled Paper

COMMENTOR NO. 28: STATE OF TENNESSEE, DEPARTMENT OF ENVIRONMENT AND CONSERVATION OAK RIDGE, TENNESSEE

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

March 18, 1998

Charles E. Bradley, Jr.
Office of Facilities (NE-40)
US Department of Energy
19901 Germantown Road
Germantown MD 20874

Dear Mr. Bradley

Programmatic Environmental Impact Statement For Alternative Strategies For The Long-Term Management And Use Of Depleted Uranium Hexafluoride

The Tennessee Department of Environment and Conservation, DOE Oversight Division (TDEC/DOE-O) would like to request an extension on the comment period for the "Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride." This is an important issue for the State of Tennessee, and we would like additional time to complete a thorough review of this document. An extension of the comment period to May 7, 1998, will be sufficient. Please let us know if this is acceptable.

28-1

If you have any questions, please contact Rebecca Charles at (423) 481-3032 or me at (423) 481-0995.

Sincerely

John Owsley

John Owsley
Assistant Director

jao496.99

COMMENTOR NO. 29: UNITED STATES SENATE, MOSELEY-BRAUN, CAROL; DURBIN, RICHARD & POSHARD, GLENN WASHINGTON, D.C.

CAROL MOSELEY-BRAUN
ILLINOIS

COMMITTEES:
BANKING, HOUSING, AND URBAN AFFAIRS
FINANCE
SPECIAL AGING

United States Senate
WASHINGTON, DC 20510-1302

March 19, 1998

The Honorable Frederico Pena
Secretary
The United States Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Secretary Pena:

We are writing to express our interest in the important work underway at the Department of Energy (DoE) to evaluate strategies for the long-term management and use of depleted uranium hexafluoride. As you know, there are over 1 billion pounds of this uranium enrichment by-product stored at the enrichment plants in Ohio and Kentucky, as well as in Oak Ridge, Tennessee. We are aware that the Department is currently soliciting public comments on a Draft Programmatic Environmental Impact Statement on various uranium hexafluoride management strategies. We commend you for moving to address this health, safety and environmental issue for the employees and neighbors of these facilities. 29-1

One of the options under the consideration by DoE is a technology which can convert uranium hexafluoride to a safe and stable form of uranium suitable for long-term storage, retrievable disposal, or further use. This process is essentially the reverse of the uranium conversion process performed by AlliedSignal in Metropolis, Illinois. The technology, which is being tested through a joint DoE - industry partnership in Metropolis, offers two key benefits.

First, it converts the uranium to a solid, or oxide state, making it safer to store and available for possible future use. Secondly, it captures the Hydrogen Fluoride contained in the uranium hexafluoride which can then be recycled for use in the ongoing uranium conversion process, and for other manufacturing processes such as the production of non-ozone depleting refrigerants. The benefit to DoE and the country is that the danger posed by the existing uranium hexafluoride containers can be removed and the government can be compensated for the value of the captured Hydrogen fluoride. 29-2

We realize that DoE will not make a final decision on a uranium hexafluoride management strategy until early next year. Our hope is that the time between now and then can be used productively to fully demonstrate this technology so its full costs and benefits can be determined. In order for this to happen, DoE funding needs to continue through fiscal year 1999. We hope that sufficient funding for the current fiscal year is available within the Department's FY 1998 appropriation. Please inform us of the current and future funding plans for this

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COMMENTOR NO. 29: UNITED STATES SENATE, MOSELEY-BRAUN, CAROL; DURBIN, RICHARD & POSHARD, GLENN (CONT'D.) WASHINGTON, D.C.

important environmental management program.

We thank you for your time and attention to this matter.

Sincerely,

Carol Moseley-Braun
U.S. Senator

Richard Durbin
U.S. Senator

Glenn Poshard
Member of Congress

COMMENTOR NO. 30: UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
URBANA, ILLINOIS

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Department of Chemical Engineering
114 Roger Adams Laboratory, Box C-3
600 South Mathews Avenue
Urbana, Illinois 61801
USA

March 23, 1998

Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U. S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Charles:

I am interested to see that things are moving ahead much as you told us they would, when we were preparing our National Research Council Report, "Affordable Clean Up". [Dr. Fred Schneider and I wrote the chapter on "Disposition of the UF_6".

At the time we saw little to suggest that conversion to metal made any sense, but I see that mentioned as one of DOE's ambitions. I wonder if you are really serious about that.

In your PEIS (Summary version, page S-44) you indicated that DOE is "committed to continuing its support for the development of applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted UF_6 cylinder inventory". Now that position bothers me! We have had this material in storage for 50 years and have been studying options for using the stuff for a large number of those years. Continued storage and study is just a way of avoiding a decision in my opinion. Only DOE would consider such an option!

30-1

I read where the money allotted to DOE clean-up activities is well below that required for expeditious clean-up. But the UF_6 ought to be on the list somewhere, not just relegated perpetually to the future.

Sincerely,

Wesley G. May

W. G. May
Professor of
Chemical Engineering

WGM:djj

Phone (217) 333-3640 • Fax (217) 333-5052

1434

COMMENTOR NO. 31: FRIENDS OF OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE

Friends of Oak Ridge National Laboratory
1052 West Outer Drive
Oak Ridge TN 37830
2 April 1998

Mr. Charles E. Bradley, Jr
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874

Subject: Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride. Summary, DOE/EIS-0269, December 1997.

The Friends of Oak Ridge National Laboratory, an organization of retired and present employees and of others interested in the welfare of the Laboratory and the community, wishes to comment on the referenced PEIS.

Roughly 46,000 cylinders containing depleted UF_6 (not counting 8000 under management of the United State Enrichment Corporation) are stored at the three gaseous diffusion sites, about 4,700 of them in Oak Ridge. Each is partially filled with 10 to 14 tons, solid at ambient temperature, for a total in the neighborhood of 500,000 tons. DOE plans between 2009 and 2020 to convert the material to HF and a solid form of uranium, likely U_3O_8. There is an established market for HF, and the hope is to find beneficial uses for the uranium. Barring the breeding of nuclear fuel, not likely in the next few decades, prospects for use of a substantial fraction of it are dim.

31-1

There does not seem to be agreement in estimates of the costs of conversion, except that they will be large. If we assume for discussion, $3 a pound, net of HF value, a total of about $3 billion would be be required. Quoted current costs for management of the inventory range from fifteen to thirty million/year. If there were no significant risks involved and if the maintenance costs were to track inflation, there would be no particular urgency for getting on with conversion, because interest on the conversion investment would easily exceed present annual outlays. We have serious doubts about both premises.

31-2

COMMENTOR NO. 31: FRIENDS OF OAK RIDGE NATIONAL LABORATORY (CONT'D.)
OAK RIDGE, TENNESSEE

The cylinders are constructed of carbon steel, of nominal thickness 0.312 inches (older ones were of twice this thickness). Although internal corrosion from UF_6 appears small, so long as integrity of containment is maintained, there is abundant evidence of general external corrosion from exposure to the elements, particularly of those in Oak Ridge, which tend to be older. Of more concern, there is pitting and crevice corrosion. Seven of the cylinders are known to have developed cracks, five involving handling, but two from corrosion alone. In these cases, atmospheric moisture has hydrolyzed the uranium hexafluoride to UO_2F_2, which has acted as a seal. The HF produced has dissipated harmlessly, and the contamination of water with soluble uranium compounds has not yet caused serious embarrassment. The benign effects of these failures seem to have lulled policy makers about untoward events during the thirty years projected before completion of conversion to a form safe for indefinite storage. 31-3

However, even if events having serious consequences are discounted, steep rises in the annual costs of custodial care and in the eventual costs of conversion seem inevitable. As corrosion worsens, there will be increasing numbers of breaches requiring patches. The weakening of the cylinders will increase the costs and dangers of handling them in periodic painting or in removing the contents for conversion. If all are to be converted at a single site, more and more will have walls that do not meet the minimum 0.25-inch walls DOE specifies for safe transportation by highway or rail. 31-4

Confidence that there is small risk of more damaging events may be misplaced. The cylinders support about 250,000 pounds force from the atmosphere (25000 in^2 times 10 psi differential). In addition to this evenly distributed stress is that from resting on the surface and, for the bottom layer, from those stacked on top. Many of the cylinders are forty years old. The program to clean and paint the outer surfaces lags deterioration. 31-5

There are a number of conceivable scenarios for catastrophic failures of containment, beyond what uranyl fluoride could seal, from an earthquake or transportation accidents, for example. Over the interval before planned conversion, with the number involved, stacked as they are, collapse in place of some is hard to exclude. If such an event occurred in a wet situation, a dangerous plume of HF could be produced. In Table 6.3 on page 6-17 of the referenced Summary, it is estimated that such a failure might occur in 1 to 10 years under dry conditions; on the next page, the frequency of a more serious accident, involving three cylinders apparently being transported, is given as 1 in 100,000 years under wet conditions. Chemical exposure from the latter is projected to have adverse effects on 1900 of the public, and on 1000 non-involved workers (of which 300 would suffer irreversible effects). With the climate here and the difficulty of reaching cylinders in the middle of storage areas, the 1 to 10 year single-cylinder failure might well occur under wet 31-6

1435

COMMENTOR NO. 31: FRIENDS OF OAK RIDGE NATIONAL LABORATORY (CONT'D.)
OAK RIDGE, TENNESSEE

conditions, perhaps with less, but still unacceptable, effects.

There seems to be general agreement that conversion is eventually necessary. We advocate acceleration. We recommend that conversion begin in Oak Ridge as the pilot. The cylinders here are in the worst condition and are likely most risky to transport. We believe that work should not be delayed until a market for the uranium develops, a long shot at best. We encourage research to lower costs of conversion, but not at the expense of timely action. In the meantime a major overhaul of the cylinder storage situation at Oak Ridge should be a high priority. 31-7

As we understand it, the cylinders are not considered waste, and as a result conversion is not on the table when remediation priorities are set. If funding for conversion is not available in the appropriate category, we believe DOE should rise above administrative barriers and assess the possible problems from the cylinders in comparison with the risks from delays of other remediation projects. 31-8

Respectfully,

William Fulkerson, President

COMMENTOR NO. 26: DIETZ, LEONARD A. (CONT'D.) NISKAYUNA, NEW YORK

Detailed Reasons for Choosing the Second Alternative

Design of the DU Processing Plant and its Containment Efficiency

The processing of DU hexafluoride into uranium oxide or uranium metal requires extensive chemical processing, melting and casting operations. The pyrophoric nature of uranium makes it inevitable that significant quantities of uranium oxide aerosol particles will be formed. There does not have to be an accident at a DU processing plant for the public to be exposed to dangerous concentrations of aerosol micrometer particles of uranium oxide. Exposure can occur from DU aerosol particles released into the atmosphere during normal operations. To illustrate this, we assume that a well-designed and super-efficient processing plant can be built that would contain 99.99999% of all the uranium it processes. In such a plant only 1-gram in 10-million grams of DU would escape into the environment. We examine how this relates to the large amount of DU proposed to be processed from the years 2009 through 2028 and then compare it with an actual experience in New York State.

Using the data given on page S-2, Vol. I, The depleted UF_6 cylinders currently managed by DOE plus the cylinders produced by the United States Enrichment Corporation total approximately 54,422. They contain about 600,000 metric tons of DU hexafluoride. Continued operation of the Portsmouth and Paducah diffusion plants could double this amount by the year 2028. Therefore, the DU hexafluoride that must be processed each year for 20 years beginning in 2009 is approximately 60,000 metric tons, of which two thirds is the element uranium. Thus, it appears that up to 40,000 metric tons of DU will be processed per year.

Containment of DU within the processing facility or facilities will be a major problem, even with the very best technology available. For example, if as postulated, 99.99999% of the DU can be contained successfully, then in 40,000 metric tons of DU processed each year, 4,000-grams will escape at an average rate of 333-grams per month.

26-3

The New York State Experience with a DU Processing Plant

The estimated rate of 333-grams of DU escaping into the atmosphere per month must be compared with the New York State experience with National Lead Industries, a former DU processing plant near Albany, NY. At NL Industries DU was processed into DU metal penetrators for 30-mm cannon rounds and into airplane counterweights made of DU. In February 1980, a court order by NY State citing public health reasons shut down NL Industries for exceeding a NY State Department of Environmental Conservation monthly radioactivity limit of 150 microcuries (387-grams of DU) for airborne emissions. Recently the highly contaminated plant was razed and a large quantity of radioactively contaminated structural material and soil has been prepared for shipment to a disposal site.

The NL Industries plant caused massive contamination to the residential area and commercial properties outside the perimeter of the plant. In 1984, 1985 and 1988 a total of 950 cubic meters of radioactively contaminated soil were removed by DOE from 53 of 56 vicinity properties.[3] My hypothetical super-efficient plant would release 333-grams (129 microcuries) of DU airborne particles per month into the environment. This amount of DU is not significantly different from the 150 microcuries per month limit set by New York State. It is highly unlikely that a release rate of 150 microcuries of DU per month into the atmosphere will ever again be allowed by a local government or by citizens affected by the fallout. The containment efficiency of a DU processing plant would have to

[3]DOE Report No. DOE/OR/21950-888, "Engineering Evaluation/Cost Analysis (EE/CA) for the Colonie Interim Storage Site (CISS) Buildings," June 1993, p. ES-1.

14 36

COMMENTOR NO. 26: DIETZ, LEONARD A. (CONT'D.) NISKAYUNA, NEW YORK

be at least 10 times better than I have assumed, allowing less than 1-gram of DU in 100-million grams (100 metric tons) of DU to escape into the environment. This extremely high requirement may be impossible to meet. The control and containment of DU emissions inside the plant would have to be even more stringent. When processing such huge quantities of DU it will be extremely difficult if not impossible to keep workers inside the plant from becoming contaminated with it.

26-3 (Con't.)

Transport of DU Particles in the Atmosphere

Another serious issue is what happens to the uranium particles that escape into the atmosphere and become dispersed far and wide by wind action. In the fall of 1979 I worked at the Knolls Atomic Power Laboratory in Schenectady, NY. The laboratory was operated by the General Electric Company for the Department of Energy. While troubleshooting a problem for the radiological group, my colleagues and I accidentally discovered DU aerosols collected in environmental air filters exposed at the Knolls site. The source of the uranium contamination was the NL Industries plant in Colonie, 10 miles east of the Knolls site, outside Albany, NY. We also discovered DU in air filters exposed at the Kesselring site in West Milton, NY, where crews for the nuclear Navy are trained, 26 miles NW of the NL plant. This is by no means the maximum fallout distance for uranium aerosols. A radius of 26 miles encompassed an area of more than 2,000 square miles around Albany where this fallout occurred. In January, 1980 I wrote and issued an internal technical report that documents our mass spectrometer measurements.[4] Airborne uranium aerosol particles act like dust and can go everywhere that dust goes. The scientific explanation of how micrometer-size uranium particles can easily travel such large distances when airborne is given in a survey paper that is available on the Internet.[5]

26-4

Use of DU Metal in Large Commercial and Military Airplanes

The use of DU metal counterweights in commercial and military airplanes should be banned. Until about 1980 each Boeing 747 passenger jet contained 1,500 kilograms of DU metal counterweights used for dynamic flight control.[6] In a crash and ensuing intense fire DU metal will begin to oxidize rapidly and sustain slow combustion when it is heated in air at a temperature of 500° C.[6] This can cause DU oxide particles to be formed that can become airborne and poison large numbers of people and their surroundings.[7] This scenario has already happened. In 1977 two Boeing 747s crashed into each other and burned on a runway at Tenerife, Canary Is. In 1988 a Boeing 747, Pan Am Flight 103, crashed and burned at Lockerbie, Scotland. And in 1992 an El Al Isralei Boeing 747 crashed into an apartment building and burned in Amsterdam, Holland.

26-5

Fire and safety personnel exposed to the combustion products of DU are at risk. How many fire and safety emergency crews at airports or in cities have been trained and provided with equipment that will protect them from uranium particles that have been generated in intense fires?

[4]L. A. Dietz, CHEM-434-LAD, "Investigation of Excess Alpha Activity Observed in Recent Air Filter Collections and Other Environmental Samples," Jan. 24, 1980, unclassified technical report, Knolls Atomic Power Laboratory, Schenectady, NY 12301; obtained under the Freedom of Information Act. Copies available from L. A. Dietz if desired, a certified copy should be available from Schenectady Naval Reactors

[5]L. A. Dietz, "How Gulf War Veterans and Others became Contaminated by Depleted Uranium," available on the world-wide web at the WISE Uranium Project home page <http://www.nirs.org/uranium/>

[6]Lowenstein, P., "Industrial Uses of Depleted Uranium," photocopy in *Uranium Battlefields Home & Abroad: Depleted Uranium Use by the U.S. Department of Defense*, Bukowski, G. and Lopez, D. A., March, 1993, p. 136.

[7]Parker, R. L., "Fear of flying," *Nature*, Vol. 336 22/29 Dec 1988, p. 719.

COMMENTOR NO. 32: PUBLIC HEARINGS
PADUCAH, KENTUCKY

UNITED STATES DEPARTMENT OF ENERGY

PUBLIC HEARING REGARDING

DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

HEARING DATE: February 19, 1998

TIME: 7:00 p.m.

****

A&A COURT REPORTING

****

Anita Gale, CSR
240 Colonial Drive
Paducah, Kentucky 42001
(502) 554-9349 (800) 253-7866

1437

COMMENTOR NO. 33: PUBLIC HEARINGS
OAK RIDGE, TENNESSEE

TRANSCRIPT OF THE

DEPARTMENT OF ENERGY'S PUBLIC HEARING

ON THE DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

DARRYL ARMSTRONG -- FACILITATOR

FEBRUARY 24, 1998
5:00 to 9:00 p.m.
RAMADA INN AND SUITES
OAK RIDGE, TENNESSEE

****

ARIANNE KYSER, RPR
MILLER & MILLER COURT REPORTERS
12804 UNION ROAD, KNOXVILLE TN 37922
1-423-675-1471 * 1-800-532-5950

COMMENTOR NO. 34: PUBLIC HEARINGS PORTSMOUTH, OHIO

UNITED STATES DEPARTMENT OF ENERGY

...

In re: :

Public Hearing. :

...

Rifle Vocational School
Piketon, Ohio
February 26, 1998
5:00 p.m.

...

BEFORE:
Darryl Armstrong, Facilitator.

Also present:
Charles Bradley and Thomas Marshall, Cylinder Management Program;

Halil Avci and Marsha Goldberg, Argonne National Laboratory;

Gene Gillespie, Plant Manager.

...

JENNIFER L. RENO REPORTING
P.O. BOX 594
WAVERLY, OHIO
(614) 947-9001

1438

COMMENTOR NO. 35: PUBLIC HEARINGS WASHINGTON, D.C.

UNITED STATES OF AMERICA

DEPARTMENT OF ENERGY

- - - - -

PUBLIC HEARING ON THE DRAFT
PROGRAMMATIC ENVIRONMENTAL IMPACT
STATEMENT FOR ALTERNATIVE STRATEGIES
FOR THE LONG-TERM MANAGEMENT AND
USE OF DEPLETED URANIUM HEXAFLUORIDE

- - - - -

TUESDAY
MARCH 10, 1998

- - - - -

WASHINGTON, D.C.

The public hearing was held in Room 1E-245 of the U.S. Department of Energy Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C., at 1:00 p.m., Darryl Armstrong, facilitator, presiding.

PRESENT:

Darryl Armstrong
Charles Bradley, Jr.
Andrew Lukimer
Annie Makhijani
William Quapp
Gene Hoffman

COMMENTOR NO. 36: STATE OF ILLINOIS, DEPARTMENT OF NUCLEAR SAFETY SPRINGFIELD, ILLINOIS

STATE OF ILLINOIS
DEPARTMENT OF NUCLEAR SAFETY
1035 OUTER PARK DRIVE
SPRINGFIELD, ILLINOIS 62704
217-785-9900
217-782-6133 (TDD)

Jim Edgar
Governor

Thomas W. Ortoiger
Director

April 1, 1998

Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Mr. Bradley:

The Illinois Department of Nuclear Safety (IDNS) hereby submits its comments on the Department of Energy (DOE) Preliminary Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (UF6). IDNS applauds DOE's early recognition of Illinois' unique situation relative to this issue and appreciates the opportunity to comment on the Draft. IDNS considers itself a stakeholder in this process for two reasons. Clearly, IDNS is interested in any environmental impacts from changes in the mission of the Paducah Gaseous Diffusion Plant (PGDP) facility because of its proximity to Illinois. However, IDNS is also interested for a reason not reflected in the PEIS; the close proximity to the subject facility of the Allied-Signal Metropolis Works in Illinois. *36-1*

Fundamentally, IDNS supports the general strategy of converting UF6 to more chemically stable forms such as U_3O_8 as soon as possible. We agree that DOE needs a longer-term plan for management of UF6 that goes beyond inspections and repairs of leaking cylinders in storage yards. We also agree with the general strategy of trying to find markets for the by-products of the conversion process, although we have some concerns about radioactive contaminants in these by-products which we will discuss below. *36-2*

The major shortcoming of the PEIS in our view, however, is its failure to recognize that the Allied-Signal Metropolis Works does exist and that there is a reasonably high probability that it will have an important role to play in DOE's UF6 management strategy. DOE must recognize that given Allied-Signal's *36-3*

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COMMENTOR NO. 36: STATE OF ILLINOIS, DEPARTMENT OF NUCLEAR SAFETY (CONT'D.) SPRINGFIELD, ILLINOIS

experience in the conversion business and the existing infrastructure at Metropolis, the Metropolis Works may be the only facility in the United States capable of handling the UF6 to oxide conversion at a reasonable cost. *36-3 (Con't.)*

IDNS understands that given the method that DOE generally employs to develop a PEIS, siting issues are not addressed until the second phase of the NEPA approach. However, we feel that the decision to recognize or ignore Allied-Signal, even at this early stage, has significant impact on evaluating the risks and benefits of DOE's management options. *36-4*

Page 2-5 - This section describes the option of long-term storage as depleted UF6. This option is the least desirable from IDNS' point of view. Associated with this option would be all the risks of transportation with none of the benefits of conversion to oxide. We suggest that this option be given no further serious consideration. *36-5*

Section 3.1.7 - The description of the affected environment surrounding the PGDP fails to recognize the presence of the Allied-Signal Metropolis Works as another major uranium processing facility in the immediate vicinity. Allied-Signal's effluent releases and impacts on the environment are thereby not considered in this review. *36-6*

Page 3-14 - The region of influence includes Massac County, Illinois (not Massaic). *36-7*

Page 3.4 - Check the map scale. 3000 km is not roughly equivalent to 2 miles. *36-8*

Table F.2 - If Allied Signal were considered as a site for a conversion facility, most of the health risks and potential benefits would need to be evaluated. Risks and benefits from construction activities would be particularly impacted. While on one hand, ecological and land use impacts would be smaller, economic benefits from increased employment would also be smaller. *36-9*

Page F-11 - Anhydrous HF may have been a valuable product at one time, however, given the glut of UF6 on the market, one questions the value of a product whose primary use is the production of more UF6 from ore. *36-10*

Page F-12 - IDNS is concerned about the depleted uranium content of the anhydrous HF that could be produced by a conversion process. IDNS would be interested in any uncertainties associated with the 1 ppm figure quoted. In any *36-11*

COMMENTOR NO. 36: STATE OF ILLINOIS, DEPARTMENT OF NUCLEAR SAFETY (CONT'D.) SPRINGFIELD, ILLINOIS

case, we do not believe it is certain that the material will have commercial value if it is known to be contaminated at any level.

Table F.25 - We assume that the source of the figures in this table are from (LLNL 1997) which is an estimate based on theoretical considerations. We suggest that actual historical low-level radioactive waste generation figures from Allied-Signal would be more useful. *36-12*

Page J-7 - The failure to consider existing facilities has led to inconsistencies in making assumptions. In Appendix J, the analysis of transportation risks is based on the assumption that the distance between the storage and conversion facilities is 1000 km. However, in Appendix F, it assumed that the facilities are co-located. *36-13*

Questions on our comments should be addressed to Richard Allen, Manager, Office of Environmental Safety at 217-782-1322.

Sincerely,

Thomas W. Ortciger
Director

TWO:tlk

14440

COMMENTOR NO. 37: NURMELA, LILLIAN OAKLAND, CALIFORNIA

Lillian Nurmela, 145 Monte Cresta Ave., #201, Oakland, CA 94611 (510) 652-5766

April 4, 1998

Mr. Charles E. Bradley, Jr.
U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, MD 20874

Dear Mr. Bradley:

Re: Disposition of Depleted Uranium

The only responsible course for the Department of Energy to follow regarding the huge DU inventory is to establish safe, long-term storage of this material, which remains radioactive for what amounts to eternity. *37-1*

DU should definitely NOT be used for military purposes. We must not be responsible for blanketing battlefield areas with this long-lived radioactive material. *37-2*

Sincerely yours,

Lillian Nurmela
Lillian Nurmela

COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

PHONE: (423) 574-9930
FAX: (423) 576-6118
INTERNET: lg7@ornl.gov

OFFICE BOX 2008
OAKRIDGE, TN 37831-6248

April 3, 1998

Mr. Charles E. Bradley, Jr.
Office of Nuclear Energy, Science and Technology
Office of Facilities, NE-40
Department of Energy
19901 Germantown Road
Germantown, Maryland 20874-1290

Dear Mr. Bradley:

Comments on the *Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*

I am enclosing comments and observations generated by my staff pertaining to a review of the subject document. Please contact Gordon E. Michaels (423) 574-4187 or David L. Moses at (423) 574-6103 if you have questions concerning these comments.

Sincerely,

R. G. Gilliland
Associate Director for
Energy and Engineering Sciences

Enclosure

RGG:jlp

c/enc: H. E. Clark, DOE-ORO
A. G. Croff
C. W. Forsberg
E. C. Fox
S. R. Greene
M. J. Haire
G. T. Mays
G. E. Michaels
D. L. Moses
R. L. Reid
A. W. Trivelpiece - RC
V. S. White
D. L. Williams

ornl - *Bringing Science to Life*

1471

COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY (CONT'D.)
OAK RIDGE, TENNESSEE

1. **Retain adequate depleted UF_6 to support the Surplus Plutonium Disposition Program under the "No action alternative" long-term management strategy for depleted UF_6.**

One of the options for dispositioning the surplus weapons-grade plutonium is for use as mixed-oxide (MOX) fuel in light water reactors. A small portion, less than 0.3% of the available supply of the depleted UF_6 (ORNL/TM-13417 Rev. 1), should be set aside and reserved for use in the Surplus Plutonium Disposition Program. The required UF_6 to be removed from inventory is approximately 1400 MT as indicated in ORNL/TM-13466, Rev. 1, which is a Data Report to be released concurrently with the Surplus Plutonium Disposition Environmental Impact Statement.

The depleted UF_6 should be stored at the Portsmouth site since that is the only facility with operating transfer autoclaves for emptying the depleted UF_6 from the 12.7 MT (14 ton) storage cylinders into 2.28 MT (2.5 ton) feed cylinders. The smaller cylinders are required for transporting the depleted UF_6 by truck to commercial conversion facilities where the depleted UF_6 will be converted to uranium oxide and subsequently blended with oxide derived from surplus plutonium to make MOX fuel at a proposed government-owned fuel fabrication facility. The UF_6 cylinders will be selected based on a depleted uranium assay specified by the consortium selected to provide MOX fuel fabrication and reactor irradiation services. The feed requirement for the depleted uranium expected to be required by the Surplus Plutonium Disposition Program is approximately 0.25 wt % as indicated in ORNL/TM-13466, Rev. 1. *38-1*

The PEIS (Section S.5.1 and Section 1.6) acknowledges that other DOE programs, such as the Surplus Plutonium Disposition Program, have requirements for small amounts of depleted UF_6. It is stated that this small fractional requirement of the UF_6 inventory would not affect the selection of a long-term management strategy in the Record of Decision (ROD) to be issued following the publication of the final version of the PEIS. However, the comments under Item 1 above are relevant in that specific cylinders of excess depleted UF_6 should not be considered surplus to all government programs and will be requested to be stored at Portsmouth for potential use in the disposition of surplus plutonium.

COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY (CONT'D.) OAK RIDGE, TENNESSEE

2. **Consider the benefit of using the depleted uranium in geological disposal sites such as Yucca Mountain and the Waste Isolation Pilot Plant (WIPP) under the "Use as Uranium Oxide" long-term management strategy for depleted UF_6.**

Depleted uranium can be used to improve the performance of the repository for disposal of spent nuclear fuel (SNF). Depleted uranium reduces the radionuclide release rate from a SNF waste package and minimizes the potential for long-term nuclear criticality. In this context, the U.S. Nuclear Waste Technical Advisory Panel—the Congressionally-mandated scientific review panel for the DOE Yucca Mountain project— stated (U.S. Nuclear Waste Technical Review Board, *Report To The Congress And The Secretary of Energy: 1995 Findings and Recommendations*, Arlington, Virginia, April 1996):

"The Board suggests that DOE consider increasing the criticality control robustness of the EBS (Engineered Barrier System)... In particular, the use of depleted uranium in filler, invert, or backfill material, or in all three, is a concept the program has not yet explored adequately. Conceivably, increasing the criticality control robustness of the EBS could turn a potentially intractable analysis of external criticality into a comparatively easy one."

38-2

The recommendations of nationally recognized, congressionally-mandated scientific review boards on uses of depleted uranium should be explicitly considered in the PEIS. It is also noted that the Spanish repository program is investigating the use of depleted uranium to improve repository performance. This use of depleted uranium is receiving attention worldwide.

Additional information on this option can be found on pages 8-9 of the paper "Beneficial Uses Of Depleted Uranium," authored by Colette Brown of DOE and Allen Croff and M. Jonathan Haire of ORNL. The paper was prepared for the Beneficial Re-Use '97 Conference held in Knoxville, Tennessee, on August 5-7, 1997.

3. **Expand the discussion in the PEIS of potential "Use Options" of the depleted UF_6, either as Uranium Oxide or Uranium Metal.**

The primary use of the depleted UF_6 discussed in the PEIS, either as uranium oxide used to make high density concrete (Section 2.2.4) or as uranium metal (Section 2.2.5), is as

38-3

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COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY (CONT'D.) OAK RIDGE, TENNESSEE

shielding for spent nuclear fuel or high-level waste (HLW) storage containers. The detailed discussion should be expanded to include other options which could potentially use substantial amounts of the depleted UF_6, such as its use in industrial counterweights for forklift trucks. Another potential option would be the use of the depleted UF_6 in the manufacture of casks for low-level wastes (LLW), as recently proposed in a Technical Development Initiative for Fernald. The discussion of each "use option," including the use of the depleted UF_6 as shielding, should address the economic and technical viability of each option since these issues have been challenged in the public hearings for this PEIS held in Paducah and Oak Ridge. Additional information on these options can be found in the paper "Beneficial Uses of Depleted Uranium," referenced in Item 2.

38-3 (Con't.)

4. **Account for the end of life disposal requirement for any application under the "Use Options" for long-term management strategy for depleted UF_6.**

DOE is considering using depleted uranium in the manufacture of casks for spent nuclear fuel or high-level waste (HLW) storage containers. One application is to covert the depleted UF_6 to an oxide which in turn would be used as the aggregate to make depleted-uranium-concrete. The high density of the uranium allows the same shielding effectiveness with approximately half the thickness of conventional concrete. This concrete would then be used to manufacture oxide-shielded casks.

Another option would be to chemically-convert the depleted UF_6 to uranium metal which could be enclosed between the stainless steel shells making up the body of the casks. The uranium metal would be the primary shielding material in the casks which could be reduced in thickness relative to casks using only steel as the shielding material. The PEIS (pages 2-14 and 2-15) states that no assumptions were made regarding the fate of depleted-uranium-concrete casts or the uranium metal casks following use. However, the disposal requirements for depleted uranium at end of life have a major impact on "use options." When the depleted uranium is used for an application such as shielding, at the end-of-life it must be converted into an acceptable waste form. The end-of-life costs to convert depleted uranium into an acceptable form may far exceed manufacturing costs. The consequence of this requirement should be evaluated in the PEIS.

38-4

COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY (CONT'D.) OAK RIDGE, TENNESSEE

5. **Consider disposal of the depleted uranium at the Yucca Mountain repository for spent nuclear fuel and high-level waste under the "Disposal Alternative" long-term management strategy for depleted UF_6.**

The draft PEIS (Section 2.2.6) lists three options under the "Disposal Alternative": shallow-land earthen structures, below ground vaults, and mine disposal. At least two of these three options, shallow-land earthen structures and below ground vaults, do not meet regulatory requirements for protection of public health and safety according to the detailed analysis in Appendix I of the draft PEIS. The detailed analysis within the draft PEIS on page I-23 states:

"The maximum dose to an individual, assumed to live at the edge of the disposal site and use the contaminated water, was estimated to be about 110 mrem/yr, which would exceed the 25 mrem/yr limit specified in 10 Code of Federal Regulations Part 61. Possible exposures (on the order of 10 rem/yr) could occur for shallow earthen structures and vaults if the cover material were to erode and expose the uranium material..."

38-5

The detailed technical analysis within the draft PEIS Appendix I is consistent with the U.S. Nuclear Regulatory Commission (NRC) analysis that near surface disposal of large quantities of depleted uranium is not acceptable (J. W. N. Hickey, *Letter from J. Hickey, Chief Fuel Cycle Safety Branch, U.S. Nuclear Regulatory Commission To Louisiana Energy Services, L.P.*, Docket No 70-3070, U.S. Nuclear Regulatory Commission, Washington D.C., September 22, 1992). It is also consistent with DOE performance assessments for near-surface disposal at specific sites (Martin Marietta Energy Systems, Inc.; EG&G Idaho, Inc.; and Westinghouse Savannah River Co., *Radiological Performance Assessment for the E-Area Vaults Disposal Facility*, WSRC-RP-94-218, Oak Ridge National Laboratory, Grand Junction, CO., 1994). Additional analysis is necessary to determine the viability of mine disposal of the depleted uranium to meet regulatory requirements for protection of public health and safety.

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COMMENTOR NO. 38: OAK RIDGE NATIONAL LABORATORY (CONT'D.) OAK RIDGE, TENNESSEE

At the current time, the only facility being planned in the United States that would meet the requirements for disposal of this material is the proposed Yucca Mountain repository for spent nuclear fuel and high-level waste. Because this is the only current option that meets the regulatory requirements for safe disposal of this material, it should be included as a disposal option in the PEIS.

6. **Clarify the "no action alternative" long-term management strategy for depleted UF_6 in the PEIS with the preferred waste form for final disposition of depleted uranium favored by the U.S. NRC.**

The no action alternative as initially announced in the "Notice of Intent" to prepare this PEIS included eventual chemical conversion of the UF_6 to oxide followed by storage. However, after public scoping and internal DOE reviews, it was determined that the no action alternative should consider the continued storage of UF_6 cylinders indefinitely at the three current storage sites, as indicated on page 2-2 of the PEIS. The NRC stated that the preferred waste form for final disposition of depleted uranium is U_3O_8 (J. W. N. Hickey, *Letter from J. Hickey, Chief Fuel Cycle Safety Branch, U.S. Nuclear Regulatory Commission To Louisiana Energy Services, L.P.*, Docket No 70-3070, U.S. Nuclear Regulatory Commission, Washington D.C., September 22, 1992). The NRC, in the referenced license application for the private Louisiana Energy Services enrichment plant, further stated that conversion of the depleted UF_6 to uranium oxides should be done on a specific schedule.

38-6

It is ORNL's recommendation that the two points of view on the storage form of depleted UF_6 be reconciled between the DOE and NRC.

COMMENTOR NO. 39: CITY OF OAK RIDGE, ENVIRONMENTAL QUALITY ADVISORY BOARD OAK RIDGE, TENNESSEE

CITY OF
OAK RIDGE

ENVIRONMENTAL QUALITY ADVISORY BOARD

POST OFFICE BOX 1 • OAK RIDGE, TENNESSEE 37831-0001

April 9, 1998

Charles E. Bradley, Jr.
U S Department of Energy
Office of Nuclear Energy, Science and Technology
Office of Disposition Technologies
19901 Germantown Road
Germantown, MD 20874

Dear Mr. Bradley:

Members of the Environmental Quality Advisory Board (EQAB) have reviewed the Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride (DOE/EIS-0269). The City of Oak Ridge has a strong interest in the future management of the DOE depleted uranium hexafluoride (UF_6) inventory, since about 10% of this inventory is stored at the East Tennessee Technology Park (ETTP, formerly K-25 Site) in Oak Ridge.

As explained in the draft programmatic environmental impact statement (PEIS), the continued storage of depleted hexafluoride in steel cylinders in outdoor storage yards does not pose an imminent threat to workers, public, or the environment. However, continued safe storage requires an ongoing program of surveillance and maintenance, and the job of assuring safe storage will become more difficult as time passes. Furthermore, the continued presence of this material at the ETTP may adversely affect ongoing site reuse initiatives, both by presenting a negative aesthetic image to prospective ETTP tenants and by preventing new uses of the areas occupied by cylinder storage yards. 39-1

EQAB members support the concept, embodied in most of the alternatives considered in the PEIS, of converting the depleted UF_6 to a more stable form (either uranium oxide or metal) that would be suitable for long-term storage, reuse, or disposal. However, we think the timetable for action that is presented in the PEIS is much too slow. Instead of waiting until 2009 to start converting this material (and finishing the job in about 2028), DOE should act now to start the conversion process as soon as feasible. (There appear to be no technical barriers to starting the conversion process.) The Oak Ridge Gaseous Diffusion Plant operated for about 40 years (1945 to 1985), the federal government owes it to this community not to wait an additional 43 years (1985 to 2028) to deal responsibly with the byproducts of gaseous diffusion. 39-2

Thank you for the opportunity to review and comment on this document.

Sincerely,
For the Board

Gerald L. Paleu

Gerald L. Paleu
Chairman

cc: Honorable Mayor and Members, Oak Ridge City Council
Amy S. Fitzgerald, Special Assistant to the City Manager
James Hall, DOE Oak Ridge Operations Office

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COMMENTOR NO. 40: DORTCH, JOTILLEY PADUCAH, KENTUCKY

4205 Buckner Lane
Paducah, KY 42001
7 April 1998

Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Mgmt. Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear DOE Representatives:

A PEIS for UF_6 strategies and management must take all available information on the subject into consideration. This PEIS does not cite the following:

1. "Draft Preliminary Report - DOE Independent UF_6 Cylinder Assessment Team"; DOE draft; 25 Mar 1992.
2. "Integrity of Uranium Hexafluoride Cylinders" ONFSB Technical Report; 5 May 1995. 40-1
3. "Affordable Cleanup? — Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities"; National Research Council; 1996.

Why weren't these studies used as a basis for addressing this problem and its solutions?

The above-ground cylinder storage is risky. There are many styles of containers of varying wall thicknesses. Rust, both visible and under the paint, has weakened many. Improper storage — too close to the ground, too close together to be inspected all around, stacking incompatible styles, damage to cylinders in transport all add to the danger. Leaky or degraded valves and cylinder ID tags missing or unreadable are a problem. 40-2

How full the cylinders are presents another problem. Many were filled before the current limits were 40-3

COMMENTOR NO. 40: DORTCH, JOTILLEY (CONT'D.) PADUCAH, KENTUCKY

established.

The geology of the area at PGDP includes high risk earthquake zones. It is not a stable place to store or reprocess UF_6. It is not a good place to store the product until a market opens up or a use is discovered". 40-4

A viable long-term solution is to convert the cylinder contents to U_3O_8, a more stable oxide that can be reconverted if the need arises. France does this very thing. 40-5

The problems that have surfaced since we have come off the "production-at-all-cost" mentality do not need bandaids. They need real and permanent solutions based on sound technology and upon sound geologic grounds. 40-6

Sincerely,
jotilley dortch
4205 Buckner Lane
Paducah, Ky 42001

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COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

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Charles E Bradley, Jnr.,
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US Department of Energy.
19901 Germantown Road,
Germantown MD 20874-1290

Direct tel. 01925 834204
Direct fax: 01925 832026

Your ref:
Our ref: peis1.doc

14th April 1998

Dear Ched,

Please find enclosed the BNFL response to the draft PEIS. The response document is an amalgamation of expert opinion within the Company from those with experience of various aspects of depleted hex tails processing, storage and disposition. The responses are presented as general comments or specific to the appendices of the PEIS.

You will note that one of the main concerns that we have is the omission of an option for depleted uranium metal as a medium for long-term storage/disposal. As you are aware the technology BNFL is currently developing to process our own tails has as products, uranium metal and fluorine gas. BNFL's view is that uranium metal is feasible for long-term storage and disposal and could have clear cost and environmental advantages. This has not been adequately recognised or assessed in the report. 41-1

If you have any queries about the BNFL comments, please contact me or Marilyn Meigs at BNFL Inc.

Yours sincerely

A J Lorimer

Assistant Director International Development

cc: Ms M F Meigs
Mr P R Gregson

Registered in England no.1002607
Registered office:
Risley Warrington Cheshire WA3 6AS

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

COMMENTS ON THE DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

A Note by BNFL plc

GENERAL COMMENTS

1. BNFL supports the strategy of safe storage as UF_6 pending the development of suitable uses. These uses would be most likely within the nuclear fuel cycle. *41-2*

2. The Engineering Analysis has several significant omissions and inaccuracies which although unlikely to affect the overall environmental impact, could weaken the conclusions of the PEIS and the Cost Analysis. *41-3*

3. The approach taken for the assessment of the environmental impacts arising from the various management options is good and the methodologies are suitably transparent to scrutiny. However, there are a number of general areas where the assessment methodologies could be improved and these are detailed below. *41-4*

4. The methodologies used in the Cost Analysis are considered to be sound. However the report is based on the Engineering Analysis and the comments made for that report will also have cost implications and might alter the conclusions of the Cost Analysis. In particular, the basis for the revenues or credits for the sale of AlIF, CaF_2 and radiation shields require robust justification. *41-5*

5. Long-term storage as uranium metal has not been analysed even though it was a feasible recommendation in the Technology Assessment Report and there are significant volume and cost benefits which might make the economics of this route more attractive than U_3O_8 or UO_2. *41-6*

6. Disposal as uranium metal has not been analysed even though it was a feasible recommendation in the Technology Assessment Report and there are significant volume and cost benefits which might make the economics of this route more attractive than U_3O_8 or UO_2. The PEIS shows that reducing the volume of the material disposed significantly reduces the impacts on the environment, suggesting that uranium metal, which has the minimum volume, would minimise the environmental impacts. Although current DOE Orders restrict such disposal, there is no equivalent restriction at the commercial disposal sites. *41-7*

7. The environmental impacts of disposing of, or recycling, the products containing uranium metal or oxide at the end of their useful life should be analysed. *41-8*

Detailed comments are presented below.

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COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

COMMENTS ON THE ENGINEERING ANALYSIS

General

The Engineering Analysis uses conservative assumptions resulting in excessive rather than realistic costs and tending to preclude meaningful comparison of the options. Examples are: taking 7 years to build a facility, not considering use of several existing facilities in the USA, and the high projected manning levels. *41-3 (Con't.)*

Transportation Module

Cylinder Preparation for Shipment

The suggestions for the Pre-transport Preparations of UF_6 Cylinders appear to be compliant with the recommendations in IAEA Safety Series 6, 7, 8, 37 and 80.

An overcontainer used for a cylinder which does not meet DOT requirements would need to contain any leakage from the cylinder. To achieve this, the overcontainer would need to meet the requirements of a Type A Package, as defined by the IAEA. An overcontainer "slightly bigger than the cylinder" which meets DOT regulations may not achieve this. It would be more prudent to plan for the transfer of the UF_6 to a new cylinder to cater for the instance of an over-pressure and damaged cylinder which could not be transported even in an overcontainer. *41-9*

The engineering required to deal with some of the severely degraded cylinders has been underestimated. It is not reasonable to assume that these cylinders can be placed into overcontainers nor that their contents can be transferred in the manner described. *41-10*

Accidents considered for the Cylinder Preparation Options involving cylinders of solid UF_6 assume releases of UF_6 in dry conditions and HF in wet conditions (rain). Accidents involving UF_6 vapour assume releases of UO_2F_2 and HF. Releases of any physical form of UF_6 result in reaction with water vapour in the air, producing UO_2F_2 and HF vapour. The PEIS therefore has underestimated the impacts of such accidents. *41-11*

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

Emptied Cylinder Treatment

The residue remaining after the cylinder has been washed out and the water has evaporated will be UO_2F_2, rather than a "mixture of uranium and fluorine".

The cleaned cylinders could be cleaned further and monitored for free-release, or could be recycled to fabricate other containers for use in the nuclear industry. *41-12*

Conversion Module

The vast majority of process and other buildings use reinforced concrete in their construction. The use of reinforced concrete for the conversion process buildings cannot in itself be considered a safety feature. *41-13*

Control of HF vapour by limiting the temperature of the building will not work. The vapour pressure of HF at 32°F is nearly half an atmosphere so even at this low temperature HF will vaporise quite quickly. Control of vapour in the manner described is analogous to saying that a cup of coffee does not give off water vapour because it is below the boiling point of water. *41-14*

Upgrading the concentrated HF as described in both the U_3O_8 and UO_2 options will produce approximately equal quantities of azeotropic HF, a highly corrosive liquid, and AHF. The azeotropic HF has relatively little value, and no disposal or use route is described. However, the reduction of UF_6 to UF_4 with hydrogen or cracked ammonia to produce metal does indeed produce just anhydrous HF as a by-product. *41-15*

U_3O_8 Option

A dry conversion process could produce dense U_3O_8 *41-16*

UO_2 Option

UO_2 is a metastable oxide which could react with oxygen or air to form U_3O_8 with an increase in volume. *41-17*

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COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

Sintering in a hydrogenous atmosphere is required to achieve the densities quoted (9 gm/cc). The hazards associated with hydrogen have not been addressed. *41-17 (Con't.)*

Uranium Metal Option

A continuous metallothermic reduction process produces a uranium/iron compound with a lower melting point than that of pure uranium, allowing the operating temperature of the process to be lower. This is necessary to control the magnesium evaporation rate since magnesium has a significant vapour pressure at temperatures well below the melting point of pure uranium. The uranium/iron compound is much less dense than uranium metal and would be a relatively inefficient gamma radiation shielding material. The two metallothermic reduction processes are not therefore equivalent for the production of metal for use and should not be compared. *41-18*

The Unlikely Accident during Conversion to Metal "Uranium metal fire" would be better described as a conventional fire causing some oxidation of the adjacent uranium derbies. The large size of the uranium derbies would prevent them from catching fire. *41-19*

Pressurisation of the metallothermic reduction vessel caused by vaporisation of excessive magnesium has not been considered. This should be a "Likely Accident". *41-20*

The estimated quantity of uranium released to atmosphere from the conversion facility is very small given the throughput of the facility. *41-21*

Use Module

For shielding gamma radiation, it is not only the material's density which makes it an effective shield, but, as in the case of uranium, a high atomic number is also significant. There are alternative dense metals such as tungsten for applications which need solely high density and mass: in such applications, uranium is usually preferred only when particular mechanical properties are required in addition to density. *41-22*

The number of UO_2 shielded casks and the number of uranium metal shielded casks seem to be derived by dividing the weight of uranium in the tails UF_6 by the weight of uranium in each cask. This number should be compared with the number of casks needed by the US nuclear power program for the storage/disposal of irradiated fuel.

Uranium metal is a much more effective gamma shield than UO_2, and so more spent fuel could be loaded into each metal-shielded cask, thereby reducing the transport and final disposal costs of the spent fuel. *41-23*

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

The proposed method of fabricating the casks with uranium metal shielding is not practicable and is hazardous. Molten uranium forms low melting point eutectics with Fe, Cr and Ni, therefore the molten uranium will dissolve the steel shells, liberating large quantities of heat and resulting in a major spillage of uranium. There are, however, other, methods available to fabricate casks from depleted uranium that do not have these safety problems

41-24

No reason is given why solidified ash waste from the facility producing uranium metal shielding components should require disposal in a special cell or mine.

41-25

The estimated quantity of uranium released to atmosphere from the manufacturing facility is very small given the throughput of the facility.

41-26

The release from accidental mishandling/drop of drum/billet inside the plant should be more for the oxide case than the metal case since the oxide is at this stage a loose and powdery material and the metal is in massive billet form.

41-27

The chemical form of a release due to failure of a uranium metal furnace should be U_3O_8 and not UO_2.

One factor which limits the useful market for uranium is its radioactivity which means that at the end of life it cannot be disposed of by the user in a straightforward manner. The Engineering Analysis considers the manufacture and use of the depleted uranium in both oxide and metal forms for the shielding of spent nuclear fuel. However there is only a disposal route defined for the oxide form since uranium metal is not considered suitable for disposal. The environmental impacts of disposing of, or recycling, the products containing uranium metal or oxide at the end of their useful life should be analysed, including impacts from disposal of the shielding with the spent fuel still in it.

41-28

Long-Term Storage Module

Recommendations from the Technology Assessment Report to store the uranium as metal have not been analysed even though they were considered feasible. Storage of bulk metal does not produce metal flakes so the pyrophoricity issue is not relevant. Corrosion of uranium metal by moisture can produce hydrides in the metal, but these are only a hazard if oxygen (or air) are excluded. The possibility of an explosion if the hydrogen from corrosion is collected in closed containers only arises when the containers are opened and air is admitted. Storage of bulk uranium metal in a building in air, as opposed to closed containers, is entirely practicable and safe. Should the consequent slow corrosion be

41-29

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COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

unacceptable, it is feasible to consider development and application of a protective coating.

In a response to a comment on the storage of uranium in forms other than oxide, received during the scoping process for the PEIS, it was stated that "the rationale for the selection of these chemical forms for analysis will be presented in the PEIS". The same response questions the suitability of uranium metal, as opposed to uranium oxide, for storage on the grounds of "higher conversion cost, lower stability and uncertainty of the suitability of the metal form for eventual disposal". The Engineering Analysis, Cost Analysis and PEIS fail to justify any of these assertions. No account is taken of the introduction of new technologies which would produce uranium metal at significantly lower cost.

41-30

Disposal Module

Using 30 gal drums for UO_2 disposal is not an optimum solution. There are no real reasons why 55 gal drums (about 2,000kg weight) cannot be used and handled efficiently. This would reduce the number of drums to be disposed with consequential lower environmental impacts.

41-31

Recommendations from the Technology Assessment Report to dispose of the uranium as metal have not been analysed even though they were considered feasible. Uranium metal is accepted at commercial disposal sites in the USA, and there are no NRC regulations which would prevent such disposal. The DOE Orders which specifically exclude fluorides and metal from the Nevada Test Site and Hanford should be comprehensively reviewed to identify the adverse consequences/impacts, if any, which lead to the dismissal of U metal as a suitable form for disposal.

41-32

The U oxides are stated to be the preferred forms for disposal because of their stability and slow dissolution rates in water. Uranium metal is slow to dissolve in water, and therefore should be considered for disposal especially when the much smaller volume of metal is taken into consideration.

41-33

The reduced volume of the uranium metal would significantly reduce the impacts on the environment as the PEIS shows that most environmental impacts tend to be proportional to volume. The observations that impacts for the denser UO_2 are less than for U_3O_8, and the impacts for ungrouted wasteforms are less than for grouted wasteforms because the volumes are lower (about 50%) should enhance the case for disposal as U metal because metal volumes will be even lower. Disposal as U metal blocks would not involve grouting and would therefore also have lower environmental impacts through the avoidance of the long term effects of grouting.

41-34

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

It is not correct to describe surface oxidation of U metal as "similar" to HF formation from reaction of uranium fluorides with water. The consequences of the two are very different. *41-35*

COMMENTS ON THE PEIS METHODOLOGY

Areas where the Assessment Methodologies could be improved

The treatment of uncertainty in any kind of assessment methodology is a vital issue, especially where generic (non site specific) settings have been used. The uncertainties in the input parameters and assumptions in conceptual models, and their effect on the predicted consequences, need to be determined, usually by a sensitivity analysis technique. Measures can then be taken to reduce the uncertainties.

Uncertainty has been recognised as important in the PEIS but little has been done to analyse the issue. Instead, assumptions have been made with the intention that the various anticipated environmental impacts result in conservative rather than realistic estimates. As it turns out, in most cases (except groundwater contamination in the disposal option) the impacts are still low enough to be acceptable. However, this approach tends to obscure meaningful comparison between the alternatives and is not always appropriate. When a management option and suitable site are chosen, the environmental impacts for that site should be assessed on a realistic basis. *41-4*

One exception to this conservative approach is the assumption that manufacture of shielded containers would bound any impacts associated with other products. In this case, the shielded containers are as large a product as can be reasonably imagined. Smaller products would require more operators per unit weight of uranium processed, and would be less self-shielded, giving much larger total involved worker doses.

Radiation and chemical effects are analysed by considering the maximally exposed individual (MEI) in three groups, "involved workers", "noninvolved workers" and "members of the general public". However, no account seems to have been taken for cumulative exposures between groups (the MEI in the involved worker group could also be the MEI in the general public group if he/she lives near the site). This approach has resulted in some anomalies, such as in the case of the manufacturing facility where the MEI radiation dose and hazard index of a member of the general public are predicted to *41-36*

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COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

be greater than those for a noninvolved worker, under normal operating and certain accident conditions. A preferable approach would be to use a larger number of critical exposed groups, chosen to be mutually exclusive.

The chemical and radiation risk to the MEI for the involved worker group during normal operations has not been quantified. The reason given is that worker activities are uncertain at this stage. However, uncertainties such as this have not stopped the authors from making conservative assumptions in order to quantify environmental impacts in many other areas of the PEIS. The PEIS approach must be consistent. *41-36 (Con't.)*

The impacts to the involved workers of clearing up from the assumed accidents have not been considered. The amount of material released inside the plant which the involved workers would have to clean up is likely to be significantly more than the amounts quoted in the PEIS, which are presumably the amounts released to the environment outside the process buildings. *41-37*

The environmental impacts due to human intervention (deliberate and inadvertent) do not appear to have been addressed. While human intervention is most applicable for the disposal option (post-closure phase), where mining and construction activities could bring material back to the surface, there are also human intervention scenarios plausible for all of the other options. No mention is made of any institutional controls likely to be in place to help prevent such occurrences. Assessment of the risks resulting from human intervention is usually carried out by an expert elicitation process to determine the probability and consequences of various human actions. *41-38*

The environmental impacts due to the disposal of secondary wastes such as MgF_2 from the conversion options have not been fully addressed. The only impact addressed is the extra burden on the capacity of the disposal sites and the environmental impacts due to the construction of new disposal sites to cope with the increase in demand. The post-closure impacts of such sites are not addressed in the PEIS. *41-39*

The prediction of groundwater contamination is highly site specific. Most of the calculations in the PEIS connected with this issue have to make large assumptions over the geochemical and hydrological characteristics of generic sites and the value of environmental impacts calculated in this way is questionable. Only site-specific data should be used when calculating risks from a groundwater pathway. *41-40*

Specific Comments on the Storage Option

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

Cylinder yard doses do not seem consistent with a strict care, maintenance and inspection regime. Portsmouth at 2mSv (196mRem/yr) is most realistic. (probably plausible if a large number of personnel are used, and/or remote inspection equipment or shielding is implemented) *41-41*

Assumption of 0.0041 breaches per cylinder move (Appendix B Section B3) would result in 2 x(28351+13388+4683)X0.0041 = 380 breaches if all containers were moved for painting. This does not seem consistent with number of breaches quoted in Table B1. *41-42*

Comprehensive wall thickness testing at time of refurbishment would aid future decision making. However corrosion rates will be difficult to estimate if initial wall thickness is unknown. *41-43*

Thorough inspection, testing and painting will result in high doses potentially. *41-44*

In the event of aircraft crash on any of the UF_6 storage areas, the environmental impact would be far greater than for any storage option e.g. UO_2. *41-45*

Uranic oxide powders stored in 200 litre drums expose operators to higher dose rates than UF6 cylinders. Thin drums are stored indoors to prevent corrosion but periodic inspection is required. *41-46*

Specific Comments on the Disposal Option

There is no description of the methodology used for estimating post-closure risks for the UF_6 disposal option in the PEIS. *41-47*

The term "indefinite period" needs to be defined in the context of monitoring and maintaining a disposal facility post-closure. Monitoring and maintenance in perpetuity is not a realistic scenario. *41-48*

The impact of post-closure peak doses from uranium daughters at 1,000 years is not sufficiently long since peak doses from uranium daughters occur much later. A more reasonable assumption would be 10^6 years. *41-49*

The PEIS finds that groundwater contamination in the post-closure phase of a disposal site in a wet location could lead to both the radiation dose to the public exceeding *41-50*

/450

COMMENTOR NO. 41: BRITISH NUCLEAR FUELS PLC (CONT'D.)
RISLEY WARRINGTON CHESHIRE, UNITED KINGDOM

regulatory limits and the concentration of uranium causing adverse health effects. These effects are dismissed by stating that the water could be treated or an alternative source used. Given that this is one of the few instances in the PEIS that such limits are exceeded, this is neither a scientific nor a publicly-reassuring stance and does not fit in well with the general environmental impact assessment approach used in the PEIS. This is an example where the PEIS would have benefited from utilising a full treatment of uncertainty/sensitivity analysis to give realistic rather than conservative estimates. *41-50 (Con't.)*

Vaults appear to perform less well than shallow trenches in terms of human health impacts. Does this imply that vaults should be dismissed in favour of shallow earthen structures? Some clarification is needed as to the reasons why "...the concentrations from the vault would be greater than those from shallow earthen structure by a factor of 1.2". *41-51*

BNFL

April 1998

COMMENTOR NO. 42: KARPIN, TIMOTHY L., CHMM
DAVIS, CALIFORNIA

Comments

Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride

The Depleted UF_6 Management Program

To: Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290
Fax: 301-428-0145

From: Timothy L. Karpin, CHMM
2640 Portage Bay Avenue, #19
Davis, California 95616
Phone/Fax: 530-757-6840
E-mail tkarpin@mother.com

Date: April 20, 1998

General Comments

In summary, I agree with the DOE's position that depleted UF_6 can and should be reprocessed into either a uranium oxide or uranium metal form for use in commercial or industrial settings. The American public, whether they cared to or not, has spent significant funds during the last 50 years on the mining, milling, processing, and enrichment of uranium. It would be economically negligent to reprocess and dispose of depleted UF_6 into a form and location, respectively, that can no longer be of use or benefit to American citizens or industry. Such a process would also be in contrast with America's recognition of the value of recycling valuable raw materials. 42-1

The Draft PEIS is relatively complete and informative. I do have several specific comments as noted below:

Comments related to Volume II, Appendix E

1 Why not ship all casks in clamshell cases? 42-2

- A. No UF_6 transfer facility would be needed, which would reduce potential environmental impact and permitting activities.
- B. The use of clamshell cases could possibly reduce the number and cost of ultra-sonic wall thickness tests
- C. Clamshell case costs would not go up if a local facility is used to process UF_6 (i.e. it may be more economical to build 2 or 3 facilities near each gaseous diffusion plant.)
- D Public perception would be more favorable toward the DOE if the DOE shows demonstrated caution by using clamshell cases. The DOE's decision tree would be reduced by one layer, and one area of judgment/opinion would be eliminated
- E. Accident scenarios would decrease with regard to potential environmental and health impacts.

1451

COMMENTOR NO. 42: KARPIN, TIMOTHY L., CHMM (CONT'D.)
DAVIS, CALIFORNIA

- F. Consider modifying nearby runways and flying MD-17s in and out with clamshell cases (MD-17s are civilian versions of the new C-17 military transport). Of course, an economic study would be required to validate this concept.
- G. The costs and energy/resource consumption of a transfer facility would be very high in comparison to clamshell case use.
- H. One important issue was not directly discussed. You would need a separate facility or partitioned area at the UF_6 processing facility to decontaminate the clamshell cases (if necessary).

42-2 (Con't.)

Thank you for allowing me the opportunity to comment on this document. Good luck on the final version.

Sincerely,

Timothy L. Karpin

Timothy L. Karpin, CHMM

COMMENTOR NO. 43: VERSGROVE, TOM
POMONA, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 43-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 43-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 43-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 43-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 43-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 43-6

Thank you for considering these comments.

Sincerely,

Tom Versgrove
Tom Versgrove
Box 44
Pomona, IL 62975

1452

COMMENTOR NO. 44: THOMPSON, THOMAS
SIMPSON, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 44-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 44-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 44-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 44-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 44-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 44-6

Thank you for considering these comments.

Sincerely,

Thomas Thompson
Rt 1 Box 278
Simpson, IL
62985

COMMENTOR NO. 45: DONHAM, MARK & HANSON, KRISTI BROOKPORT, ILLINOIS

.harles Bradley
Office of Facilities (NE-40)
US Dept. Of Energy
19901 Germantown Rd.
Germantown, MD 20874

April 5, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted UF6 Draft PEIS.

(1) We are concerned about the failure of DOE to reference or mention the 3 studies and/or reports which specifically address the cylinder problem. These are "Draft Preliminary Report - DOE Independent UF6 Cylinder Assessment Team", from the Oak Ridge Field Office, Mark 25, 1992; "Integrity of Uranium Hexafluoride Cylinders" and "Affordable Cleanup? - Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities", National Research Council, National Academy Press, 1996. 45-1

(2) One of the first key issues which must be addressed is the earthquake risk at Paducah from the New Madrid fault/rift zone. Any strategy for dealing with the cylinders has to address this problem, as well over half the cylinders are in Paducah. Most of these cylinders are stored on soils with liquefaction potential. Due to the close stacking of the cylinders, and the configuration of the stacks, breach of cylinders due to puncturing from other cylinders in the event of a seismic event strong enough to move he cylinders is probable. Any punctures in the cylinders would result in .he slow release of hydrogen fluoride and uranium and other radionuclides, which would then accelerate the further corrosion of the cylinders. 45-2

Because the tens of thousands of cylinders are stacked in a configuration which makes it virtually impossible to access cylinders in the center of the stacks in a timely fashion. These factors are why the seismic risk at Paducah has to be considered in any long term strategy to deal with the cylinders.

(3) In considering the long term seismic risk at Paducah and its effect on cylinder management, the first question to ask is, will any future conversion/storage take place at Paducah. If the answer is yes, and if the plans are to bring cylinders in from Portsmouth and Oak Ridge, then these facilities have to be built to highest earthquake standards available. In addition, transportation risks from Portsmouth and Oak Ridge to Paducah must be considered.

If the answer is yes, but only for the Paducah cylinders, then either three conversion facilities will have to built or the facility will have to be mobile, which means it will have to be transported contaminated or will have to be completely decontaminated. None of these alternatives is looked at in the PEIS. 45-3

If the answer is no, there will not be conversion/storage at Paducah, then the massive transportation burden to get the 40,000 cylinders at Paducah, some of which it is doubtful could be moved, from Paducah to wherever the conversion/storage would take place. This is not considered properly in the .EIS.

Connected Actions/Cumulative effects

(4) To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of 45-4

1453

COMMENTOR NO. 45: DONHAM, MARK & HANSON, KRISTI (CONT'D.) BROOKPORT, ILLINOIS

impacts. They include: (a) Actions (other than unconnected single actions) which may be: (1)Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they: (i) Automatically trigger other actions which may require environmental impact statements. (ii) Cannot or will .otproceed unless other actions are taken previously or simultaneously. (iii) re interdependent parts of a larger action and depend on the larger action for their justification. (2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement. (3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography An agency may wish to analyze these actions in the same impact statement. It should do SO when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

It is clear that the UF6 DPEIS is inadequate in both its scope and its cumulative effects analysis, and that this flaw is serious.

Certain alternatives for dealing with the DUF6 cylinders are provided in the DEIS. Those alternatives include conversion to Uranium oxide, conversion to uranium metal, and long term storage. 45-4 (Con't.)

In order to convert to either uranium metal or uranium oxide, several unavoidable, connected steps must be undertaken. These include (1) building the facilities which will empty the cylinders and convert the DUF6; (2) the ylinders will have to be moved to the facility; (3) the material will have .o be defluorinated; (4) the emptied cylinders will have to be washed and dealt with, and a wastewater treatment plant will need to be built to treat the effluent, which will contain small amounts of transuranics; (5) the hydrogen fluoride will have to be placed into cylinders and stored or disposed, which will require facilities; (6) the empty DUF6 cylinders will have to be dealt with; (7) the converted material will have to be disposed or stored.

If one of the conversion alternatives is chosen as the preferred alternatives, there is no avoiding any of the above steps. These are all clearly "connected actions" as described above. Yet, the DEIS defers analysis of the effects of the conversion process until a future NEPA document. This future NEPA analysis would come at a time when a decision has already been made committing to one of these alternatives. NEPA requires that information be made available to decision makers and the public before decisions are made and actions taken.

In addition, at all of the facilities involved (Paducah, Portsmouth, and Oak Ridge) there are other cleanup activities ongoing, either under the WM or ER programs of DOE. These activities are clearly "proposals" and could have cumulative effects in regard to releases of radionuclides and other hazardous substances. The cumulative effects analysis of this DEIS (and the segmented NEPA analysis of the other cleanup projects ongoing at the sites) needs to be looked at in combination. The DEIS fails to make this important analysis.

Incorporation by Reference

(5) As is true is most DOE NEPA documents, there are sweeping impact assumptions based upon referenced material, mostly internal DOE information. .EPA requires that agencies which incorporate by reference material in an EIS make that material readily available to the public for review. Yet there is no mention where such referenced material (such as the GENII model) could be reviewed or obtained. This is a serious and blatant flaw in the 45-5

COMMENTOR NO. 45: DONHAM, MARK & HANSON, KRISTI (CONT'D.) BROOKPORT, ILLINOIS

DEIS
(6) NEPA does not allow conclusory assertions of no impact to suffice for a hard look. Assumptions in an EIS must be supported by objective or espirical data. By DOE making sweeping, conclusory statements of no impact (for example, of the environmental impact of the release of radiation from the activities associated with DEIS) based upon internal studies, which are not explained or described and which are not readily available to the public, DOE is violating one of the main tenants of NEPA - to inform the public of their proposed actions. 45-6

Thank you for considering these comments.

Sincerely

Mark Donham
Kristi Hanson
RR # 1, Box 308
Brookport, IL 62910

14574

COMMENTOR NO. 46: BARNWELL, CARLENE GOREVILLE, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 46-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 46-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 46-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 46-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 46-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 46-6

Thank you for considering these comments.

Sincerely,

Carlene Barnwell
3485 Goreville Rd.
Goreville, IL
62939

COMMENTOR NO. 47: WESTERMAN JONES, CAROL & JONES, ANTHONY E.
CARBONDALE, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 47-2

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Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 47-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 47-6

Thank you for considering these comments.

Sincerely,

Carol Westerman Jones & Anthony E. Jones
3310 HWY 127
Carbondale, IL
62901

1455

COMMENTOR NO. 48: KLUETER, KARLA
CARBONDALE, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 48-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 48-3

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Thank you for considering these comments.

Sincerely,

Karla Klueter
6829 Sparrow Ln
Carbondale IL
62901

COMMENTOR NO. 49: MOBLEY, E.V.
IDAHO FALLS, IDAHO

File A:\uf-6..wpd UF-6 Comments Rev 1, 03-26-98

I have reviewed DOE/EIS-0269, PEIS for UF-6 Management, 12/97. I have the following comments:

1. I agree with and support the DOE preferred alternative i.e, use rather than disposal of the UF-6. 49-1

2. Vol. 1, S.5.1, contains an informative summary of possible uses for converted UF-6 in addition to cask shielding, but its location in the document makes it a surprise. I suggest that other possible uses be mentioned in paragraph S.2. 49-2

3. The radiation effects calculations are based on the linear-no-threshold (LNT) hypothesis (Vol 1, S.4.3.1.1.2 and Vol.2, C.4.2.2). A number of studies, for example those cited in The Scientist, March 3, 1997 and in Nuclear News, June 1997, indicate the LNT hypothesis is excessively conservative and in some cases is detrimental. I suggest an improved analysis practice that includes evaluating the magnitude of the conservatism instead of merely stating that the result is conservative. Data are available for derivation of best-estimate or most-probable health effects. A more realistic presentation in the UF-6 PEIS would result if there were a comparison of best-estimate and conservative health effects. 49-3

4. In Volume 2, paragraphs C.4.1.5, C.4.2.2, and C.4.2.3, it appears that four different dose to health effects conversion standards were used. I suggest some additional explanation to avoid the appearance of confusion. 49-4

E V Mobley

1456

COMMENTOR NO. 50: WHEELER, NORMA S.
MARION, ILLINOIS

Note: As a longtime environmental activist, I'm accustomed to writing my own opinions. My schedule today forces me to use this form letter, but I assure you that I feel very strongly about the issue & hope that the DOE, after decades of irresponsibility, will take realistic steps to control these grave hazards.

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 50-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 50-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 50-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 50-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 50-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 50-6

Thank you for considering these comments.

Sincerely,

Norma S. Wheeler
13250 Griffith Ln
Marion IL
62959-6163

COMMENTOR NO. 51: WHAYNE, SUE; ROBERTS, MARY LEE & RAY, BETTY
CLINTON, KENTUCKY

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 51-1

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Thank you for considering these comments.

Sincerely,

Sue Whayne 992 St. Rt. 182 E Clinton, Ky
Mary Lee Roberts 338 St Rt. 1011 " " 42031
Betty Ray 31 St. Rt. " "

14 57

COMMENTOR NO. 52: RHODES, CRAIG & BROWN, CHARLENE
BROOKPORT, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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Thank you for considering these comments.

Sincerely,

Craig Rhodes / Charlene Brown

Craig Rhodes & Charlene Brown
3883 Mt. Pleasant Rd.
Brookport, IL 62910

COMMENTOR NO. 53: HOFFMAN, EUGENE
KNOXVILLE, TENNESSEE

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@comail.gmt.saic.com

Apr 14, 1998

Comments: My comments (4 pages, 9 comments) are given in the attachment. If any of my comments or questions are not clear, I would appreciate being contacted. — 53-1

How will comments on the draft PEIS be documented by DOE? What is the status of the sale of the enrichment plants to USEC? Please call me at your convenience. — 53-2

Sincerely,
Gene Hoffman

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name: EUGENE E HOFFMAN (optional) ☑ Please add my name to the Depleted UF6 mailing list.
Organization: DOE-Retired ☐ Please take my name off the Depleted UF6 mailing list.
Address: 10511 Shadypine Lane (optional)
City: Knoxville State: TN Zip: 37922-5519
Phone number: (423) 966-3964 (optional)
E-mail address: _____ (optional)
FAX (423) 966-3964
(must call first)

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874 • 301/903-4781

458/

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

COMMENTS BY EUGENE E. HOFFMAN (DOE-RETIRED) TO THE U.S. DEPARTMENT OF ENERGY ON THE DRAFT PEIS ON MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE, DOE/EIS-0269, DECEMBER, 1997

1. **The DOE "preferred alternative" (see PEIS, pp. S-42, -44) is to "use the entire inventory of material" based on market demand for uranium oxide (UO_2), uranium metal and fluorine products. "Safe management of the cylinder inventory would continue until 100% of the inventory had been converted for use." - - - This DOE preferred alternative would be supported by everyone if the DOE assumed use potential had any basis in fact. Every documented evaluation of potential use of the DUF6 by independent investigators, DOE contractors, and commercial firms in the uranium business during the past ten years has concluded that future use of only a small fraction of the 1,200,000,000 plus pounds of the depleted UF6 can be projected.** — 53-3

   In the PEIS, DOE evaluated six alternative management strategies (see page S-6). However, an option to continue storage of a reasonable (small) fraction of the DUF6 (only the best cylinders, under shelter) for future use and begin conversion of the most degraded cylinders to the safe, stable form (U_3O_8) was not considered. WHY?? — 53-4

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Comments by E. E. Hoffman (cont'd) - 2 -

2. The 1100-page draft PEIS did not cite or reference the three independent reports that directly relate to the subject of the PEIS. These are listed below:
   a) *"Draft Preliminary Report - DOE Independent UF6 Cylinder Assessment Team", DOE Oak Ridge Field Office, dated March 25, 1992 (never published).*
   b) *"Integrity of Uranium Hexafluoride Cylinders", Defense Nuclear Facilities Safety Board Technical Report DNFSB/TECH-4, May 5, 1995.*
   c) *"Affordable Cleanup? - Opportunities For Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities", National Research Council, National Academy Press, 1996*
      Chapter 7. Disposition of the DUF6

53-5

3. The draft PEIS presents brief and totally inaccurate statements regarding the New Madrid earthquake safety issue, which is of particular importance to the Paducah plant site which has in excess of 28,000 of the DUF6 cylinders. (PEIS reference - page 3 -7)

53-6

4. The French have been converting hundreds of millions of pounds of their depleted UF6 to the safe, stable oxide and stored it in steel containers in metal framed, earthquake resistant buildings since 1977 to avoid the hazards associated with storing UF6.

53-7

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Comments by E. E. Hoffman (cont'd) - 3 -

5. At least 17,475 of the DUF6 cylinders exhibit accelerated corrosion (Reference: DOE/ORO Work Agreement document, dated 10/30/96). The current DOE schedule for cleaning, inspecting, and re-painting of the cylinders will require at least 30 years, especially when the fact is considered that many of the cylinders will have to be re-cleaned and re-painted at least three times during that period. Each handling operation risks rupture. (Reference: Letter, S. J. Pawel to M. S. Taylor, Feb. 10, 1997, ORNL/CST-SP-021097-05, *Update on Development Activities, page 4, "The life of the paint system presently in use is not analytically known, but current estimates suggests that a 12-year life (on average) prior to significant maintenance or re-painting is reasonable".*

53-8

6. The DUF6 safety and accident concerns presented in the Defense Nuclear Facilities Safety Board report (DNFSB/TECH-4, May 5, 1995) are not cited in the draft PEIS.

53-9

7. On February 18, 1998 a USAF B-1 supersonic bomber weighing in excess of 200,000 pounds crashed and burned approximately 40 miles from the Paducah cylinder storage yards. The Barkely Regional Airport is located approximately 2 miles from these storage yards. Has the accident scenario of a large plane crash into the cylinder yards on a rainy day been analyzed? Under such circumstances a number of cylinders would be ruptured and large quantities of hydrofloric acid gas would be generated which could caused additional ruptures and make control of the accident very difficult.

53-10

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

EUGENE E. HOFFMAN

10504 Sandpiper Lane
Knoxville, TN 37922-5518
(423) 966-3964

Education: BS in Metallurgy, University of Notre Dame, 1951
MS in Metallurgy, University of Tennessee, 1959

Work Experience:

(1996) Retired from the U.S. Department of Energy-Oak Ridge Operations (DOE-ORO)

(1981-1996) DOE-ORO) ORO Manager of DOE National Materials Programs for the Breeder Reactor Program, the Space Nuclear Reactor Program (SP-100), the Radio-isotope Thermoelectric Generator (RTG) Program and the Advanced Gas Turbine Materials Program. Served as a member and chairman of DOE-ORO formal investigations related to material problems at Doe facilities.

(1979-1981) DOE-ORO) Manager, Fossil Energy Materials Branch

(1972-1979) DOE Headquarters, Germantown, MD Chief, Materials and Chemisty Branch, Breeder Reactor Program

(1963-1972) General Electric Company, Nuclear Systems Programs, Cincinnati, OH
Manager,
Systems Materials Technology (35 professionals and technicians)

(1951-1963) Oak Ridge National Laboratory, Metallurgy Division , Manager and Research Metallurgist, Materials Compatibility Group

Expertise: High-temperature materials technology directed at energy production for space and terrestrial applications. Authored over 30 open literature papers and topical reports in the high-temperature materials research and development field.

Honors: 1960 Chairman, Oak Ridge Chapter, American Society for Metals (ASM)
1976 Deputy Team Leader, Breeder Reactor Team visit to USSR
1982 Elected Fellow, ASM
1990 Selected as DOE-Oak Ridge High-Tech Federal Employee of the Year
1992 Designated Life Member, ASM International
1995 Named Tennessee Colonel by Governor Don Sunquist

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpt from "Integrity of Uranium Hexafluoride Cylinders", Defense Nuclear Facilities Board (DNFSB) Report DNFSB/TECH-4, May 5, 1995

page 6. The review conducted by the DOE Independent UF6 Cylinder Assessment Team (*Reference: "Draft Preliminary Report: DOE Independent UF6 Cylinder Assessment Team", DOE Oak Ridge Field Office, March 25, 1992)* was a comprehensive assessment of the entire cylinder program. The team reviewed the design, fabrication, transportation, filling, storage, handling, inspection, legal considerations, safety and health considerations, environmental considerations and ultimate disposition of the cylinders

Unfortunately, this report is still considered "draft" after three years.

Reports on DUF6 Cylinders by Independent Investigating Teams

"Draft Preliminary Report - DOE Independent UF6 Cylinder Assessment Team", DOE Oak Ridge Field Office, dated March 25, 1992

This report resulted from a DOE Memorandum "Uranium Hexafluoride Feed and Tails Cylinder Program Review" dated January 29, 1992 to P.Gross, et al., from Joe LaGrone, Manager, DOE Oak Ridge Field Office. The charter to the review team included the following statement:

You should assess the design, fabrication, transportation, filling, storing, handling, inspection, legal considerations, safety and health considerations, environmental considerations, and ultimate disposition of the cylinders.

Status of this report: Contrary to normal investigations of this type by DOE, this report was never formally issued and made available to the public.

"Integrity of Uranium Hexafluoride Cylinders", Defense Nuclear Facilities Safety Board Technical Report DNFSB/TECH-4, May 5, 1995.

Status of this report: This comprehensive report was issued and made available to DOE/HQ and the public and resulted in DNFSB Recommendation 95-1 to DOE/HQ. (Not cited in the Draft PEIS on DUF6, December, 1997)

"Affordable Cleanup? - Opportunities For Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities", National Research Council, National Academy Press, 1996.

Status of this report: Available to the public. Contains much information on the depleted uranium hexafluoride situation in the U.S., including recommendations. (Not cited in the Draft PEIS on DUF6, December, 1997)

1461

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Seismic Risk-Paducah Site

Depleted UF6 Draft PEIS, December, 1997, Vol. 1 - Page 3-7

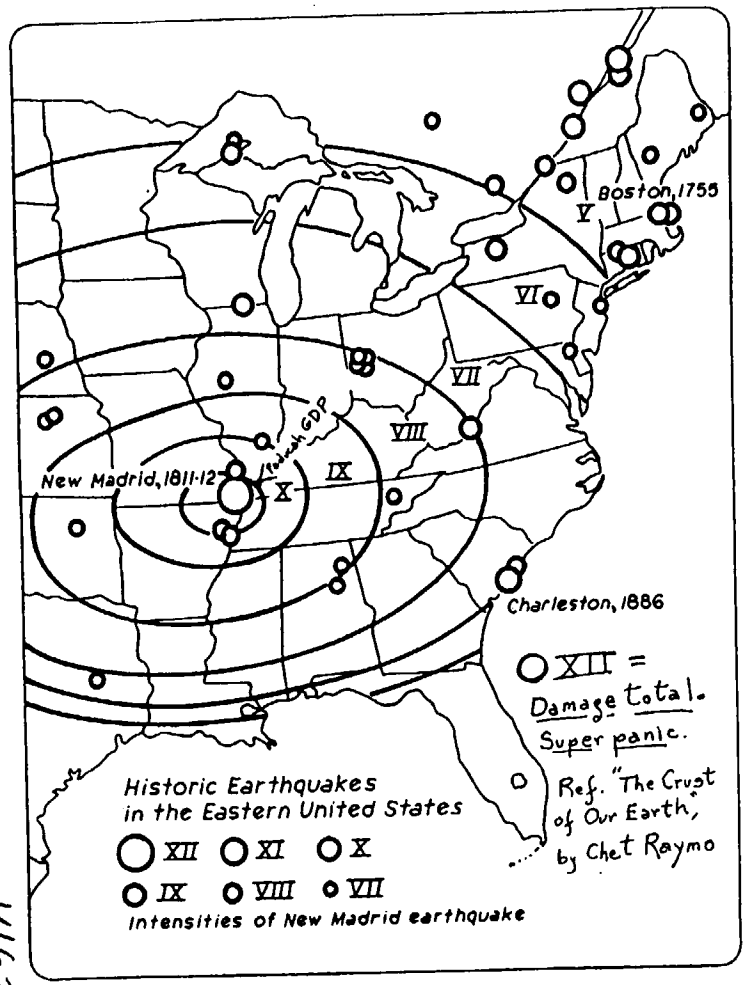
The largest recorded earthquake in the region occurred in 1812 and was centered in the New Madrid fault zone. This earthquake had a magnitude of 7.3 on the Richter scale, and the epicenter was 60 miles (96 km) southwest of the site (ANL) 1991 a). The estimated 1,000-year return period peak ground acceleration is 0.45 of the acceleration of gravity (DOE 1995c).

"The Coming Quake" by T. A. Heppenheimer, Times Books,1988 - References to the New Madrid Earthquake

p.238 The December 16, 1811 quake had been of magnitude 8.5 or 8.6 making it up to twice as powerful as the worst in California. Its largest aftershock had rated at 8.2, very close to the 8.3 of California's earthquakes of 1857 and 1906. The shock of January 23, 1812, had been less powerful, at 8.4. But the main quake of February 7 went all the way up to 8.7 or 8.8-- as much as three times the force of the California shakings.

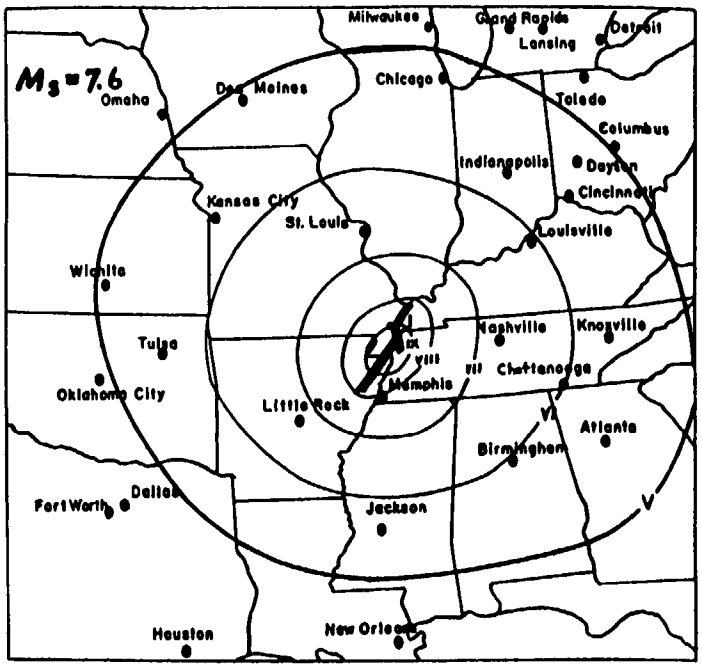
p.244 Nuttli (Otto) estimates that at present (1973), enough stress has built up along the faults to produce a quake of magnitude 7.6. That is the tremor worth fearing; and it has the potential to strike this very day.

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE



1462

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE



Map by Otto Nuttli showing damage areas, as indicated by zones of various Modified Mercalli intensity, that must be expected from a magnitude-7.6 earthquake on the New Madrid faults. Such a quake could occur today. The zigzag mark at the center is the trace of the New Madrid faults. (Courtesy U.S. Geological Survey)

"The Coming Quake," T.A. Heppenheimer, 1988, p 24b

THE CRUST OF THE EARTH
Chapter 13 - The Greatest Quake
by Chet Raymo

The New Madrid earthquake was rated XII on the modified Mercalli scale of intensity. XII is the highest rating on that scale. The scale describes a level XII quake in this way; "Super panic. Damage total. Waves seen on ground surfaces. Lines of sight distorted. Objects thrown upward into the air."

It was the greatest earthquake to shake the United States in historic times, and possibly one of the greatest ever to rock the crust of the earth.

1463

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Inventory of Thin-wall UF6 Cylinders at Three DOE Sites

- May 3, 1990 Inventory List Given to DOE-ORO Investigating Team by Martin-Maretta staff in February, 1992

10-Ton Cylinders	4,230	Model T
14-Ton Cylinders	1,000	Model 48 HX
	3,640	Model 48 H
	6,602	Model O
	16,602	Model OM* (*4450 not codeable)
	23,806	Model 48 G

Total 14-Ton Cylinders 51,419
Total Thin-wall Cylinders 55,649

- Number of UF6 Cylinders in Long-Term Storage in Table given to DOE/ORO Investigating Team by D.L.Mason (Martin-Marietta, 1/92) 54,000

- Number in DOE/ORO Report, March 25, 1992 - 54, 768
- Number in DNFSB Report, May 5, 1995 - 55, 649
- Number in Draft PEIS, December, 1997 - 46,422

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Ref., "UF_6 Long-Term Storage Cylinder Integrity Management Plan," M.S. Taylor et al., K/ETO-114, September, 1992

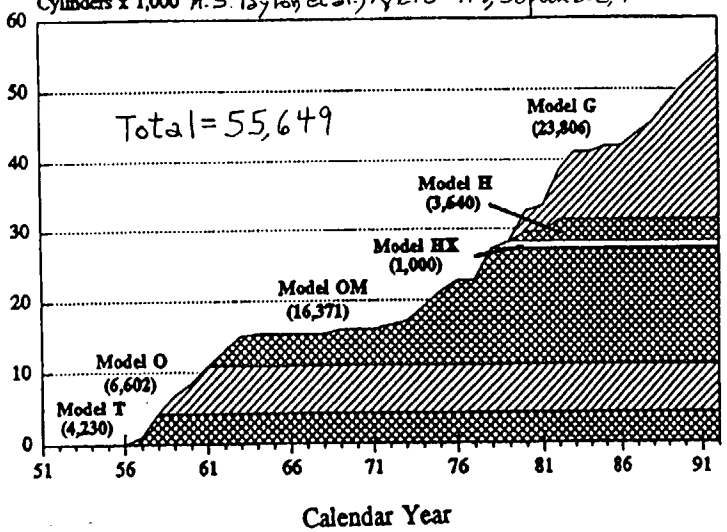


Figure 1. Cumulative "thinwall" cylinder purchases.

1464

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

DOE INDEPENDENT UF_6 CYLINDER ASSESSMENT TEAM

DRAFT PRELIMINARY REPORT

DOE OAK RIDGE FIELD OFFICE

March 25, 1992

TABLE 2
POTENTIAL DEFICIENCIES IDENTIFIED WITH LONG-TERM STORAGE UF_6 CYLINDERS

CONDITION	PGDP	PORTS	K-25	TOTAL
Total in long-term storage	35,339	13,359	6,070	54,768
Channel type stiffener (Type O)	5,313	83	163	5,559
Thin-wall skirted (Types T, H, and HX)	2,576	3,282	2,397	8,255
Bottom longitudinal weld		2,095 (Type T)		
In/near ground contact	2,818	0	949	3,767
Inaccessible plug end	10,162	10,259	810	21,231
Improper support upper tier	1,620		390	2,010+
Stacking incompatible designs		83	166	249+
Shell to lug contact	3,644	352	450	4,446
Other handling damage		4	285	289+
Valve leakage	Assessing	2	Assessing	Assessing
In poor drainage yard	12,153	0	100	12,253
Deficient saddles	19,994	0	12	20,006
Substandard bonnet nut/port cap	60/3	526/17	47/36	633/56
Valve replaced with plug			5	5+

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

UF_6 LONG-TERM STORAGE CYLINDER INTEGRITY MANAGEMENT PLAN K/ETO-114 September 1992

Table 2. Long-term storage inventory potential deficiencies

	Identified Potential Deficiency	Number of Cylinders
A.0	Direct Container Integrity Concerns	
A.1	breached cylinders- cylinders with holes in the cylinder shell	6
A.2	corroded cylinders- cylinders with visible pitting and/or scaling rust	15,000
A.3	leaking valves- valves and plugs that have recurring contamination	10*
B.0	Storage Facility Concerns	
B.1	substandard facilities- sinking or poorly drained load-bearing surfaces	12,000
B.2	improper support- upper tier cylinders supported by unsound points of contact	3,000
C.0	Uranium Control Issues	
C.1	non-depleted material- Normal or enriched material located in DU storage facilities	8
C.2	ID plates- loose or detached identification plates	200*
D.0	UF, Transfer Issues	
D.1	fill-limit consideration- cylinders without certified internal volumes or cylinders filled above the current maximum allowable limit established in ORO-651[15]	15,000
D.2	substandard valves- valves with missing or cracked parts, teflon tape on threads, bent stem, and/or improper engagement	3,000
D.3	plug replacing valves- plugs in place of valves	1,000*
D.4	defective cylinders- cylinders that do not pass the inspection criteria established in ORO-651 for liquid transfer	100*
D.5	non-conforming cylinders- cylinders that will not fit into currently designed autoclaves	140
E.0	Best Storage Practice Issues	
E.1	inaccessible cylinder- cylinders that cannot be accessed at both heads for a visual inspection	22,000
E.2	above internal vacuum- cylinders with internal pressure above the ideal vacuum conditions	1,000
E.3	uncoated cylinder- cylinders with no or little rust protective coating	23,000*

* Improved estimates are to be determined from the baseline inspection.

1465

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

DELIVERABLES/MILESTONES/DATES OF COMPLETION (continued)

S. By September 30, 1996, remove all full depleted uranium cylinders from ground contact at Paducah.

T. Complete the required inspection of 12,340 cylinders as part of the triennial inspection program by September 30, 1996.

U. Complete annual inspection of 17,475 cylinders exhibiting accelerated corrosion and other problems (as defined in ETO-114) by September 30, 1996.

V. Continue the Biological Monitoring effort at Paducah and issue the annual report by April 30, 1996.

W. Complete the milestones and markers as defined in the FY 1996 baseline program plan.

WAD ISSUE DATE: October 1, 1995

SIGNATURES:

LOCKHEED MARTIN: L.E. Hall — Date: 10-26-95

DOE CONTRACTING OFFICE REPRESENTATIVE: J.W. Parks — Date: 10/26/95

DOE CONTRACTING OFFICER: Signature — Date: 10/31/95

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts from "Investigation of Breached Depleted UF6 Cylinders", POEF-2068, ORNL/TM-11988, E.J.Barber, et al., September, 1991

page 4. Because the green salt deposit closely matches the color of the paint covering the cylinder, very careful inspection was required to spot the hole when viewed from the front of the cylinder.

page 29. An additional design fault in the UF6 storage cylinders is the protective coating applied to these cylinders. The color of the paint is so similar to that of UF4 that it hinders visual identification of reaction products from a breached cylinder. When a patch of rust forms under the paint, it has the same appearance as UF4 concealing a breach. It should also be mentioned that the quality of paint is highly variable and, in many cases, it offers little long-term surface protection.

14466

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts From Report KY/EM-187, "Lessons Learned From Paducah Site Pilot UF6 Cylinder Painting Project", R.I.Reynolds,et al. Nov.26,1996

page 1. "1231 cylinders have been painted with painting operations continuing."

page 2. "The cylinders are placed on their stiffening rings on wood timbers asnd chocks which supports the cylinder approximately 14 inches off the floor. The paint utilized is a one-coat system and consists of a Carboline inorganic zinc coating approximatelly three-to-five mils in thickness."

page 8. "Currently, the results indicate the following:

1. Most of the cylinders have relativelly loose and wispy rust but approximately 1,000 cylinders at Paducah have an underlayer of rust that is quite adherent and brittle. These cylinders are generally cylinders that have been in ground contact which accelerates rusting and pitting.
2. Although many cylinders manufactured after the late 1970's have some degree of painted surfaces, the paint is generally poorly adherent and brittle. Only the 6,000 DOE cylinders painted since 1990 have paint which provides some significant corrosion protection.
3. ---Bottom row cylinders vary according to storage conditions with most ground contact cylinders varying between 200 to 220 mils with the worst cylinder idenfied at about 177 mils. ---

Figure 3 Breached Cylinder at Oak Ridge K-25 Site

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

U.S. Department of Energy Memorandum, February 20, 1992, "Plans for Ultimate Disposition of Depleted Uranium". To: Leo P.Duffy, Director, Office of Environmental Restoration and Waste Management, EM-1. From: Philip S. Sewell, Deputy Assistant Secretary for Uranium Enrichment, Office of Nuclear Energy

page 4. It is assumed that, beginning in 2020, 5,000 cylinders of depleted UF6 are emptied each year and the UF6 is converted to U3O8. Based on a schedule where conversion of UF6 begins in 2020, all the cylinders containing UF6 would be emptied by about 2065.

page 7. Summary. - - If alternate uses for the depleted uranium are not found to be feasible by approximately 2010, then steps will be taken to convert the UF6 to an oxide of uranium, U3O8, as the most appropriate form for ultimate storage and ultimate disposition. The U3O8 will be stored until it is determined that all or a portion of the depleted uranium is no longer needed. At that point, the U3O8 will be disposed as low-level waste.

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts from "Depleted Uranium Hexafluoride Management Program", UCRL-AR-120372, June 30, 1995

Information Package 1, page 4

In 1977, French officials determined that storage of depleted UF6 from enrichment operations should be limited in time and quantity. License conditions were established for the enrichment facilities, which resulted in Cogema implementing a project for converting the depleted UF6 inventory to U3O8 on an industrial scale. Currently, Cogema packs and stores the U3O8 in 3-cubic-meter metal containers. Each container has a capacity of 9 tons. The containers are placed on concrete pads and are housed in metal framed, seismic resistant modular sheds. Each shed can hold 2,600 containers. With 12 sheds located onsite, Cogema estimates a U3O8 storage capacity of roughly 20 years (Cogema 1989)

(Gene Hoffman Note: One of the principal potential long-term uses of DUF6 cited by DOE is for application in future U.S. breeder reactors. If the U.S. persues breeders ever this application is many decades away. In addition it should be noted that the French are far ahead of the U.S. in breeder reactor demonstration and yet they still chose to convert their DUF6 to U3O8 for storage over 20 years ago.)

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpt from "An Integrated Solution For UF6 Tails Management", S. L. Rock, Allied Signal, Inc. and L. G. Davis, General Atomics, Proceedings of the Third International UF6 Conference, Paducah, Ky, November, 1995

"Storage in a Stable Form. Thirdly, the tails can be converted to a usable or uranium-retrieveable form such as metal or oxide. It should be noted that uranium metal cannot be stored simply, but must be protected from corrosion. U3O8 is the end product of all uranium decomposition. Also the production of metal from UF6 is relatively expensive compared to conversion to U3O8 and historically has created a significant hazardous material waste stream. -- Both the Department of Energy and the Nuaclear Regulatoriy Commission have gone on record as favoring conversion to U3O8 as the most desirable and sensible approach."

Excerpts from letter Allied Signal, Inc (M.D. Kosmider, plant manager) to Martin Marietta (Joe Russell), Subject: Critique of ORNL Report Entitled "Investigation of Breached Depleted UF6 Cylinders", dated February 7, 1992

"The only thing that disturbed me about the report was the lack of any mention of the long-term solutions to this problem. - - There are already 40,000 tails cylinders in storage; many are already dented from contact with surrounding cylinders lifting lugs; the number of tails cylinders is increasing by several thousands per year; and the report indicated that even a cylinder which is not dented has a storage life which probably does not exceed 50 - 60 years. In other words there exists a large potential for future problems which will not be resolved by improving painting, handling, inspecting, and stacking practices. Improving these practices will probably only delay the inevitable. - - - it must at least be mentioned that de-conversion of the tails to a relatively non-hazardous oxide form is the only way to eventually solve the problem."

1469

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Conversion of DUF6 To Safe (U-metal), Safer (UO2) and Safest (U3O8) Forms

--- 4,683 cylinders at Oak Ridge (oldest and most heavily corroded)

--- 13,388 cylinders at Portsmouth

--- 28,351 cylinders at Paducah

- o Transportation of degraded cylinders is a problem on-site and a much more challenging and expensive off-site transportation problem.
- o Conversion of Paducah cylinders on-site would eliminate off-site transportation problem.
- o Conversion of Oak Ridge and Portsmouth cylinders at a second conversion facility should be considered, this would -
  - expedite more timely conversion of the most hazardous cylinders and
  - provide technical and cost competion which would benefit the taxpayers

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpt from "Affordable Cleanup?", Report of the Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities, National Research Council, D.F. Stein, Chairman, National Academy of Science, *National Academy Press, 1996*

Executive Summary - DUF6

A DOE study has found that past practices for storage of DUF6 have been inadequate in several respects (see reference below). There have been no serious consequences, however, and there is a vigorous program to correct past deficiencies.

There is general agreement, however, that DUF6 is an unsuitable chemical form for long-term storage; it is to reactive and volatile. Eventually it needs to be converted to the more suitable form of uranium oxide (U3O8). No large-scale uses have been identified, and the most promising potential uses do not preclude conversion to oxide.

> Recommendation. The committee recommends that, if consistent with the prioritized cost-and risk-reduction process, the DUF6 should be converted to the more stable chemical form, U3O8, for storage or disposal.

Reference: DOE, 1992, U. S. Department of Energy Independent UF6 Cylinder Assessment Team Draft Preliminary Report. Oak Ridge, Tennessee: DOE Oak Ridge Field Office.

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpt from Draft PEIS, December, 1997

"In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing uranium hexafluoride have occurred that have caused diagnosed irreversible adverse effects among workers."

Excerpt from U. S. Nuclear Regulatory Report NUREG-1198, dated June, 1986, Executive Summary

"On January 4, 1986, at 11:30 a.m., a Model 48Y cylinder filled with uranium hexafluoride (UF6) ruptured while it was being heated in a steam chest at the Sequoyah Fuels Corporation facility near Gore, Oklahoma. The incident resulted in the death of one plant worker and injuries to several others as a result of exposure to hydrofluoric acid, a reaction product of UF6 and airborne moisture."

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpt from CONF-9110117, Second International Conference, Uranium Handling Conference, 1991, *"UF6 Overfilling Prevention at Urodif Production, Georges Besse Plant, p.65*

" On January 4th, 1986, a 48 Y model cylinder of uranium hexafluoride opened up while it was being heated in an oven at the uranium fluorination plant located near Gore, Oklahoma (USA) and operated by the Sequoyah Fuels Corporation. This accident caused the death of a plant employee and intoxication of several other people subsequent to exposure to the vapors produced by the released uranium hexafluoride (UF6), especially the hydrogen fluoride. Emission of toxic vapors lasted roughly 40 minutes. Carried by winds blowing at 40 km/hr, the cloud was visible more the 1.5 km away from the site of the accident. " (Accident reported in NUREG-1179, Vol. 1, February, 1986)

"The accident is one of the most serious accidents known yet involving uranium hexafluoride (UF6), given both the human consequences as well as the amount of UF6 released: approximately 13 tons of natural UF6."

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

FILL LIMIT PROBLEM

Excerpts from "A Review of UF6 Cylinder Practices and Criteria", C. W. Walter, KY/L - 1522, March, 1989

page 3. The determination of a maximum fill limit involves concern for system safety and efficiency. During much of the past 40 years of filling Model - 48 cylinders, a uniform safety factor was not established and even today discussions and changes are being made as concerns are raised and evaluated. - The physical property of UF6 to expand in volume as much as 40 percent when heated from a solid state at ambient temperature to a liquid at working temperature can create substantial containment problems. A cylinder, when completely filled with liquid at 175 degrees F and then heated above that temperature, will rupture due to hydraulic forces generated by the expanding liquid, thereby spilling the contents of the cylinder.

page 5. However, there are cylinders in storage yards that are filled to earlier fill limits which assumed greater minimum volumes than presently assumed and based on 100 percent fill. These cylinders cannot be shipped unless the excess material is removed and the cylinder meets the current shipping limits.

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Corroded DUF6 Cylinders (less than 0.25-in. wall thickness) Unloaded By Improper Process

Reference: Occurrence Report No. ORO-MMES-PGDPOPERD-1992-0018, dated March 10, 1992

Excerpts from Item 15. Description of Occurrence:

Two cylinders of non-enriched uranium hexafluoride (normally called "feed") were not fed by the precautionary method (normally called "cold feed") because hold tags had not been attached to them. -- Information that these steel cylinders had thin areas in parts of their surfaces was not properly communicated nor responded to. The "cold feed" method eliminates the possibility of surface rupture of cylinders with thin surface areas. "Cold feeding" is a plant practice whereby cylinders with surface thickness less than .250 inches are fed at reduced temperature, keeping cylinder pressure below atmospheric pressure. - -The two cylinders in question had areas of .245 inches and .223 inches respectively.

Item 23. Evaluation : (By Facility Manager/Designee

There appears to be deficiencies in both clearly defined procedures and formality in communication in this area. The lack of clearly established roles and responsibilities led to this occurrence.

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Bending of Cylinder Walls

Excerpt from Martin Marietta Internal Memorandum, "Fourteen Ton Cylinder Problems", Victor M. Perez, PORTS, Chairman of UF6 Safety Handling Committee, to Roger McDermott, dated June 21, 1990.

page 1. "It was reported that another cylinder was stepped on by a UMH supervisor, and he felt the wall give. The Committee agreed to investigate this situation further.

Additional Information on Bending of Cylinder Walls

There are undocumented accounts of transport drivers noting flexing of cylinder walls during tie-down of cylinders on trailers.

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Table 7-3. Comparison of Management Options for UF6

Evaluation Factor	Conversion to Oxide	Continued Storage
Health and Safety	Reduces hazard by conversion to a more stable form Potential for occupational exposure and injury during conversion	Hazard from storage of very reactive UF6 Hazard greatest during periodic transfer into new containers and if exposed to fire
Future Considerations	No legacy to future generations. Oxide can be used as feedstock or disposed of.	Decommissioning of GDP site cannot be completed with this option. DUF6 still requires ultimate disposition.

Reference: "Affordable Cleanup?", National Research Council, 1996, page 171

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts from "Integrity of Uranium Hexafluoride Cylinders, Defense Nuclear Facilities Safety Board, DNFSB/TECH-4, May 5, 1995, p. 16

"A paper entitled *Investigation of Breached Depleted UF6 Cylinders*, presented at the Second International Conference on Uranium Hexafluoride Handling, proposed experimental effort directed at examining the effect of a hole near the top of the cylinder that remains undetected. Scenarios had been proposed that could lead to a steam-driven expulsion of contaminmated liquid and HF from the cylinder due to the accumulation of water in the vapor space (due to rain and condensation) and subsequent chemical reactions. Further examination of this potential accident would appear warranted, based on the information available to-date."

"Consequences of seismic events in the storage yards are not addressed."

(Gene Hoffman Note: The hole-in- top of a cylinder safety concern cited above is justified by the possibility of cracks or holes resulting from transportation accidents or seismic events. The consequences of seismic events are very important when one considers that all options evaluated by DOE in the PEIS involve storage of degraded DUF6 cylinders for many, many years. This is especially true in view of the documents produced by many New Madrid experts, including Otto Nuttli. In 1973 Nuttli estimated that a 7.6 earthquake could occur in the Paducah region <u>today.</u>)

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts from "Integrity of Uranium Hexafluoride Cylinders" Defense Nuclear Facilities Board (DNFSB) Report DNFSB/TECH-4, May 5, 1995

page 5. The report (*The Ultimate Disposition of Depleted Uranium, T. R. Lemons, et al., K/ETO-44, December, 1990)* discussed possible options for ultimate disposition, such as transfer or sales to other government programs or to the private sector, but recognized that commercial and government sectors would use only a small fraction of the depleted uranium in the foreseeable future. The report recommended that: UF6 cylinders be inspected on a semi-annual basis; cylinder maintenance and storage yards be up-graded; and depleted uranium be converted to U3O8 for long-term storage or disposal. Contrary to the last recommendation, the present plan established by DOE provides for long-term storage of the depleted uranium stockpile as UF6 until conversion to uranium oxide begins in fiscal year 2020.

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COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Excerpts from "UF6 Long-Term Storage Cylinder Integrity Management Plan, K/ETO-114, September, 1992

page 2. With the growing inventory of depleted UF6, a study of the ultimate disposition of DU was conducted by Energy Systems in 1990. This study reviewed the actual and potential used for DU and provided recommendations toward the ultimate disposition. The study concluded that there are currently few alternative uses of this material.

page 3. In the past two years, significant substandard conditions have been identified. For example, cylinders in and near ground contact have been observed with accelerated corrosion; accelerated corrosion at the skirt-to-head connection has been reported, and improper stacking of these cylinders has been identfied. All of these conditions can affect the life expectancy of the containment vessels.

COMMENTOR NO. 53: HOFFMAN, EUGENE (CONT'D.)
KNOXVILLE, TENNESSEE

Uses for Depleted Uranium (Reference: "Affordable Cleanup?", National Research Council, 1996, pp. 158-163.

Shielding Applications

" The UO2 suggested for Ducrete represents a very high density oxide but is not the thermodynamically stable form; U3O8 (uranium oxide) has a lower density but is the stable form and would probably be the preferred form for any Ducrete planned for long-term use. Consequently, proposals for the use of Ducrete would not conflict with a decision to convert DUF6 to a more stable oxide."

Use as a Fluorination Agent

"An inherent disadvantage of these fluorination schemes using UF6 is the need to introduce uranium into otherwise nonradioactive chemical plants, with the resulting complications of licensing, radiation protection,and low-level waste generation."

Re-enrichment or Dilution

DUF6 Enrichment by AVLIS - "AVLIS requires uranium metal feed, so the DUF6 must be converted to metal; this conversion is an expensive process. - - Final decisions on AVLIS. in praticular the use of DUF6 feed, are probably several years in the future. In the meantime, significant quantities of low 235U assay UF6 (less than 0.21 percent 235U) could be converted to U3O8 without affecting the potential use as AVLIS feed."

Blending Agent - "The volumes of material required for blending are not large. Thus a blending agent would have little effect on a decision to proceed with conversion of the DUF6 to U3O8."

Potential Energy Resource for Reactors - "The deployment of the breeder reactor in the United States is uncertain. Based on an economic analysis, a recent NRC report notes the advanced liquid-metal reactors may become competitive with advanced light-water reactors sometime in the latter part of the 21st century (NRC, 1996). Hence, the potential use of DUF6 as a resource for breeder reactors is relatively far in the future."

1475

COMMENTOR NO. 54: HANSON, KRISTI & DONHAM, MARK
BROOKPORT, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 54-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 54-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 54-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 54-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 54-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 54-6

Thank you for considering these comments.

Sincerely,

Kristi Hanson Kristi Hanson
Mark Donham Mark Donham
RR1
Brookport Il. 62910

COMMENTOR NO. 55: KENTUCKY RADIATION HEALTH & TOXIC AGENTS BRANCH FRANKPORT, KENTUCKY

Depleted Uranium Hexafluoride Management Program

Comment Form

The Department of Energy is interested in your comments on the *Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

There are several ways to provide comments on this document and these include:

- ✓ attending public hearings and giving your comments directly to DOE officials
- ✓ returning this comment form to the registration desk at the hearing
- ✓ returning this comment form or other written comments to the address on the back
- ✓ faxing your comments to 301/428-0145
- ✓ commenting via the Depleted UF_6 World Wide Web site: http://www.ead.anl.gov/uranium.html
- ✓ calling toll-free and leaving your comments via voice mail, 1-800-517-3191
- ✓ commenting via electronic mail: depleted_uf6@comail.gnet.saic.com

Comments

(1) DOE must immediately move to convert the entire inventory of DU to the oxide for long term storage. — 55-1

(2) Conversion can not wait for ten years or any period of time. — 55-2

(3) DOE must conduct the conversion to the oxide at its present storage location. No transportation of DUF6 a conversion facility — 55-3

(4) all Cylenders must be checked for integrity prior to moving to the on-site conversion facility. All such must be stored on-site under cover. — 55-4

Thank you for your input. Please use additional sheets if necessary and attach them to this form.

Name John A. Volpe PhD (optional) ☒ Please add my name to the Depleted UF_6 mailing list.

Organization Kentucky Radiation Health & Toxic Agents Branch ☐ Please take my name off the Depleted UF_6 mailing list.

Address 275 E Main St. MC HS2E-A (optional)

City Frankfort State KY Zip 40601

Phone number 502/564-3700 (optional)

E-mail address jvolpe@mail.state.ky.us (optional)

UF_6

Depleted Uranium Hexafluoride Management Program • Charles E. Bradley, Jr.
Department of Energy • Office of Nuclear Energy, Science and Technology • Office of Facilities
19901 Germantown Road • Germantown, MD 20874-1281/903-4781

9741

COMMENTOR NO. 56: OAK RIDGE RESERVATION LOCAL OVERSIGHT COMMITTEE OAK RIDGE, TENNESSEE

LOC INC
Oak Ridge Reservation
Local Oversight Committee

April 22, 1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Submitted Via Fax: (301) 428-0145

Subject: Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (UF6)

Dear Mr. Bradley:

The Citizens' Advisory Panel (CAP) of the Oak Ridge Reservation (ORR) Local Oversight Committee (LOC) submits the following comments on the subject document. Several members of the CAP attended the February 24, 1998, public hearing on the PEIS and reviewed the available documentation. The LOC Board has not had the opportunity to review and approve the comments and thus these comments should be considered submitted by the CAP only.

The LOC is a non-profit regional organization funded by the State of Tennessee and established to provide local government and citizen input into the environmental management and operation of the DOE ORR. The Board of Directors of the LOC is composed of the County Executives of Anderson, Knox, Loudon, Meigs, Morgan, Rhea, and Roane Counties; the Mayor of the City of Oak Ridge; and the Chairs of the Roane County Environmental Review Board (RCERB), the City of Oak Ridge Environmental Quality Review Board (EQAB), and the LOC Citizens Advisory Panel (CAP). The CAP currently has 19 members with diverse backgrounds representing the greater ORR region.

The CAP concurs that the alternatives considered in the PEIS are appropriate, but the assumptions which delay action to 2009 with completion in 2028 are not acceptable. We understand that the continued storage of the UF6 cylinders does not pose an immediate health or environmental threat. However, as time passes, the task of assuring safe storage will become more demanding, with increasing cost for surveillance and maintenance of the deteriorating cylinders. — 56-1

The condition of the oldest cylinders at Oak Ridge and Paducah should be considered when planning for decontaminating and decommissioning (D&D). The toxicity of the fluorine component is the primary concern with regard to health risk, although release of depleted uranium to the environment could result in a costly public relations disaster. — 56-2

Anderson • Meigs • Rhea • Roane • City of Oak Ridge • Knox • Loudon • Morgan

136 S Illinois Ave., Suite 208 • Oak Ridge, TN 37830 • Phone (423) 483-1333 • Fax (423) 482-6572 • E-mail: locinc@aol.com

COMMENTOR NO. 56: OAK RIDGE RESERVATION LOCAL OVERSIGHT COMMITTEE (CONT'D.) OAK RIDGE, TENNESSEE

C. E. Bradley, Jr.
April 22, 1998
Page 2

As you may know East Tennessee Technology Park (ETTP, formerly K-25) has an active reindustrialization program underway. The continued presence of the UF6 cylinders might negatively impact the site reuse activities from an aesthetic viewpoint or as a perceived risk to co-located workers, as well as by the loss of the storage yard land to new uses. 56-3

DOE has a responsibility to begin reducing its stockpile of UF6. The CAP urges that an expedited conversion program be started immediately. We have reviewed the voluminous amount of information associated with this subject and the variety of suggestions on how to properly handle this situation. Our recommendations follow: 56-4

1. Increase and expedite the current maintenance program to clean and paint all cylinders starting with the most needy. 56-5
2. Improve the storage conditions so that all cylinders are accessible and safe.
3. Convert the UF6 to the more stable oxide (triuranium octaoxide) or metal form. There do not appear to be any technical barriers to beginning conversion. Begin the conversion process as soon as feasible. 56-6
4. Start conversion with the oldest cylinders and those in the worst physical condition.
5. Place the conversion products in interim storage until a decision is made for permanent storage, use, or disposal.

The Energy Policy Act of 1992 provides for payment of the costs of remedial actions at gaseous diffusion facilities from the Uranium Enrichment & Decommissioning Fund. Appropriations received to date have lagged behind the available funds by an approximate factor of two. We urge that this money be made available in a timely manner for the UF6 processing that is needed. 56-7

The LOC's CAP appreciates the opportunity to comment on the *Draft PEIS for Alternative Strategies for the Long-Term Management and Use of Depleted UF6*. If you have any questions, please call me at (423) 483-1333.

Sincerely,

Susan L. Gawarecki, Ph.D.
Executive Director

cc: LOC Board
LOC Citizens' Advisory Panel
Earl Leming, TDEC DOE-O
Bill Pardue, Chair, ORREMSSAB

1477

COMMENTOR NO. 57: LAMB, RONALD KEVIL, KENTUCKY

APRIL 22,1998

CHARLES E BRADLEY, JR.
OFFICE OF FACILITIES (NE-40)
OFFICE OF NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY
U.S. DEPARTMENT OF ENERGY
19901 GERMANTOWN ROAD
GERMANTOWN, MD 20874-1290

COMMENTS: DEPLETED URANIUM HEXAFLUORIDE MANAGEMENT PROGRAM

THE CYLINDERS SHOULD CONTINUE TO BE STORED. THE OLDER OR COMPROMISED CYLINDERS SHOULD BE PLACED IN OVER PAKS LIKE THOSE USED TO PROTECT DRUMMED WASTE. ALL CYLINDERS SHOULD BE STORED IN AN EARTHQUAKE SECURE FACILITY. 57-1

NO CONVERSION TO U308 SHOULD TAKE PLACE AT THE PADUCAH SITE DUE TO THE PROXIMITY OF THE NEW MADRID EARTHQUAKE FAULT AND THE CLOSE PROXIMITY OF THE PLANT NEIGHBORS 57-2

CONVERSION TO U308 WILL ADD TO THE WASTE INVENTORY BECAUSE OF THE LARGE VOLUME OF CYLINDERS. IF CONVERSION HAD BEEN CONSIDERED AT AN EARLIER TIME THE WASTE STREAMS COULD HAVE BEEN HANDLED EASIER. 57-3

QUESTIONS:

IF CYLINDERS SHOULD BUMP INTO EACH OTHER DURING A SEISMIC EPISODE AND BREAK OFF NUMEROUS FILL VALVES, ARE THERE PROCEDURES IN PLACE TO HANDLE A LARGE NUMBER OF VALVE REPLACEMENTS ? 57-4

HOW MANY BROKEN FILL VALVES IN THE 30,000 PLUS CYLINDERS WOULD CONSTITUTE A EMERGENCY ? 57-5

WOULD STACKING THE CYLINDERS TWO HIGH IN CLOSE ROWS ADD TO THE DAMAGE OF MORE FILL VALVES BEING BROKEN DURING A SEISMIC EPISODE ? 57-6

THANK YOU,

RONALD LAMB
10990 OGDEN LANDING RD.
KEVIL, KY. 42053

COMMENTOR NO. 57: LAMB, RONALD (CONT'D.)
KEVIL, KENTUCKY


```
[elrond.ceri.memphis.edu]
Login name: quake                       In real life: Quake Informa
Directory: /ceri3/scis/quake            Shell: /usr/local/bin/tcsh
Last login Mon Oct  6, 1997 on ttyp6 from yavanna
Unread mail since Thu Apr  9 22:50:24 1998
Plan:

The following catalog is for earthquakes in the New Madrid seismic zo
ano is produced by the Cooperative New Madrid Seismograph Network (CN
a member of the Council of the National Seismic System.  CNMSN suppor
comes from the United States Geological Survey and the State of Tenne

In the early 1800's, the New Madrid seismic zone was the site of what
are considered to be the largest earthquakes to have occurred in the
conterminous United States.  During the winter of 1811-1812, a series
of three earthquakes, estimated at magnitude 8 or larger, struck in a
period of three months.  There have been several magnitude 6-7 events
since that time and there is a continuing activity of small earthquak
that defines the present day seismic zone.  The principal seismic act
is found in western Tennessee, northeast Arkansas, and southeast Miss

Other catalogs for various regions of the United States can be obtain
using the finger mechanism 'finger quake@machine'.  The following lis
gives the machine names for different regions.

        uldfs.cr.usgs.gov       (USGS NEIC/NMIS world-wide)
        andreas.wr.usgs.gov     (Northern California)
        scec.gps.caltech.edu    (Southern California)
        fm.gi.alaska.edu        (Alaska)
        seismo.unr.edu          (Nevada)
        mbmgsun.mtech.edu       (Montana)
        equinfo.seis.utah.edu   (Utah)
        sisyphus.idbsu.edu      (Idaho)
        quake.eas.slu.edu       (Central United States)
        tako.wr.usgs.gov        (Hawaii)

Additional catalogs and information are available on the World Wide W
at the URL 'http://www.geophys.washington.edu/seismobig.html'.

The Date/Time is given in Universal Time Coordinates (UTC), which
is 6 hours ahead of Central Standard Time (5 hours ahead of CDT).

Magnitudes are reported as Md (local duration magnitude) unless
otherwise noted.

Q denotes the location quality: A = good, D = poor.

Updated on December 12 10:00 CDT 1997.

  DATE-(UTC)-TIME   LAT     LON      DEP  MAG  Q       COMMENTS
yy/mm/dd hh:mm:ss   deg.    deg.     km
97/02/10 13:25:35  36.25N  89.45W  10.0 1.0   B  RIDGELY, TENNESSEE
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97/02/17 16:32:28  35.05N  90.60W  30.0 2.4   D  COOBERTOWN, ARKANSAS
97/02/19 15:38:44  35.75N  90.14W   0.3 1.4   B  LENNIE, ARKANSAS
97/02/24 03:48:10  35.76N  90.14W   4.5 2.0   D  MISSISSIPPI CO., ARK
97/03/05 21:11:32  36.05N  89.80W   7.3 2.3   D  COOTER, MISSOURI
97/03/06 12:40:51  36.24N  89.44W   5.6 2.3   B  RIDGELY, TENNESSEE
97/03/07 23:38:58  36.26N  89.51W   7.5 2.0   B  RIDGELY, TENNESSEE
97/03/09 06:38:10  36.23N  89.43W   8.8 1.9   A  BOGOTA, TENNESSEE
97/03/12 11:16:12  36.54N  89.62W  24.7 2.2   D  CONRAN, MISSOURI
97/03/16 16:59:56  36.54N  89.67W  25.0 2.2   D  PORTAGEVILLE, MISSOU
97/03/16 19:07:28  34.27N  93.49W   5.0 3.4   D  GLENWOOD, ARKANSAS
97/03/21 03:07:56  36.15N  89.70W   9.1 2.1   A  ACORN CORNER, MISSOU
97/03/21 17:39:13  36.81N  89.51W   2.0 2.5   D  DOGWOOD, MISSOURI
97/03/23 09:36:34  36.18N  89.41W   9.1 1.9   B  MITLSFIELD, TENNESSE
97/04/06 14:41:12  36.25N  89.46N  10.5 1.6   A  RIDGELY, TENNESSEE
97/04/06 16:48:34  36.24N  89.46W  10.6 1.7   A  RIDGELY, TENNESSEE
97/04/12 02:27:18  36.01N  89.83W  25.7 1.4   B  HERMONDALE, MISSOURI
97/04/18 09:40:03  36.07N  89.89W  10.0 2.0   D  DENTON, MISSOURI
97/04/20 15:50:56  36.12N  89.75W  13.5 2.1   A  ACORN CORNER, MISSOU
97/04/26 00:50:26  36.46N  89.58W  16.0 1.0   D  PLEASANT POINT, MISS
97/05/02 03:13:48  36.25N  89.42W  10.8 1.3   B  RIDGELY, TENNESSEE
97/05/14 20:40:21  37.74N  87.58W  10.0 2.3   D  HENDERSON CO., KENTU
97/05/18 20:50:40  35.24N  91.25W  13.5 2.6   D  PATTERSON, ARKANSAS
97/05/20 05:20:32  36.65N  89.59W   5.0 2.2   D  KEWANEE, MISSOURI
97/05/20 22:24:57  36.32N  89.57W   5.6 1.6   A  MOORING, TENNESSEE
97/05/22 14:58:01  36.32N  89.54W   6.9 1.7   A  MOORING, TENNESSEE
97/05/23 05:34:00  36.63N  89.57W  11.4 2.0   B  KEWANEE, MISSOURI
97/05/31 21:32:55  36.31N  89.53W   5.9 2.1   B  MOORING, TENNESSEE
97/06/02 19:39:52  36.29N  89.46W   7.9 1.9   A  MADIE, TENNESSEE
97/06/14 05:43:48  37.16N  89.32W   2.0 2.2   D  SANDUSKY, TENNESSEE
97/06/17 01:30:41  36.30N  89.53W   8.1 1.8   A  MOORING, TENNESSEE
97/06/17 06:14:40  36.28N  89.54W   8.9 2.1   A  MOORING, TENNESSEE
97/06/26 17:55:30  36.67N  89.60W   3.1 2.5   D  KEWANEE, MISSOURI
97/07/03 12:45:00  36.33N  89.53W  11.8 2.0   B  MOORING, TENNESSEE
97/07/10 02:25:32  35.43N  89.55W  10.0 2.2   D  MASON, TENNESSEE
97/07/13 02:18:20  36.11N  89.76W  10.0 2.1   B  ACORN CORNER, MISSOU
97/07/21 20:30:43  36.44N  89.56W  15.5 2.2   A  POINT PLEASANT, MISS
97/08/09 19:07:50  35.60N  90.51W  11.4 2.2   D  TRUMANN, ARKANSAS
97/08/21 19:29:35  35.99N  89.05W  13.6 2.3   D  BLYTHEVILLE, ARKANSAS
97/09/03 10:16:40  36.63N  89.57W  8.01 2.2   D  NEW MADRID, MISSOURI
97/09/17 18:16:32  35.66N  90.48W   5.0 3.4   D  TRUMANN, ARKANSAS
97/09/24 04:20:26  35.58N  89.88W  26.0 3.0   D  TALLAPOOSA, MISSOURI
97/09/20 05:55:57  36.91N  90.69W  10.9 2.5   D  66.21 km west of Dex
97/09/27 12:14:11  36.19N  89.42W   6.6 2.9   B  CLOVERDALE, TENNESSE
97/10/02 06:56:16  36.00N  88.99W  15.0 1.9   B  25km E of DYERSBURG,
97/10/06 03:13:29  36.42N  89.45W   5.0 1.5   D  RIDGELY, TENNESSEE
97/10/17 09:50:51  36.15N  89.03W  10.0 1.5   D  MARTIN, TENNESSEE (A
97/10/20 01:50:46  36.02N  89.21W  10.0 1.2   D  DYERSBURG, TENNESSEE
97/10/24 08:35:16  31.17N  87.25W   5.0 4.9       BREWTON, ALABAMA (NE
97/10/26 23:27:12  31.10N  87.30W  10.0 3.7Lg     BREWTON, ALABAMA (NE
97/10/28 09:00:10  31.10N  87.30W  10.0 3.0Lg     BREWTON, ALABAMA (NE
97/11/03 17:06:02  35.63N  90.39W       1.6   C  MARKED TREE, ARKANSA
97/11/09 20:40:57  36.41N  89.48W   0.7 1.4   D  RIDGELY, TENNESSEE (
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COMMENTOR NO. 57: LAMB, RONALD (CONT'D.)
KEVIL, KENTUCKY

finger?quake@elrond.ceri.memphis.edu at sunwi... Page 3 of 3

97/11/29	10:20:45	36.09N	89.73W	11.0	2.5	B	PEMISCOT CO, MISSOUR
97/12/02	23:41:15	36.57N	89.51W	7.9	2.7	B	FULTON CO. KENTUCKY
97/12/12	08:42:21	33.73N	87.20W	10.0	4.0Lg	A	WALKER CO. ALABAMA (
98/01/09	09:05:59	36.5GN	89.52W	7.0	2.2	B	New Madrid, Missouri
98/01/17	19:40:07	36.59N	89.62W	6.5	2.2	B	New Madrid, Missouri
98/01/27	09:58.40	36.12N	89.57W	12.0	2.5	A	Dyersburg, Tennessee
98/01/28	22:05:12	36.10N	89.76W	11.4	2.7Lg	B	Caruthersville, Miss
98/02/12	09:47:49	36.14N	89.71W	9.6	3.0	A	Caruthersvi,lle Miss
98/02/19	14:05:27	36.54N	89.58W	8.9	2.7	A	New Madrid, Missouri
98/02/19	22:22:49	36.48N	89.56W	8.2	1.9	A	New Madrid, Missouri
98/02/26	02:10:25	36.49N	89.56W	5.2	2.5	B	New Madrid, Missouri
98/03/12	08:09:43	36.63N	89.37W	5.0	1.5	C	13.63 km northwest o
98/03/13	03:05:27	36.26N	89.61W	7.4	2,0	B	10.69 km north of Ca
98/03/19	06:56:46	36.43N	89.52W	5.3	2.5	B	6.63 km northwest of
98/03/21	06:57:23	36.15N	89.47W	15.8	1.6	B	12.51 km south of Ri
98/04/08	18:16:54	36.60N	89.02W	15.1	3.2Lg	D	16.16 km east of Hi:
98/04/09	05:13:41	36.40N	89.52W	6.8	2.7Lg	B	3.48 km norwest of T

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Comments of the Institute for Energy and Environmental Research on the draft of the Department of Energy Programmatic Environmental Impact Assessment for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride, December 1997

by

Annie Makhijani and Arjun Makhijani

March 1998

The Department of Energy's Draft Programmatic Environmental Impact Statement (PEIS)for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride purports to analyze the impacts of the storage, use and/or disposal of the 560,000 metric tons of depleted uranium hexafluoride currently stored in 46,422 cylinders at three sites located near Portsmouth, Ohio; Oak Ridge, Tennessee; and Paducah, Kentucky. This long term management is for the depleted uranium generated prior to 1993.

In this report the DOE examines six alternatives:

- The "no action" alternative which would be a continuation of the current management program, that is storage on site in cylinders of the depleted uranium hexafluoride.
- Two storage alternatives based on retrievability
  - in UF_6 form in yards, buildings or an underground mine
  - in oxide form in buildings, below-ground vaults or an underground mine
- Two use alternatives
  - radiation shielding for casks for storage of spent fuel or high level wastes after conversion to metal
  - radiation shielding for casks for storage of spent fuel or high level wastes after conversion to oxide
- Disposal as low-level waste in the oxide form in drums placed in
  - shallow earthen structures
  - vaults
  - mines

The Draft also makes mention of other possible uses of depleted uranium as part of the use alternatives (see below).

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One of these alternatives will be selected in the Record of Decision, which is scheduled for this year. DOE's preferred alternative is to use the entire inventory of depleted uranium after its conversion to a metal and/or oxide form.

The DOE's effort to address the long-term management of the country's depleted uranium hexafluoride, specifically the realization of the importance to convert this material into a stable form is long overdue. The draft PEIS is seriously deficient because it does not address the most environmentally appropriate option - specifically, the DOE did not include the alternative of disposing of depleted uranium according to the rules of 40 CFR 191 which govern the disposal of transuranic (TRU) wastes. IEER, in its comments (Mar 22, 1996) on DOE's Notice of Intent (Jan 25, 1996), had already noted that the proposed list of alternatives was incomplete since it did not include the option of disposal under 40 CFR 191. The DOE has rejected our comments without providing any technical or environmental explanation. Our comments of March 22, 1996 are attached . DOE should include this option in the Final PEIS.

58-1

IEER agrees with DOE that the no action alternative is inappropriate and should be rejected because of the dangers of UF_6 storage. For the same reason, long-term UF_6 storage in new containers should also be rejected. Overall, conversion to oxide would reduce risks. While conversion poses risks to workers and the off-site population, continued storage also poses serious risks.
However, the various alternatives the DOE has considered have not been properly assessed in this PEIS.

58-2

A. Conversion of uranium hexafluoride

Most of the alternatives considered involve the conversion of uranium hexafluoride. Three alternatives would convert uranium hexafluoride to an oxide and one alternative would convert uranium hexafluoride to a metal. This conversion would have the positive result of putting the depleted uranium in a more stable chemical form, therefore eliminating the chances of an hazardous releases of UF_6 and hydrofluoric acid from aging corroding cylinders. DOE's analysis is incomplete or deficient in regard to the

58-3

- fate of the empty cylinders,
- commercial use of contaminated anhydrous hydrogen fluoride (produced during the conversion process),
- the radiological effects on workers.

1. Fate of the empty cylinders

DOE admits that ".. the ultimate disposition of the empty cylinders was not analyzed in detail as part as the alternative management strategies." The empty cylinders would become part of the DOE scrap metal inventory. The options for disposition are: recycling

58-4

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"... into LLW disposal containers, reuse as LLW containers, free release for re-melting, and disposal as LLW." However DOE has not analyzed the environmental and health impacts of these proposals. This lack of analysis is a serious problem since the volume of contaminated metal involved is large and doses to the public and to workers may be significant.

58-4 (Con't.)

2. Commercial use of contaminated HF and CaF_2

The DOE has not properly assessed the management of both HF, a by-product of the conversion process, and calcium fluoride (CaF_2), a product of the neutralization of HF. Both these products will be slightly contaminated and in the Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride concerns are expressed as to the public acceptance of the uranium contaminants. Regardless of this concern, the DOE, in its Draft PEIS, assumed that these products could be commercially sold for unrestricted use. It is unacceptable to release a non-labeled contaminated product which has not received public acceptance. The Cost Analysis Report also states that the demand for HF is "still very uncertain". An other option is to use the HF for the production of UF_6. For this option as well as the commercial use option, DOE has not addressed the fact that part of the UF_6 inventory is recycled UF_6 which is contaminated by radionuclides other than uranium-238, such as Tc-99 and U-236 which both have a long half life.

58-5

3. Radiological effects on workers

In their calculation of radioactive dose assessment, DOE does not take into account internal radiation doses that would be received by involved workers during the conversion process. This is a serious deficiency since involved workers are the most at risk. DOE claims that measures taken to prevent inhalation and ingestion of radioactive material would effectively protect the involved workers. The emphasis on prevention measures is not enough without a monitoring program installed for health purposes. DOE also claims use of respirators will reduce workers doses. But routine reliance on respirators is unacceptable as a radiological control practice. Moreover, some of the depleted uranium comes from the enrichment of UF_6 from recycled uranium from spent fuel. This UF_6 contains some radionuclides of concern such as technitium-99, a long lived beta emitter and uranium-236, a long lived alpha emitter. DOE does not seem to have analyzed the radiological impacts.

58-6

B. Uses of depleted uranium

1. Uses unalyzed

DOE's preferred alternative is to use the entire inventory of depleted uranium after its conversion to a metal or an oxide form for radiation shielding in storage casks for spent fuel. However since these casks would have to be licensed by the NRC (6.11-9-1 Engineering analysis report) this choice is premature. Even if the licensing is approved cask fabrication creates more problems than solutions. The problems are that

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- it is not a final solution since the casks envisioned do not meet the criteria for deep repository disposal. Hence this is not a solution but a stop-gap storage method that would create more contamination and radioactive waste in the form of used casks. The DOE has not done the preliminary work ascertaining the license ability of the casks. DOE's choice of preferred option is premature and inappropriate.
- DOE doesn't say what will happen to the DU in the casks. It only states that: "No assumptions were made regarding the fate of the oxide- and metal-shielded casks after use. The empty casks could be recycled, stored, or disposed of as LLW." (p. H-32).

58-7 (Con't.)

For the manufacturing casks as with the conversion process, the contribution to the dose from internal radiation to involved workers has not been assessed.

2. *Other uses not analyzed in depth*

With the long-term storage options DOE preserves the possibility to pursue the use of depleted uranium in light water reactor fuel cycle, advanced reactor fuel cycles and, dense material applications. The light water reactor option has two sub-options: the re-enrichment of DU and the use of DU for MOX. Among these options, the fact that the use of depleted uranium in advanced reactors (that is fast neutron reactors, also known as breeder reactors) is at all considered is particularly disturbing. Depleted uranium being the raw material for plutonium production, by converting it into a material not only much more radioactive but also weapons usable would not only defeat the stated purpose of the PEIS which is to "achieve the safe and effective long-term management of depleted UF_6." It would also have serious proliferation consequences.

58-8

3. *Uses not analyzed*

The feasibility of using depleted uranium hexafluoride for the blending down of surplus highly enriched uranium was not considered in this PEIS. Although it would utilize only a small portion of the stock, this use would have several advantages, among them: the contribution to non-proliferation, a minimum of handling, and incorporation of depleted uranium into spent fuel. This use option could be made part of any of the alternatives except UF_6 storage.

58-9

C. IEER's recommendations

IEER recommends that:

- depleted uranium be classified as a waste equivalent to TRU waste for management purposes

58-1 (Con't.)

- UF_6 be converted to an oxide form and declared a waste to be handled on a par with repository-designated TRU waste, with the possible exception of a relatively small quantity to be used for the blending down of highly enriched uranium. This should be the preferred option in the Final PEIS

58-2 (Con't.)

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- The issue of internal radiation for involved workers during conversion and cask fabrication be addressed carefully along with an assessment of the effects of uranium-236 and technitium-99

58-6 (Con't.)

- the fate of the empty UF_6 cylinders and their proper disposition should be studied

58-4 (Con't.)

- the fate of the anhydrous hydrogen fluoride and calcium fluoride should be properly studied
- radioactive materials such as HF from UF_6 processing and steel from empty UF_6 cylinders not be circulated in the civilian economy.

58-5 (Con't.)

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Comments of the Institute for Energy and Environment on the Department of Energy Notice of Intent addressing the Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride, Federal Register, Thursday, January 25, 1996

by

Arjun Makhijani and Annie Makhijani

22 March 1996

The Department of Energy has announced its intent to prepare a programmatic environmental impact statement addressing the use and/or disposal of the 560,000 tonnes of depleted uranium hexafluoride currently stored in cylinders at three sites located near Portsmouth, Ohio; Oak Ridge, Tennessee; and Paducah, Kentucky.

The DOE plans to consider a set of six preliminary alternatives:

- The "no action" alternative which would be a continuation of the current management program, that is storage on site in cylinders of the depleted uranium hexafluoride.
- Two storage alternatives based on retrievability
  - in the UF_6 form
  - in the oxide form
- Two use alternatives
  - radiation shielding after conversion to metal
  - radiation shielding after conversion to oxide
- Disposal as low-level waste in the oxide form in drums placed in
  - engineered trenches
  - below-ground concrete vaults
  - mines

IEER welcomes the DOE's effort to address the long-term management of the country's depleted uranium hexafluoride. However the DOE list of alternatives does not include all reasonable alternatives. Specifically DOE should add another option to the above mentioned list. This option would be the disposal of depleted uranium according to the rules of 40 CFR 191 which govern the disposal of transuranic (TRU) wastes.

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Currently, uranium is still classified as a source material. In cases where it might be disposed of as a waste the Nuclear Regulatory Commission has put it by default into the category of class A low-level radioactive waste according to 10 CFR 61.55 (6). 10 CFR 61.55 allows near surface disposal. The inappropriateness of this default classification is demonstrated be the NRC's own assessment that shallow-land burial of depleted uranium could result in unacceptably high doses to future generations. [1] However in its notice of intent, the DOE has left the low-level category of depleted uranium ambiguous. In the three scenarios of the disposal alternative, the DOE does not specify in which low-level waste class it puts depleted uranium. The first one - disposal in engineered trenches - corresponds to a classification of depleted uranium as class A low-level radioactive waste. The last two - disposal below-ground in concrete vaults and disposal in mines - imply that the current classification is inadequate. DOE should clearly include waste classification as an issue as it relates to depleted uranium in its implementation plan and address it in detail in the PEIS.

We set forth below the scientific reasons why depleted uranium should be put in the same classification as transuranic wastes for the purpose of waste management and disposal. This would mean that depleted uranium would have to be placed in a deep geological repository.

The current definition of TRU waste according to 40 CFR 191.01 (i) is: ". . .waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than twenty years, per gram of waste . . . ."

What matters to health and environmental considerations is the specific activity of the radioactive wastes, the nature of the radiation being emitted during the radioactive decay (alpha or beta and whether the decay is accompanied by gamma radiation) and, the energy per radioactive decay. Depleted uranium is, in these essential respects, the same as the transuranic constituents of TRU waste. The specific ways in which uranium or the transuranic radionuclides in TRU waste might affect people will, of course, depend on the chemical form of the waste, the packaging, and the disposal method.

There is one nominal difference between TRU waste and depleted uranium. TRU waste consists of elements with atomic numbers greater than or equal to 93 -- that is of elements with atomic numbers greater than uranium, whose atomic number is 92. But this is a difference of nomenclature; it has no bearing upon health and environmental issues.

A. Properties of depleted uranium

1. *Specific Activity*

The radioactivity per unit weight (called specific activity) of depleted uranium metal is dominated by its principal constituent, uranium-238. It also depends somewhat on the exact extent to which uranium-235, and hence also uranium-234, have been separated and

[1] Final Environmental Impact Statement for the Construction and Operation of the Claiborne Enrichment Center, Homer Louisiana, NUREG-1484, Vol. 1, August 1994.

passed into the enriched uranium stream. It may vary from about 360 nanocuries/gram to about 450 nanocuries/gram. Even assuming that only uranium-238 remains, the specific activity would be still about 340 nanocuries/gram which is 3.4 times higher than that defining transuranic waste.

The specific activity of other chemical forms is somewhat lower than for uranium metal, because when radioactive uranium is chemically bound with non-radioactive isotopes of elements like oxygen and fluorine, its specific activity is correspondingly lower. Table 1 shows the specific activity of four forms of depleted uranium. For convenience we have assumed a single reference value of 360 nanocuries/gram for the specific activity of uranium metal which is the lowest practical value in the range cited above.

Table 1 also shows, for reference, the minimum specific activity of transuranic waste as defined by regulations and the radioactivity of ore containing 0.2 percent uranium.

Table 1
Specific Activities of various chemical forms of depleted uranium, TRU waste and 0.2% uranium ore

Chemical form	Specific activity, nCi/g
uranium metal (U)	360
uranium oxide (U_3O_8)	300
uranium tetrafluoride (UF_4)	270
uranium hexafluoride (UF_6)	240
transuranic activity in TRU waste	>100 (See note 2)
0.2 % uranium ore	4 (See note 3)

Notes for Table 1
1. Specific activities of the four forms of uranium have been rounded to two significant figures, and that of uranium ore to one significant figure.
2. The minimum limit of 100 nanocuries/gram of transuranic elements for waste to be classified as TRU waste includes only those isotopes of transuranic elements with half-lives greater than 20 years. The most common isotope in TRU waste that is eliminated from the counting in this way is plutonium-241, which has a half-life of 14.4 years. However the decay product of plutonium-241, americium-241 is included in TRU waste because it has a half-life of about 432 years. All these uranium isotopes we are dealing with in these comments have half-lives far longer than 20 years.
3. The specific activity of 0.2 percent uranium ore shown includes all decay products of uranium-238 up to and including radium-226, assuming they are in secular equilibrium with uranium-238. Radon-222, and its decay products are not included.

It is clear from Table 1 that depleted uranium is comparable in specific activity to transuranic waste. This conclusion is independent of the chemical form of the depleted uranium. Note that depleted uranium is far more radioactive than uranium ore because the ore is mixed with large quantities of non-radioactive materials. Thus, putting depleted uranium in mines is in no way like replacing the original material that was mined out of the ground. Rather it is analogous to putting TRU waste in the ground.

2. *Mode of decay, energy of decay, and half-life*

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The main radionuclide of concern in most TRU waste is plutonium-239. Other radionuclides that are present in significant quantities are plutonium-240, plutonium-238, neptunium-237, and americium-241. The predominant mode of decay of all of these radionuclides is alpha decay. That is also the case with all three uranium isotopes (uranium-238, uranium-234, and uranium-235) present in depleted uranium. In all these cases, the emitted alpha particles have energies between 4 and 6 MeV, so that the total energy deposited in tissue per picocurie of radioactive material in the body is the same. Thus, once a unit of radioactivity of TRU waste or of depleted uranium is in the body, the amount of radiation dose per unit of time is approximately the same.

Table 2 shows the principal characteristics of concern of the main radionuclides in TRU waste and in depleted uranium. Note that the decay products of uranium-238 build up over hundreds of thousands of years, and we have ignored these for the sake of argument in these comments.[3]

Table 2
Properties of Uranium Isotopes and Selected Transuranium Elements

Isotope	Main decay mode	Alpha particle energy, MeV	Half-life, years	Comments
uranium-238	alpha	4.1	4.46 billion	
uranium-234	alpha	4.8	245,000	
neptunium-237	alpha	4.8	2.14 million	
plutonium-238	alpha	5.5	87.7	
plutonium-239	alpha	5.1	24,110	
plutonium-240	alpha	5.1	6,537	
plutonium-241	beta	see note 2	14.4	not included in TRU waste definition
americium-241	alpha	5.5	432	strong gamma emitter

Notes
1. All energies rounded to two significant figures. The alpha emitting radionuclides emit alpha particles with more than one characteristic energy, with each energy level being produced with a known probability. The alpha particle energy shown is an approximate average of these particles energies, weighted by the emission probability.
2. Plutonium-241 is not included in the definition of TRU waste since it has a half-life of less than 20 years. Its beta particle energy is 0.021 MeV.

B. Chemical forms of depleted uranium

As has been shown, regardless of its chemical form, depleted uranium is always more radioactive than the lowest specific activity defining TRU waste. However, some chemical forms are more reactive than others. For example UF_6 is very reactive. In the

[3] In general, the specific activity of wastes containing mainly plutonium-239 will decline as time progresses, but that of wastes containing mainly uranium-238 will increase as time progresses, due to the differences in half-lives of the decay products of these two radionuclides

COMMENTOR NO. 59: INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH (CONT'D.)
TAKOMA PARK, MARYLAND

presence of moist air, UF_6 reacts with the water in the air to form uranyl fluoride particulates (UO_2F_2) and hydrogen fluoride fumes (HF) both of which are very toxic. In water hydrogen fluoride becomes a very corrosive acid. Anhydrous hydrogen fluoride is also corrosive. Other chemical forms are less reactive, the oxide forms of uranium being the most physically and chemically stable. DOE should consider disposal of depleted uranium as an oxide (U_3O_8 or UO_2) under 40 CFR 191 rules.

C. Conclusions

We recognize that in comparing uranium and plutonium on the basis of equal masses of these two elements in pure form, plutonium is far more radioactive than uranium. This is because the half-lives of the isotopes of plutonium shown in Table 2 are far shorter than those of uranium. This means that a given mass of uranium decays more slowly -- that is, it gives off fewer alpha particles per unit of time. However, the far lower specific activity of uranium isotopes in depleted uranium relative to pure plutonium is irrelevant to this discussion because we are examining the properties of materials on the basis of the radioactivity per unit mass of waste to be disposed of. TRU waste is defined as that containing more than 100 nanocuries/gram. By weight it consists mainly of non-radioactive materials mixed with small masses of transuranic elements. By contrast, depleted uranium would be disposed of in nearly pure form, with only the possible addition of and element such as oxygen. As a result, TRU waste is comparable to depleted uranium. DOE TRU waste is slated for disposal in a deep geological repository.

Therefore we believe that depleted uranium should be put in the same category as TRU waste so far as its characteristics for waste management and disposal are concerned. Therefore in the PEIS the DOE should:

- reexamine the waste classification of depleted uranium based on the explicit recognition of the scientific facts discussed above and,
- add one alternative consisting of converting depleted uranium to the oxide form (U_3O_8 or UO_2), and disposing it of in a geologic repository under 40 CFR 191 rules. The proposed PEIS would be fundamentally flawed and deficient if it omitted this option.

The implementation plan for the PEIS should include these two items.

1484

COMMENTOR NO. 60: EDMONDS, ROBERT F., JR. OAK RIDGE, TENNESSEE

Author: Robert F Edmonds Jr

Subject: Comments on"Programmatic Environmental Impact Statement for

Following are the comments of Duke Engineering and Services Inc. (DE&S) on the draft PEIS dated December 1997.

1. Volume I, Page S-3: We agree that conversion of the UF6 to U3O8 is the safest next step. This step can and should be initiated soon. The PEIS provides no compelling reason not to proceed with this step. There are abundant safety and environmental reasons, as documented in the PEIS, why continued storage as DUF6 is not the best alternative. Further, conversion to U3O8 does not preclude reuse of the depleted Uranium in the event national defense needs dictate or reuse options are ultimately proven cost effective. *60-1*

2. Cost Analysis Report, Paragraph 4.1.2 Treatment of Emptied Cylinders: The PEIS Cost Report assumes that empty DUF6 cylinders are crushed and sent to DOE facilities for disposal. There is no cost associated wiht disposal. This appears to be a completely unsupported assumption. There will be a cost, possibly a substantial cost, associated with disposal of the empty cylinders. They could be contaminated and require special handling. *60-2*

3. Cost Analysis Report, Paragraph 2.4.2 Use as Uranium Dioxide in DUCRETE for Shielding Applications: Report discusses the conversion of DUF6 to UO2 which in turn would be used to make DUCRETE. It should be pointed out that conversion of DUF6 to U3O8 and then to DUCRETE is an equally acceptable option. *60-3*

4. Cost Analysis Report, Paragraph 4.2.2 Revenue from Sale of Byproduct AHF and CaF2: This paragraph, as well as the PEIS Volume I, speak about sale of AHF byproduct. It should be noted that there is also a market for Aqueous HF. It is an equally acceptable option to make and market Aqueous HF. *60-4*

Thank you for the opportunity to comment. Please adress any questions on these comments to Bob Edmonds at the below address.

Robert F. Edmonds, Jr.
Manager, Oak Ridge Office

1485

COMMENTOR NO. 61: BARCLAY, MIKE & JANASKIE, MARK OAK RIDGE, TENNESSEE

Name: Mike Barclay, Mark Janaskie Organization: DPRA, Inc.

Date Sent: 4/23/98

Document Ref.: PEIS: DUF6 PEIS OVERALL CONTENTS

----- COMMENT -----

Comments on the UF6 PEIS QUESTION:

The preferred UF6 management scenario presented in the PEIS carries with it a huge price tag. As such, would funding availability create performance uncertainties for DOE that need to be acknowledged? Specifically, will the funds to begin conversion be available in the amounts needed to initiate large-scale conversion efforts by the year 2009? Will annual funding be available in sufficient amounts to support conversion of the entire inventory within the expected year conversion period? Both questions point to temporal uncertainties that have a bearing on DOE's strategy for interim storage and maintenance of UF6 cylinders. Lesser amounts of funding would require longer - potentially much longer - storage, and a much greater emphasis on the corrosion protection and reconditioning of UF6 cylinders. As best we can discern from the PEIS and from discussions at the public hearings, DOE's strategy for UF6 cylinder corrosion control s to paint the cylinders with the worst corrosion. Perhaps inherent in this strategy is the idea that conversion efforts will start soon enough (e.g. 2009) and will conclude quickly enough (e g. 2029) that a larger number of cylinders do not need reconditioning to prevent additional corrosion. Is this generally accurate as to DOE's underlying strategy? How many cylinders does DOE anticipate painting at the three sites? It is our understanding that corrosion coatings from paint will last about ten years. Other corrosion protection options, although slightly more costly initially, offer much longer corrosion protection. Specifically, thermal spray coatings provide 30+ years of corrosion control, and offer other significant advantage including dramatic cost savings potential when life cycle costing is factored into total cost considerations. Has DOE factored life cycle costing into its decision making regarding the choice of paint over other coating options? Why did DOE choose paint as a preferred coating choice? *61-1* *61-2*

QUESTION: As stated in the PEIS, DOE's preference is to convert the entire inventory of UF6 material into usable products. Given the large volume of UF6, it is unclear whether a correspondingly large market demand exists for products arising from the conversion effort. Has DOE conducted a thorough market analysis (applications, demand) for UF6 conversion products? If so, please describe the results of this analysis, and an estimate of the percentage of the inventory for which definable, cost-effective usages exist? *61-3*

QUESTION: Given that there appears to be a limited market for the converted uranium oxide *61-4*

COMMENTOR NO. 61: BARCLAY, MIKE (CONT'D.)
OAK RIDGE, TENNESSEE

(at least based on current information), what will happen to the remainder of the UF 6 stockpile? In terms of program management, it seems certain that the remainder of unconverted UF6 will become a waste (per U.S. EPA regulations), and therefore will likely be transferred to DOE's EM program. Given this scenario, is there an integration of efforts currently taking place between DOE programs to address this kind of future scenario? In addition, have there been any discussions between DOE programs as to how the waste would be formally transitioned into the EM program? Also, given the transition of UF6 as waste into the EM program, is there an existing remediation/cleanup fund established to manage UF6 as waste material? *61-4 (Con't.)*

QUESTION: The PEIS states that there is a very substantial cost associated with transferring the non-conforming cylinders to a central location for conversion. The actual reference case stated in the PEIS estimates this cost at more than $800 million. Of that $800 million, approx. $161 million is for what DOE terms "overcontainers". Given that reference case in the PEIS, we would appreciate responses to the following questions:

1.) Has DOE looked at other options to "re-engineer" the non-conforming cylinders for transport/shipping, so as to eliminate the need to employ overcontainers?
2.) Is there an actual U.S. Dept. of Transportation regulation/requirement to use overcontainers for the UF6 cylinders? If so, what is it?
3.) Has the DOE held discussions with the U.S. DOT to discuss the requirements for shipping non-conforming cylinders? If so, is this what DOE based its $161 million overcontainer estimate on in the PEIS?
4.) Using the DOE reference case of $161 million for overcontainers, what is the true unit cost per cylinder for transporting the non-conforming cylinders to a central location for conversion?
5.) Does the term "overcontainers" mean the same as "overpacking", as in waste operations? *61-5*

QUESTION: We understand at the Nevada Test Site (NTS) has recently changed its Waste Acceptance Criteria in the last year or so, so that it can receive more DOE waste for disposal. Given the scenario that DOE determines that UF6 conversion is not economically feasible or prudent, would anything prevent the DOE from sending the UF6 waste to the NTS for disposal, or even interim storage (retrievable storage) prior to DOE developing a better, more economically efficient method to convert theUF6? *61-5*

1486

COMMENTOR NO. 62: ROSS, WAYNE A., & HAASS, MATHEW, P.E.
RICHLAND, WASHINGTON

COMMENTS ON THE DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

BY
Wayne A. Ross, Staff Engineer
Pacific Northwest National Laboratory
And
Mathew Haass, P.E.
Geosafe Corporation, Richland, WA
04/23/98

The following comments represent those of the authors and are not official comments of Battelle PNNL or Geosafe. They result from our continuing interest in the adoption of a lower-cost, long-term management strategy for the depleted uranium hexafluoride (UF_6).

We have previously provided information on the Molten Glass Reactor (MGR) Process for the single step immobilization of the uranium hexafluoride. Attached is a copy of the material previous provided in 1995 and 1996 on this process. This process has a factor of at least two lower cost than those included in the EIS. It should also have less environmental impacts. This option was not identified or considered in the EIS and is not within the bounds of the EIS for cost or for impacts. Therefore the EIS failed to consider a reasonable, technically feasible, cost-effective and environmentally favorable alternative for the disposition of the deleted UF_6. *62-1*

We recognize that additional work will be needed to verify the process, but as was stated in the Summary of the Cost Analysis Report Section 3.0 "Most technologies would require significant engineering development." Thus the MGR process with the previous developments for high-level and mixed waste vitrification and the development of the In-situ-Vitrification Process (ISV) would make the state of development superior to many of the other proposed alternatives. Thus, the lower state of development of the MGR process is not a sufficient reason for omitting it from consideration. *62-2*

The MGR process would be generally consistent with the intent of the preferred alternatives "use of the material." The MGR process would place the uranium in a high concentration in a vitreous state near the earth's surface, thus providing the opportunity to retrieve and reprocess the material as a very high grade ore, if in the future there is a need for depleted uranium. At the same time, the uranium has very low availability to the environment, as the vitreous waste form provides very good containment of the uranium. *62-3*

The "disposition of other alternatives" in the engineering analysis documents (section 4.5) stated "Another possible suboption is vitrification, in which depleted uranium oxide would be enclosed in glass. The basic technology is developed (for disposal of high-level radioactive waste), but other types of waste preparation are generally preferred for depleted uranium. Vitrified waste would require more space for disposal. In addition, a vitrification facility would be more complicated and costly to build and operate than a cementing facility." These statements to dismiss the alternative, while possibly applicable to a stand alone vitrification processing facility that would incorporate the waste into glass in canisters for disposal, are not applicable to the MGR Process and therefore the MGR process does not qualify for exclusion based on it. The MGR would have lower disposal area requirements and lower capital and operating costs that any of the proposed facilities *62-4*

We are very interesting in developing additional information about the MGR Process. If you would like additional information please contact us.

The following are additional comments from our review of the document:

1 There does not appear to be a strong basis for the preferred option. All alternatives have similar impacts and costs. *62-5*

2 The PEIS Summary document should contain a discussion of the various life cycle cost of the alternatives. *62-6*

COMMENTOR NO. 62: ROSS, WAYNE A., & HAASS, MATHEW, P.E. (CONT'D.) RICHLAND, WASHINGTON

3. The use of discounted cash flow, while technically justifiable, obscures the actual costs for the various processes. I have not seen many DOE projects where the costs have decreased with time. They nearly always increased. Discounting at a rate of 7% makes major operating costs in the out years very small and meaningless. A constant dollar basis is more meaningful, but probably still optimistic. 62-7

4. The projection that all of the materials will be used seems highly speculative. I did not identify in the draft how all the uranium would be used. An accounting of the use of the materials should be included in the final EIS. The accounting could identify future uses currently unidentified. Some order of magnitude calculations give the following results. Page H-10 indicates that 933 casks would be produced for 20 years for a total of 18,660 casks. I don't think there is sufficient uranium to produce that many casks based on other information. The current forecast (DOE/RW-0006 Rev 12, page 23) indicates that there will be less than 90,000 MTU of commercial sent fuel. If one uses the Multiple Purpose Cask (MPC) as the model cask, then each cask will hold 11 MTU. Thus, if all the spent fuel was to be shipped in MPC, about 8200 shipments is all that would be needed. It seems unrealistic, however, that all of the fuel would be shipped to the repository in single use casks. It would be far more economical for reactor operators to use reusable casks that can be use for 100's of shipments. Thus the use of most of the inventory for casks seems unrealistic and the preferred alternatives basis that all materials can be used is high speculative. Your position would be greatly strengthen if you had some statements from DOE-RW that they were planning on using the uranium for this purpose. With respect to the Hanford SNF in K-Basins there has been serious concerns expressed about the present of uranium mental in the repository. Further, we anticipate that the use of uranium as counter weights would not be highly regarded by industry, when they found the needs for radiation monitoring and inventory control were necessary. This leads us to the conclusion that a significant fraction of the materials will need to be processed and disposed. The MGR being a modular process could accomplish this very effectively and could be implemented in a relatively short period of time. 62-8

5. It was interesting to note that one of the major hazards identified was the shipment of HF. The MGR process converts the fluoride to calcium fluoride and dissolves it in the glass structure thus eliminating the HF hazard. It also means that there is only one transportation operation in the MGR process further reducing transportation impacts.. 62-9

6. The concentrated form of the final waste form requires less land space that other options since all of the uranium could be disposed in an area about 1200 ft by 1200 ft (33 acres). Note this is less than the disturbed area for one cask manufacturing facility (36 acres). 62-10

14487

COMMENTOR NO. 62: ROSS, WAYNE A., & HAASS, MATHEW, P.E. (CONT'D.) RICHLAND, WASHINGTON

Attachment

TREATMENT AND DISPOSAL OF UF_6 BY A MOLTEN GLASS REACTOR

Wayne Ross, John Tixler, and Xiangdon Feng
Pacific Northwest Laboratory[1]

SUMMARY

An economical method for the treatment and disposal of uranium hexafluoride (UF_6) has been conceived and is described in this proposal. The method would react the UF_6 within a large molten glass reactor (MGR), which would leave the uranium in moderate concentration in a highly stable glass form in a disposal site. The large processing capacity, minimal need for processing chemicals, and low operational labor should make the process very cost-effective. Order-of-magnitude estimates indicate that it will cost less than one-half of previous estimates, which only included costs to convert the UF_6 to UO_2 without considering disposal costs. The process could be implemented in phases using the mobile equipment so large capital expenditures for treatment facilities are not needed. This enables processing of the most hazardous fraction of the current inventory in the near term, in concert with recent recommendations of the Defense Nuclear Facilities Safety Board. The needs of the associated development program are identified.

BACKGROUND

Uranium hexafluoride has been accumulating for 40 years at the nation's enrichment facilities. The national inventory is now of the order of 500,000,000 kilograms, with the largest inventories at Paducah and Portsmouth and a smaller inventory at Oak Ridge. The Defense Nuclear Facilities Safety Board has recently reviewed the situation and found increasing hazards for the continued storage of the tails as uranium hexafluoride and has recommended that DOE take several actions. Its recommendations include: 1) action to protect against the dispersal of large amounts of uranium to soil and groundwater in years to come, 2) an early start to remedial action should be planned and then instituted, and 3) a study be instituted to determine whether a more suitable chemical form should be selected for long-term storage of the depleted uranium. In doing this, the Board also recognized that it could be a massive problem with extraordinary financial costs.

A 1991 study done by Oak Ridge[2] on just the conversion of the material to UO_2 estimated that the cost would be about $1.3-3.1 billion. More recently, in a press release[3], M-4 Technologies estimated that the worldwide market for treatment of uranium hexafluoride tails would be about $6-10 billion. Thus, it is apparent that the costs for treatment and disposal of these materials could be a multi-billion dollar activity and opportunities to significantly reduce those costs should be vigorously pursed.

[1] Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO-1830.

COMMENTOR NO. 63: CRONIN, BILL & HARMON, MELINDA
CARBONDALE, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 63-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 63-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 62-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 62-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 62-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 62-6

Thank you for considering these comments.

Sincerely,

Bill Cronin
Melinda Harmon
95 Lonesome Rd
Carbondale IL 62901

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COMMENTOR NO. 64: MURRAY, ALEXANDER P.
GAITHERSBURG, MARYLAND

24305 Clematis Drive,
Gaithersburg, MD 20882,
April 21, 1998.

Charles E. Bradley, Jr.,
Office of Facilities (NE-40),
Office of Nuclear Energy, Science, and Technology,
U.S. Department of Energy,
19901 Germantown Road,
Germantown, MD 20874.

RE: Depleted Uranium PEIS:
DOE/EIS-0269, "DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE," (PEIS), dated December, 1997.

and its supporting documents:
UCRL-AR-124060, "DEPLETED URANIUM MANAGEMENT PROGRAM: THE ENGINEERING ANALYSIS REPORT FOR THE LONG-TERM MANAGEMENT OF DEPLETED URANIUM HEXAFLUORIDE," Rev. 2, Volumes 1 and 2, (EAR), dated May, 1997.

UCRL-AR-127850, "COST ANALYSIS REPORT FOR THE LONG-TERM MANAGEMENT OF DEPLETED URANIUM HEXAFLUORIDE," (CAR), dated May, 1997.

Dear Mr. Bradley,

Thank-you for the opportunity to review and comment on the Depleted Uranium Programmatic Environmental Impact Statement (DU PEIS). I find it to be interesting reading, having worked in and out of uranium-related programs for two decades. I find that the PEIS has over simplified and, in some cases, over-looked important facets of DU that have important implications for its management, and I feel compelled to comment on the subject for the record. My comments are attached. Summarizing, the comments are:

- Disposal and waste management are significant issues not well addressed in the PEIS. It is highly probable that a significant fraction of the DU - perhaps all of it - will end up as a radioactive waste, either as itself or in a reuse "product." It is not until well into the PEIS (Chapter 5) that the reader is informed that near surface disposal will significantly exceed 10 CFR Part 61 limits (for NRC/commercial facilities) and DOE limits for public doses. In other words, codified regulations will be broken. Also, mined cavity disposal, which may be a solution for DU, does not currently exist for LLW, and there are no current plans for mined cavity disposal of LLW in the U.S. 64-1

- Market demand does not and is not likely to exist for the reuse of DU, and the PEIS does not identify routes to build such a market. Currently, cost and liability are almost insurmountable hurdles for the "reuse" of DU, as its competitor for the (most likely) reuse scenarios (spent fuel shielding) is concrete. The use of DU shielding requires an integrated approach to minimize consumer, utility, and DOE costs, and DOE acceptance of DU liability (basically disposal). This implies that even for reuse scenarios, the DU form must be compatible with disposal. Myself and other authors have written on this extensively. 64-2

- No significant uses of DU currently exist in shielding applications. No licensed spent fuel casks use DU shielding, and there are no current plans or pending applications for spent fuel casks 64-3

COMMENTOR NO. 64: MURRAY, ALEXANDER P. (CONT'D.)
GAITHERSBURG, MARYLAND

using DU. DOE-RW has identified DU as a cost and machining disadvantage for spent fuel casks. The PEIS needs to openly state these points, and identify means to resolve them. Again, myself and others have written on this extensively.

- The analyses and alternatives are uneven and neither analyzed at comparable levels nor taken to equivalent endpoints. For example, all of the uranium oxides will perform differently. The gelation-produced uranium dioxide is equivalent to nuclear fuel in terms of high density and low porosity, and will have improved leach resistance, heat transfer, and sizing as compared to the other oxides (including the lower density uranium dioxide) - in short, it's a better material. Significant items have been left out of the analyses (e.g., disposition of shielding, rollup of disposal impacts, and protective action distance impacts on site sizes). There is no reconciliation between known technologies/impacts and those in the report - for example, the proposed uranium dioxide pellet furnaces used for analysis in the PEIS correspond to 100-200 teU/yr capacity, not the 7,000 teU/yr capacity claimed by the analysis. The same pellet technology also currently requires about 1 FTE/te/yr, not the 0.014 FTE/te/yr used in the PEIS. The conversion reactors (low number and large size) appear to be very optimistic. The gelation facility includes two plants (one to U3O8, and one to UO2), which is not consistent with the technology and explains why its impacts are slightly higher. The PEIS should recognize these shortcomings, limitations, and differences, and be more equivalent in its analyses. 64-4

- The limitations of the technologies should be recognized in the PEIS, and means identified to address them. Only the French conversion to U3O8 technology has been used on a scale approaching that needed for the PEIS, and it needed compactors to increase the density to circa 3 g/cc. To state that current pelletization technology is established for the throughputs and equipment used in the PEIS analyses is incorrect - the gelation route with VTF's has actually achieved higher equipment rates per unit floor area. 64-5

- Recent NRC positions in the area are not stated in the EIS, but are alluded to in the supporting documentation. The NRC (in a response to the FR notice and in a separate EIS) has clearly stated concerns about the lack of a use for the DU, the likely probability that a significant amount (if not all) of the DU will become waste, and the high probability that DU will require "deep disposal" because of unacceptably high MEI doserates from near surface disposal. Such significant conclusions by a regulator should be included and discussed in the PEIS. 64-6

- DU metal seems to receive a favorable treatment in the PEIS with impacts significantly below historical experience. This appears because some of the release fractions and impacts are underestimated significantly (beyond technological optimism). This should be corrected in the PEIS. 64-7

- Gelation technology appears to receive a less than favorable treatment in the PEIS, using TCE as a solvent instead of oil, tray instead of tube furnaces, and including a U3O8 production step, followed by nitric acid dissolution and UO2 production (the aforementioned two plants in one misrepresentation). While in the final analysis the difference is small, it is incorrect, and the PEIS should correct the misrepresentation. There are recent published articles (which you have copies of) that give a detailed description of gelation technology as applied to DU, and these should be used as references in the PEIS. 64-8

- Costs are not brought forward in the PEIS. Costs from the CAR and from published articles should be discussed and reconciled in the PEIS, as cost is likely to be a significant determinant in the DU disposition option selected. 64-9

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COMMENTOR NO. 64: MURRAY, ALEXANDER P. (CONT'D.)
GAITHERSBURG, MARYLAND

- DUSCOBS and PYRUC shielding materials are not discussed in the PEIS. DOE appears to have an interest in these materials, and they are likely to have better properties for disposal than either DU metal or uranium oxide in concrete. As such, they should be mentioned and discussed. 64-10

I hope you find these comments useful and incorporate them into the PEIS. If you have trouble finding any of the publically available articles, please let me know.

Sincerely Yours,
Alex Murray
Alexander P. Murray,
Private Consultant.

Attachment.

COMMENTOR NO. 64: MURRAY, ALEXANDER P. (CONT'D.)
GAITHERSBURG, MARYLAND

Comments:

a. Waste: In Section S.4.8 on page S-40, waste management impacts are discussed. DOE should consider briefly highlighting the potential uranium content of the secondary streams, along with a brief assessment of acceptability for either reuse/nonradioactive disposal or disposal as radioactive waste. DOE should expand the discussion in the last paragraph about uranium disposal as LLW. The DOE may wish to cite regulatory agency positions on the wastes, including the NRC position letter (from Benero) sent to DOE as part of this EIS process and the NRC LES EIS analysis. For example, the NRC documents provide analyses supporting DU disposal as a LLW, but note that its disposal could require a mine or another means of "deep" ("Non near-surface") disposal. Currently, no "deep" disposal sites exist, and all current LLW disposal sites (existing and planned) use near-surface facilities. Thus, it would seem that disposal of DU may have significant impacts and regulatory requirements beyond those listed in the PEIS. DOE should consider adding the cumulative impacts from DU oxide disposal to Section S.4.13 "Cumulative Impacts." 64-11

- Leach Rates - Page 2-22 briefly mentions leach rates and waste forms, and states that grouted wastes are representative of immobilized waste forms with low leach rates, with the implication that grouting is also representative of vitrification. DOE should clarify this text, as grouting may be representative for some parameters (e.g., facility size) but not representative in others (e.g., energy usage, emissions). Also, while grouting should provide for somewhat lower leach rates as compared to the ungrouted material, vitrification would be expected to provide for much lower leach rates than grouting (typically, 5-6 orders of magnitude less), and this may be an issue for some disposal options. Consequently, these items should be discussed. 64-12
- Empty Cylinders - The impacts from disposition of the empty cylinders are not included, although potential options are listed (page 2-23). It would seem reasonable to provide a brief discussion on these options and include impacts from cylinder disposition in the EIS. 64-13
- Water Impacts - The summary table of impacts (Table 2-2) and the supporting text for the water and soil section (page 2-50) note that the groundwater uranium concentrations will exceed drinking water guidelines. It is recommended that the expected concentrations are also expressed in terms of individual radiation doses. 64-14
- Waste - Pages 2-52 et seq present a summary of the waste management impacts from the impacts. Comparisons are primarily with the DOE waste management system, although these facilities could also be commercially operated under NRC or State regulations. Consequently, DOE should consider adding a comparison to commercial LLW generation rates and categorization per 10 CFR Part 61. The section mould also include estimated uranium levels for the magnesium fluoride waste (from DU metal production) and discuss the aspects of DU disposal, including the potential need for either a dedicated or a deep disposal facility. 64-15
- Dilution of Effluents - On page 5-51, the text indicates effluent levels exceeding EPA guidelines for uranium, but notes that the concentration would be much lower and below the guideline after dilution in nearby surface water. This should be clarified, and potential dose consequences of these effluents presented. 64-16
- Metal Waste - Page 5-76 of the PEIS presents waste management for the metal cask manufacturing route. Waste management appears to have overlooked secondary 64-17

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COMMENTOR NO. 64: MURRAY, ALEXANDER P. (CONT'D.)
GAITHERSBURG, MARYLAND

wastes related to manufacturing, which are unique to uranium metal. For example, induction furnaces for uranium metal are usually lined with graphite, which requires periodic removal and replacement (sometimes as frequently as every ten charges or so). Also, while the proposed approach appears to use primarily direct casting, some uranium metal machining operations may be required, and, historically, these generate significant wastes containing partially oxidized uranium metal. The PEIS should include these potential impacts that primarily affect only the metal route. 64-17

Doses from DU Disposal: Section 5.6 (pages 5-78 at seq) and Appendix I present the impacts from disposal of the DU, for both the operational phase and the post-closure period. The radiological impacts from the accidents seem unexpectedly high; for example, the analysis shows public doses of up to 1.1 rem and noninvolved worker doses as high as 140 rem, apparently due to earthquake initiated events, without explanation. The routine impacts also seem high for the postclosure phase and appear to follow the radiological order: mine impacts>vault impacts>trench impacts. Calculations appear to use an infiltration area effect and do not account for chemical form, solubility, and kinetic effects. Table I.31 contains zero values for the dry site doses fc. all three disposal approaches, and no collective dose estimates are included. These points are non-obvious and it is recommended that they are explained in more detail. 64-18

b. Unspecified Applications: On page S-11 and later in the summary (pages S-42 at seq), DOE identifies the preferred alternative strategy as use of 100% of the DU hexafluoride inventory, as either uranium oxide, uranium metal, or a combination of both, without specifying the use of the material and the potential impacts (positive and negative) from such DU use. The PEIS also does not provide information indicating a market demand capable of consuming 100% of the DU inventory, but the conversion of the DU hexafluoride would occur as "... uses for these [uranium oxide and metal] products become available" (page S-43). Without applications for significant quantities of DU oxides and metals, these DU materials may ultimately become a waste material. The discussion does not discuss regulatory and licensing requirements for these DU applications. It is recommended that (1) DOE identifies the likely market consumption of DU oxides and metals over the timeframe of the EIS, (2) DOE estimates the impacts from these potential DU uses, (3) DOE considers the potential of the converted DU materials becoming a waste, thus, requiring conversion into forms compatible with disposal, and (4) DOE evaluates the likely regulatory and licensing aspects. 64-19

c. DU as Cask Shielding: DOE appears to be relying upon the potential future use of DU as SNF cask shielding for a large consumption of its DU inventory (see page S-43 and 1-8, and Volume 2 of the EAR, which analyzes a DU cask manufacturing facility as the only use of DU). If this is indeed the case, DOE may wish to describe and discuss it in a little more detail in the PEIS summary and in Section 2.5 (pages 2-54 et seq), and it should be noted that no currently licensed or planned SNF cask uses DU. 64-20

d. Fate of DU Shielding: As currently written, the PEIS does not include a discussion of the eventual fate and potential impacts of the DU SNF cask after its use (e.g., see pages 2-14 and 64-21

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2-15). Pages S-55 and S-65 also mention that DU cask disposition after use is excluded, and page S-65 notes that disposal would amount to an additional 180,000 cubic meters (6.4 million cubic feet) of waste requiring disposal, with a (calculated) average specific gravity of 2.2. This does not seem inconsequential, particularly if a dedicated disposal facility is required and the impacts are estimated to be similar to disposal (e.g., page S-83 et seq; exceeding 10 CFR Part 61.41 dose limits). Also, there are statements in the document that question if significant quantities of DU metal are suitable for disposal (e.g., last paragraph on page 2-21). Inclusion of a discussion about the disposition of the DU cask after use, and potential impacts, is recommended. *64-21*

e. "Uranium Oxides." The PEIS generally combines all uranium oxide compounds under the title "uranium oxides" for consideration in the alternatives and strategies (see page S-6 et seq). This seems too all inclusive, as uranium oxides have significantly different chemical and physical properties that produce a wide range of ES&H impacts. For example, uranium octaoxide is a high porosity powder, with a low density and a significant respirable fraction. Uranium dioxide powder is also porous, and can spontaneously ignite in air. On the other hand, sintered uranium dioxide has the highest density of the uranium oxides and is essentially pore free. The presence (or absence) of pores also has significant implications for the potential disposal of the material, either as a management option or as an end-use item; a denser, essentially pore free material would appear to be advantageous. Thus, a uranium dioxide material sintered to a lower density (say, 4-5 g/cc) would not be expected to perform as well in a disposal environment as a uranium dioxide sintered to a high density (say, 9-10 g/cc). It is recommended that more qualifiers are given to the term "uranium oxides," perhaps including low and high density as the principal discriminators. *64-22*

f. Equivalent Bases and Life-Cycle Effects: The text does not seem to incorporate a life-cycle approach to the different management alternatives and compare them on an equivalent basis (see pages S-7 et seq). For example, recycle (if a market exists) and disposal would seem to be the logical endpoints for all of the alternative branches shown in Figure S.2, and may influence the impacts and potential alternative(s) selected. However, disposal is only shown for the disposal as oxide alternative. It would seem that the "manufacture and use" alternatives will ultimately result in impacts from the DU component; for example, the material (perhaps as itself or in a product) could be shipped to a disposal facility. Such potential impacts do not appear to be included in the analysis, and may even preclude some options or require additional conversion and conditioning; for example, without supporting analyses, it is unlikely that significant quantities of DU metal can meet the regulatory requirements of disposal sites. Thus, pursuit of use as a metal option may require another conversion facility (with its impacts) to convert the DU metal into a form compatible with disposal. Other examples of the need for equivalent bases include the oxide conversion routes, due to fundamental differences in the uranium oxide forms. One of the specific oxide conversion routes (gelation) appears to be manufacturing uranium dioxide with properties comparable to high density nuclear fuel which would be anticipated to have improved stability and related properties as compared to the other oxides. The gelation route also appears to include two plants - one for uranium octaoxide production and one for dissolution/uranium dioxide production - which appears inconsistent with literature reports on the process (i.e., only one plant; no production of uranium octaoxide) and *64-23*

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the other oxide conversion routes. Long-term storage also appears to lack the realization of ultimate disposal in the future. The PEIS should consider and analyze the alternatives on an equivalent basis with the same/comparable endpoints and include life-cycle effects.

g. Results: Pages S-15 et seq summarize and compare the results of the impacts for the alternative management strategies. Some of these results seem inconsistent and are not intuitively obvious. For example, it is not clear why the use as uranium oxide results in higher impacts than the use as uranium metal (see pages S-20 and S-49) - the opposite would be anticipated. Land use impacts seem uneven; conversion and metal use plants would be anticipated to have larger land use because of facility size and require potentially larger setbacks for potential accident mitigation from uranium releases (see the NRC LES EIS). It is not clear if the disposal analyses include all of the potential long-term impacts and doses from uranium leaching from the disposal area. It is recommended that DOE consider greater consistency in the results and clarify the summary. *64-24*

h. Ranking: The summary of the results (page S-15 et seq) does not include a ranking of alternatives, and implies that all of the alternatives are acceptable. DOE may wish to rank or identify those alternative(s) that appear more favorable than others based upon the analysis. DOE may also want to consider if any of the proposed alternatives are precluded by the analysis; for example, page S-84 mentions individual (groundwater ingestion) doses of 100 mrem/yr from disposal, thus exceeding 10 CFR Part 61 standards of 25 mrem/yr. Page S-84 also mentions a scenario for a hypothetical future resident living on the disposal site and receiving radiation doses as high as 10 rem/yr. The PEIS summary also mentions an NOV on storage at the Portsmouth facility, which might imply that a no-action alternative is not a viable option for this site. *64-25*

i. Technology and Equipment Development: The PEIS encompasses numerous technologies that are at different stages of development, in terms of process, understanding, equipment, (potential) impacts, and uncertainties. For example, of the conversion, application, and disposal impacts discussed within the summary, none are practiced on any scale domestically, and only conversion to the octaoxide is practiced on a large scale internationally, producing a low density product. Thus, there is only one direct analogy. DOE should consider including a technology discussion, with status and assessment, perhaps with either a time schedule or probability of success, for some of these technologies. For example, it seems like a significant extension of existing uranium dioxide sintering technology to take pellets from 100 te(U)/yr/line to 7,000 te(U)/yr/line. From the uranium dioxide technology perspective, microspheres (e.g., from gelation) may be the more mature technology because of the (potential) use of tube furnaces and pilot plant tests with equipment processing rates an order of magnitude larger. Similarly, a uranium dioxide/concrete cask approach appears to be a significantly easier technology to understand and scale than casting a 40 te(U) metal shield. *64-26*

j. Existing Facilities and Experience: There are obvious analogies with existing, commercial fuel cycle facilities, which process uranium hexafluoride into uranium dioxide (for nuclear fuel) and

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(to a lesser extent) uranium metal. These facilities are already licensed by the appropriate regulatory agencies. The PEIS does not mention these facilities, either as a source of experience or as a source of processing capacity, particularly during the development of uses for the DU materials and as a means for surge capacity. The PEIS also does not appear to draw upon the operating experience of these facilities, including waste generation and uranium content of byproducts. DOE may wish to include the experience of operating commercial facilities and comment upon their potential use (or non-use) during the development of applications and uses for the DU. 64-27

k. Regulatory Basis for Future Facilities: The PEIS indicates several facilities may be involved for the management alternatives, and may involve DOE, commercial, and/or both types of facilities. DOE should briefly discuss the regulatory bases for these facilities, potential differences (if any), and any impacts, and any effects from facilities transitioning from DOE to the NRC regulatory environment. 64-28

l. Economics: The PEIS mentions a separate Cost Analysis Report (CAR) as providing input to the PEIS (e.g., page 1-7). However, program costs do not appear to be included in the analyses. DOE should consider including the costs and other economic impacts in the PEIS, perhaps as part of the summary (e.g., in Table S-2). 64-29

m. DU Quantities: The insert on page S-2 identifies some 46,422 DU cylinders distributed between the three sites. While the total quantity is listed in the main text of the report, it would be helpful to have the approximate masses (as either MTU or MTUF6) for the three sites listed in the summary as well. The insert on page S-2 also notes that an additional 6,000 cylinders have been produced by USEC. It is suggested that this number is also divided between the sites and expressed in mass quantities. It is also recommended that a brief discussion about the USEC DU is included, perhaps as part of the first paragraph on page S-4. While the EIS excludes the USEC DU from its analysis, it also implies that there is a reasonable probability of it becoming DOE's responsibility. Consequently, DOE may want to consider that possibility in its impact analysis. 64-30

n. Other DU Uses: Page 2-21 mentions non-shield use of DU. No mention is made of quantities or relative percentages of the DU inventory. Also, it is not self-explanatory that DU cask manufacturing and uses bound all of the potential uses; for example, metal uses would appear to require a significant amount of alloying and/or machining, and involve handling and disposal concerns. DOE may wish to include a longer discussion and a better explanation. 64-31

o. Other Sites: Pages 3-56 et seq present information on the generic sites for wet and dry locations, and mention that the site data for each are derived from actual wet and dry sites. It is suggested that the actual sites which provide the basis for the generic locations are listed. 64-32

p. TimeFrame: Page 4-2 lists a 41 year time period for the EIS (through the year 2039), and

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indicates activities beyond 2039 would be subject to appropriate NEPA reviews and decisions in the future. This appears to truncate the analyses for some of the alternatives which might influence the selection of the preferred option; for example, impacts from wastes in a disposal cell are unlikely to occur by 2039, major cylinder/container replacements may be required for the storage option in the 10-20 years after 2039, significant applications may not have developed etc. DOE may wish to consider a time period consistent with the logical conclusion of the options or their "life-cycle," which may require a timeframe beyond 2039. 64-33

q. Failure Rates: Pages 5-3 and 5-19 discuss the estimated cylinder failure rates for the No Action and UF6 Storage alternative. These appear to use the opposite ends of the failure rate range - No Action uses the lowest failure rate, while Storage uses the highest failure rate - without explanation. Also, the existing cylinders may not have adequate wall thicknesses under either alternative due to corrosion over the years (see Appendix E), and the DU may have to be transferred to new cylinders within the timeframe covered by the EIS. DOE should consider presenting a discussion on these items in the text. Also, on page 5-40, Table 5.4 lists tank rupture accidents as "incredible" events. Usually, these are assigned a value corresponding to the "extremely unlikely" frequency bin. A brief discussion is recommended. 64-34

r. Site Sizes: Page 5-55 identifies land use requirements for the facilities. These seem small, particularly when compared to other proposed facilities performing similar operations (e.g., the LES EIS analyzes a generic conversion facility with a site area of 1,000 acres). The text also does not indicate if any major setbacks, protective action distances (PAD's), or planning zones are likely to be needed around the facility because of the handling of large quantities of DU, the hexafluoride, and/or the metal (including melting operations). DOE should consider a discussion in the text on these subject matters. 64-35

s. Accident Consequences: Pages 5-55 et seq discuss the use and impacts of uranium dioxide as shielding, and pages 5-66 et seq discuss the use and impacts of uranium metal as shielding. Some of the values imply non-intuitively obvious lower impacts from a metal route as compared to the oxide route; it is recommended that these are discussed and explained in more detail. For example, the text on page 5-71 estimates the highest consequences from an accident with the metal route as 15 mrem (from a fire involving three cylinders, an energetic accident with reactive materials), as compared to 270 mrem (from an earthquake during uranium dioxide storage, a low energy event with non-reactive materials) - there is no explanation for the difference. Also, the supporting information in Appendix H shows similar inconsistencies; the unlikely accidents for the oxide (Table H-5, page H-16) are significantly higher than the corresponding accidents for the metal (page H-17). Page H-17 also contains apparent inconsistencies and incongruances; the mishandling/dropping of solid DU metal accident releases a greater quantity of uranium than the molten uranium accidents. Upon further review, the source of these apparent anomalies goes back to Section 6.11 of the EAR, where different material at risk and release fractions were used. All of the metal cases examined used the least bounding values, and values inappropriately low for the phenomena being modelled per the DOE accident handbook. These errors should be corrected. 64-36

UNIVERSITY OF MARYLAND
AT BALTIMORE

UNIVERSITY PROGRAM IN TOXICOLOGY

April 21, 1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874

Dear Mr. Bradley:

Enclosed are comments on the Department of Energy's "Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269). Thank you for the opportunity to comment on this PEIS. We would appreciate being kept informed as this work progresses. If you have any questions regarding our comments, please feel free to contact either Mr. Ted Henry or myself at 410-706-8196.

Sincerely,

Katherine S. Squibb, PhD
Associate Professor

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(CONT'D.)
BALTIMORE, MARYLAND

Comments

on

The Department of Energy's Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride

By:
Theodore J. Henry, MS
Katherine S. Squibb, Ph.D.

CHAPP Center
Program in Toxicology
University of Maryland, Baltimore
April 20, 1998

COMMENTOR NO. 65: UNIVERSITY OF MARYLAND (CONT'D.)
BALTIMORE, MARYLAND

Comments on the Department of Energy's
Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride

The Department of Energy's (DOE) Draft Programmatic Environmental Impact Statement (D-PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride (DU-HF) is lacking with respect to it's assessment of the long-term impacts of converting and using DU-HF. A review of the summary clearly depicts DOE's strong interest in utilizing this stockpile, but the supporting evidence does not adequately address the legitimate environmental concerns associated with DU use - concerns which are based on a growing body of scientific data. While the summary presents a clear picture of DOE's commitment to provide "support for the development of applications for depleted uranium products," it does not, and with our current knowledge probably cannot, adequately assess the current extent of environmental impacts at the three DU-HF sites. In turn, it cannot assess what impacts to the nearby communities and the local environment will result from future releases of the evaluated alternatives. Without better scientific knowledge of the toxicity of DU, it is impossible to provide even a guess of the potential impacts, which makes the risk projections provided within this summary of little value. As a result, we support the long-term storage of this material, with improved containment and monitoring, until we are better equipped to assess the toxicity and safe uses of the DU stockpile. 65-1

Up front, it should be noted that our limited resources only allowed us to review the summary and not the entire PEIS. Thus, we acknowledge that some discussion within the body of the PEIS itself may address a few of the concerns raised in the comments that follow. We believe that it is acceptable for us to comment based solely on the summary, as this is the main document likely to be reviewed by the commenting public. We hope that these comments are still useful for DOE and we request that these comments be considered with the utmost diligence.

Current Storage

Significant concerns exist with current storage conditions based on the fact that cylinders now show evidence of corrosion and that at least seven cylinders have developed breaches. While the management plan in place is to "continue safe storage," it seems to be in question whether safe storage is currently taking place. This is supported by community concerns that have been expressed from around the sites, and the Notice of Violation that has been issued by the Ohio Environmental Protection Agency. We assume that the Defense Nuclear Facilities Safety Board has suggested improving both inspection time tables and storage approaches. 65-2

While the summary explains that a dense plug is formed by the reaction of moist air with the exposed DU-HF, the summary does not address if any studies have been made to assess the adequacy of such a plug. Certainly, this plug may not be air tight, allowing additional moisture to enter the container thereby acting as a continued source of HF gas. It would seem prudent for DOE to develop a better storage system regardless of the decision to use or store these cylinders. Either way, many 65-3

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of these containers will still house DU-HF for years or decades to come, and will require improved storage capabilities.

Assessment of Risks

While the summary lists various technical assessments that have been or are being conducted, none of these studies nor this PEIS really assess the potential environmental impacts from the current production and storage operations or the proposed alternatives. This flaw has been seen in PEISs produced for other purposes by DoD, where the PEIS selects a direction to focus development dollars, but does not consider the specific technologies that may be employed and does not consider the site-specific characteristics. In the end, such factors will strongly influence the extent of contamination and impacts from the general approach (i.e. use as oxide) selected. Once the process reaches the point where these specific factors are assessed, there will be serious pressures to make the approach work given the time and financial investments made. This limits the adequacy of the site-specific assessments when they are made. In turn, we strongly suggest that DOE take a serious look at the potential risks from converting DU-HF and its use an oxide or metal before one selects a programmatic alternative. Factors that should be considered in this evaluation are the migrating potential of DU that will be released, the cumulative impacts of such releases in conjunction with pre-existing contamination, and the potential impacts on costs of the selected approach when the toxicity of such compounds are elucidated. 65-4

Affected Environment

The summary sorely lacks a description of the environmental sampling that has been conducted at each site. In the case of Paducah, Kentucky, it is mentioned that the effluent discharges are regulated under Kentucky Pollutant Discharge Elimination System, but there is no discussion of whether radiological parameters and/or uranium metal are monitored in this system. While the specifics of such a monitoring program may be beyond the scope of this summary, whether or not environmental sampling from Big Bayou and Little Bayou Creeks has been considered in selecting the proposed alternative is relevant and critical. The extent of contamination in surface water and sediments is a significant issue, since future activity will add to the levels already present even if future emissions do not exceed the governing release limits of the time. There is no discussion of such sampling, and there clearly needs to be in order to determine the current baseline risk level at the site, both for human health and ecological receptors. The potential exposure pathways (see below) and current ambient levels are important for projecting future exposure scenarios. 65-5

As with the Paducah site, there is no mention of the current extent of contamination in local media at the Portsmouth site in Ohio. Assuming significant contamination is already present as suggested by the groundwater data that are referenced, would it affect the feasibility of the selected alternative if it were deemed necessary to conduct such operations at other sites? This question requires serious consideration, particularly since the conversion technology to be used to produce the oxide or metal is not assessed in the D-PEIS. If contamination is approaching environmental limits, then even the expected discharges may not be acceptable. As with any Brownfields site, the investor 65-6

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BALTIMORE, MARYLAND

(DOE in this case) certainly should want to know whether they will be able to conduct operations at the site or nearby (as suggested on S-14), requiring adequate site characterization. From the description of environmental settings, it is unclear whether the environmental data on the natural environment are limited to climatic conditions or if the site specific environmental data includes current contamination levels. 65-6 (Con't.)

Exposure Pathway Assessment

In Table S-2, the chemical exposure of concern for both the non-involved worker and the general public is listed as falling below a hazard index of 1. Did the calculation of such risks include all the pertinent exposure pathways which may apply, including fish/game consumption, drinking water, inhalation, etc? It would be inappropriate to consider just the workplace exposure for the non-involved worker, if that person lived nearby and fished in the local stream. In predicting future impacts or risks, one must consider the individual's total exposure. This has been a serious flaw within risk assessments at Superfund sites, and improving this approach is not unreasonable to request given that 1) this is a "looking forward" assessment which allows us to be more protective since the contamination has not yet been produced, and 2) we are still unable to adequately assess other parameters, such as synergistic effects, which do reduce the conservativeness of the risk projections being made. 65-7

Toxicity of Uranium

Based on the limited research that has been completed on the toxicity of uranium metal, it seems quite premature to be selecting an alternative in this PEIS for the next 40 years. In light of the ignorance with which the Department of Defense exposed Gulf War soldiers to DU, DOE should strongly consider whether it wants to make the same short-sighted mistake. We have been intensively studying lead for decades and we are still learning more everyday about its toxicological effects and the low levels at which such effects are exerted. We are still trying to recover from the use of this metal in paint and gasoline, which is a direct result of our inability or disinterest in predicting environmental accumulation and the resulting impacts if the compound turned out to be toxic. As a society, we must not make the same mistake again by blindly pursuing commercial use of the DU-HF stock. 65-8

Given the extensive research currently underway regarding DU, it does not seem appropriate to be completing this PEIS at the present time. Research at the Armed Forces Radiobiology Research Institute suggests that DU may be more mutagenic than lead, and that this metal can reach the brain and fetuses of exposed animals. Additionally, work is currently being conducted on exposed Gulf War veterans at the VA Hospital in Baltimore, Maryland, which may provide valuable information on the distribution of DU within the body and possible impacts on specific organ systems in humans. It would seem logical to learn from our mistakes and select long-term storage until we are better able to assess potential human health impacts from its toxicity as well as its radiological emissions in localized lung tissue. 65-9

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Until the results of these various investigations are published and reviewed by the scientific community, we cannot know if the projections of adverse effects are accurate. The chemical toxicity of low level DU exposure does not seem to have been adequately considered. The monitoring of effects in soldiers is still in progress, so we question statements describing how "a few workers have been exposed to estimated amounts of uranium approximately three times the guideline levels used for assessing irreversible adverse effects, but none of these workers actually experienced such effects." The effects used to establish the guideline values do not include low level, chronic effects of DU just now being recognized. 65-9 (Con't.)

Release and Environmental Fate

Predicting the extent of release and long-term fate of the DU released during its conversion and subsequent use should be meticulously evaluated. On page S-42, the authors state the "potential uses that are capable of consuming a substantial fraction or all of the depleted uranium inventory are not yet fully developed, and it is entirely possible that the 100% use scenario may involve some of the material being converted to an oxide and used, with the remaining portion being converted to uranium metal and used." Without reviewing the specific industrial processes to be implemented in the conversion and use alternative, it is impossible to accurately assess how much DU would be released. This is a serious issue since other industrial sites have been closed down due to the excessive release and migration of DU. This quote also reveals that little is known about what commercial applications will exist for the converted material. Despite these unknowns, the PEIS clearly reflects an entrepreneurial eagerness by DOE to utilize the stock in this fashion. This assessment of the summary is further supported by a statement on the following page in which the authors indicate that "this preferred alternative allows flexibility in responding to changing market conditions and to the continued development of new uses for conversion products." We question whether this is appropriate, as the conversion process may be pushed forward without a clear plan and understanding of its eventual use. This, in turn, will evoke significant pressures to find a use for the oxide or metal and likely reduce the quality of the decision process used to determine acceptable use. 65-10

Ecological Impacts

The consideration of ecological impacts in the summary is limited. A full paragraph discusses the loss of habitat resulting from carrying out particular alternatives. However, no concrete information is provided regarding the chemical effects of elevated uranium concentrations on ecological receptors, although the potential for such effects is mentioned. While few data exist for specific ecological impacts, a study by Los Alamos on the long-term fate of DU found significant concentrations in various aquatic plant species as well as aquatic organisms such as tadpoles. Detritus, benthic diatoms and phytoplankton were predicted to contain the highest levels of DU in the environment, and the impacts of the conversion and use alternative on these important parameters of the food chain should be considered. In short, an adequate assessment of the data that do exist should be made, and critical data gaps should be pinpointed before we decide whether use of this stockpile is prudent. 65-11

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BALTIMORE, MARYLAND

Miscellaneous Assessment Observations

Given the lack of discussion regarding the environmental assessments at the sites, a few observations are worth noting. For instance, radioactivity and/or uranium appear to have been found in groundwater at the Portsmouth and K-25 sites, but not at the Paducah site. As for the estimated maximum radiation dose to a member of the general public, the value presented for the Paducah site is 3 mrem/yr, but only 0.07 mrem/yr for the Portsmouth site. This is quite a difference for two similar sites which raises questions with regard to the adequacy of the assessment, or indicates that significant differences exist between the site estimations and/or quality of operations. Such observations within the summary suggest that DOE should take a closer look at the quality of the assessments conducted or the manner in which the assessment was presented in the summary. Even if it is the latter, this is a significant issue as many from the public who provide comments will only have the time or ability to review the summary. It is important for DOE to be as clear as possible and provide the public with the opportunity to constructively assess the PEIS without undue burden. 65-12

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COMMENTOR NO. 66: GRABER, JEAN & DICK
GOLCONDA, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 66-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored : Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 66-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 66-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 66-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 66-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 66-6

Thank you for considering these comments.

Sincerely,

Jean & Dick Graber

COMMENTOR NO. 67: CONNOLLY, DENNIS
COBDEN, ILLINOIS

Charles Bradley
US DOE (NE-40)
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Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 67-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 67-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 67-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 67-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 67-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 67-6

Thank you for considering these comments.

Sincerely,

Dennis Connolly
1145 Baker Hill Rd.
Cobden Illinois
62920-3316
4/14/98

1497

COMMENTOR NO. 68: SHORT, DUANE
STONEFORT, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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Thank you for considering these comments.

Sincerely,

Duane Short
Rt. 1 Box 208
Stonefort, Il
62987

COMMENTOR NO. 69: GANYARD, PATRICIA
POMONA, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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Thank you for considering these comments.

Sincerely,

Patricia E. Ganyard

COMMENTOR NO. 70: KNOPP, LISA
CARBONDALE, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 70-2

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Thank you for considering these comments.

Sincerely,

Lisa Knopp

Lisa Knopp
600 W. Sycamore
Carbondale, IL 62901

COMMENTOR NO. 71: SANTA FE ALLOYS & LOS ALMOS CONSULTANTS ALBUQUERQUE, NEW MEXICO

SANTA FE ALLOYS & LOS ALAMOS CONSULTANTS, (SFA/LAC)
4515 Stockbridge Ave., NW, Albuquerque, NM, 87120
(505) 899-2178, E-mail-elliottgrb@juno.com

4/28/98
Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
US DOE
19901 Germantown Rd.
Germantown, MD 20874
Ph (301) 903-5512; Fax (301) 903-4905; Charles.Bradley@HQ.DOE

Subject: Non-proprietary comments regarding the draft PEIS

Dear Mr. Bradley:

Thank you very much for talking with me and for requesting some opinions from me.

As we have discussed, Santa Fe Alloys (using Federal funding) and Los Alamos Consultants (using private funding) have devised and experimentally developed continuous metallothermic reduction procedures for production of uranium and other metals over a period of nearly 20 years. Most of the successful experiments on these procedures were carried out at the SFA/LAC laboratory in NM.

Comments on the Draft PEIS--This Writer's Opinions:

Overall High Quality: Your wise recommendation, as based on the material presented, is to convert the DUF_6 to metal or oxide and to use the DU for shielding of HLW. It was very much needed. That way the DU will be recoverable later while being protected for now.

To emphasize the need to save DU, the reader should recognize that many of the better uranium sources worldwide have already been destroyed to collect and use U-235, but leaving >99.5% of the natural U unused. Saving the remainder (mostly U-238) as breeder fuel would allow its use substantially fully as reactor fuel (as Pu-239) by future generations. Yet some people seriously recommend burying this fuel as waste! Wasting the DU would be an environmental atrocity.

(See "Management and Disposition of Excess Weapons Plutonium," National Academy Press, 1994, p.28, and DOE/NN-0007, Jan. 1997, p.39, showing that Pu fuel is now used in other countries.)

71-1

1499

COMMENTOR NO. 71: SANTA FE ALLOYS & LOS ALMOS CONSULTANTS (CONT'D.) ALBUQUERQUE, NEW MEXICO

SANTA FE ALLOYS & LOS ALAMOS CONSULTANTS, (SFA/LAC)
4515 Stockbridge Ave., NW, Albuquerque, NM, 87120
(505) 899-2178, E-mail-elliottgrb@juno.com

Avoidance of Too Strict Definitions of Processes to Be Used:
From a chemical and engineering view, this PEIS should be looked on as sketches of what sort of approach could be used to convert the DUF_6 to metal or oxide. As such these sketches allow realistic broad decisions such as saving the DU for future use, as just discussed.

However, the current overregulation from within and outside of DOE tends to turn such sketches into rigid models before experiment has shown what would be realistic. Consider, for example, the recent failures of numerous radwaste vitrification units--inadequately tested proposals rigidly specified what turned out to inadequate approaches.

71-2

Here the decision to use continuous metallothermic reductions for production of uranium for cask shielding is sound. However, as discussed below, the writer recommends versions of reductions that differ significantly from the version described, e.g., UCRL-AR-124080 Vols 1 and 2 Rev 2, Sec 8.10-4.

However, there is need to examine cost features.

Locations and Types of Facilities Needed for UF_6 Conversions to Metal or Alloy:

Alternative to Hydrogen Reduction of UF_6 to UF_4: Historically this reduction has been used before the continuous metallothermic reductions of UF_4 by Mg in molten salt as done by SFA prior to its work for AVLIS with ORNL (Lockheed Martin) and LLNL.

However, an alternative continuous metallothermic approach (description proprietary by LAC) by SFA would convert UF_6 to UF_4 in molten salt prior to continuous Mg reductions to metal or alloy.

71-3

Incorporating this LAC metallothermic reduction to UF_4 as a precursor to the U-metal production would (a) avoid the cost of separate hydrogen reduction facility and operations, (b) integrate well with the molten salt operations of the Mg-UF_4 reductions, and (c) avoid some shipping and handling.

Alternative to Aqueous Separation of MgF_2 By-product from NaCl Molten Salt Additive: Because of experimental flaws in ORNL pilot tests, which seemed to invalidate containers used by SFA for continuous metallothermic reductions, the separation of MgF_2 by-product continuously from molten salt was abandoned in the system of the PEIS--instead batch aqueous separations were incorporated into the DOE plans.

71-4

SANTA FE ALLOYS & LOS ALAMOS CONSULTANTS, (SFA/LAC)
4515 Stockbridge Ave., NW, Albuquerque, NM, 87120
(505) 899-2178, E-mail-elliotgrb@juno.com

However, SFA is eager to correct the ORNL flaws and demonstrate that continuous circulation of molten salt carrier with removal of solid, clean MgF_2 by-product can be maintained.

Alternative to Formation of U-3%Fe Alloy in UF_4-Mg Reductions: As described, the continuous metallothermic reductions lead to U-Fe alloy, which has the advantage of a lower melting point than pure U. However, the U-Fe alloy is brittle in castings and unwanted in breeding. Therefore, the production and casting of pure U should be evaluated also. 71-5

Location of U-Metal Production Facilities: To avoid the expenses and hassles of shipping radioactive materials by people's houses, it seems best to move the DUF_6 cylinders on-site at Paducah, ORNL, and Portsmouth to already HEPA-filtered buildings. Then, movable, also HEPA-filtered, UF_6-UF_4 units for continuous metallothermic reductions can be operated to produce U castings already suitable for use in casks. Then, with one radioactive shipment, the unshielded casks and the shielding castings could be assembled at the HLW site. 71-6

It seems reasonable, and in accord with many environmentalists' wishes, that the casks could be stored long-term in underground mausoleums, where they were available for remote monitoring and eventually for HLW recycle and DU reactor use.

Reduction of Costs for Operations and Maintenance in the Manufacture of Metallic Shielding: With some $800 million as the cost of Operations and Maintenance (Cost Analysis, UCRL-AR-127650, May 1997, p. 57) for manufacturing metallic shielding, it becomes very important to move the material rapidly through the processing, e.g., in ten years. 71-7

If an SFA continuous metallothermic reduction unit produced 1 cu ft of DU/hr full time for a year, the unit would produce 8760 cu ft of U. With 820,000 cu ft of U in cylinders, it would take 70.6 unit years to dispose of the DUF_6. With those assumptions, 10 SFA units could dispose of the DUF_6 within ten years.

ACTION:
With billions of dollars at stake, it seems urgent to get more

1500

SANTA FE ALLOYS & LOS ALAMOS CONSULTANTS, (SFA/LAC)
4515 Stockbridge Ave., NW, Albuquerque, NM, 87120
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experimental work from SFA. With even three months work, SFA working in its licensed DU laboratory could (presumably) demonstrate, and revalidate, containment for its water-free operations of continuous metallothermic reductions.

Later, other work could be discussed.

Sincerely,

Guy R. B. Elliott

Guy R. B. Elliott
President

COMMENTOR NO. 72: GOVERNORS PATTON, PAUL E., VOINOVICH, GEORGE V., & SUNDQUIST, DON PADUCAH, KENTUCKY; PORTSMOUTH, OHIO; OAK RIDGE TENNESSEE

April 27, 1998

The Honorable Federico Peña, Secretary
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 30585

RE: "Draft PEIS for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride," DOE/EIS-0269 dated December 1997.

Dear Secretary Peña:

More than forty years ago the U.S. Department of Energy began the uranium enrichment initiative that created a common link between Ohio, Kentucky, and Tennessee. This commonality includes the U.S. Department of Energy's legacy of waste, a significant portion of which is made up of depleted uranium hexafluoride. Today, our three states are working together in order to recommend the selection of an appropriate and lawful alternative for the long-term management and use of depleted uranium hexafluoride. We believe that such an alternative must minimize impacts on human health and the environment, as well as benefit the overall mission of our states and the U.S. Department of Energy ("DOE"). 72-1

Ohio, Kentucky, and Tennessee have the following significant concerns regarding the above-referenced document:

- DOE should consider the immediate conversion of all depleted uranium hexafluoride (DUF6) to the less hazardous uranium oxide (U3O8) and provide above ground storage of the U3O8. We do not believe that waiting for possible market demands for the DUF6 is justification for delaying this project. It is incumbent upon DOE to immediately begin seeking funds from Congress for this conversion. We urge DOE to complete conversion by the year 2018 or earlier and reduce the mortgage of maintaining the cylinders. 72-2

- A long-term strategy for DUF6 must include DOE's entire cylinder inventory, including heel and small cylinders. The 10,000+ cylinders of DUF6 generated by the United States Enrichment Corporation (USEC), which will revert to DOE ownership upon privatization of USEC, must also be considered in any plans. 72-3

- An estimated $480 million has been accrued by USEC since 1993 in order to offset the cost of the future conversion of DUF6 generated by USEC. DOE should work with Congress now to ensure this fund is not diverted into the federal treasury for an unrelated use. In addition, DOE might consider partnering with the future owner of USEC in a long-term strategy for managing and converting DUF6, in order to avoid redundancy of efforts. Any partnering effort, however, must not slow progress toward conversion. 72-4

- Natural phenomena events or accidents may not have been adequately considered in the PEIS. DOE must identify the "worse-case" cylinder conditions and explicitly use this information in the hazard modeling descriptions. 72-5

1501

COMMENTOR NO. 72: GOVERNORS PATTON, PAUL E., VOINOVICH, GEORGE V., & SUNDQUIST, DON PADUCAH, KENTUCKY; PORTSMOUTH, OHIO; OAK RIDGE TENNESSEE (CONT'D.)

- In order for states to effectively evaluate the potential impacts of the preferred alternative, DOE must provide information on the location of the sites where conversion would occur and how wastes generated from this process will be managed. In order to avoid the undue risk of transporting deteriorating cylinders, we recommend that DOE evaluate the feasibility of on-site conversion plants. 72-6

- DOE must ensure that funding for safe storage and maintenance of DUF6 cylinders and storage yards is at an adequate level to protect human health and the environment. 72-7

The States welcome the opportunity to work closely with the Department of Energy in addressing these complex issues and moving rapidly toward an alternative that will well serve the public and the environment. In addition, we urge DOE to carefully consider the more detailed comments being submitted by each of our states' environmental regulatory agencies.

Sincerely,

Governor Paul E. Patton

Governor George V. Voinovich

Governor Don Sundquist

cc: Charles E. Bradley, Jr., U.S. Department of Energy
James Hall, Manager, U.S. Department of Energy
William H. Timbers, Jr., United States Enrichment Corporation
Ohio Congressional Delegation
Kentucky Congressional Delegation
Tennessee Congressional Delegation

COMMENTOR NO. 73: HARTZOG, GEORGEANN
ALTO PASS, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874 April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 73-6

Thank you for considering these comments.

Sincerely,

Georgeann Hartzog

Georgeann Hartzog
1170 Rattlesnake Ferry Rd
Alto Pass, IL 62905

1502

COMMENTOR NO. 74: STAHNKE, LINDA
MURPHYSBORO, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874 April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

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Thank you for considering these comments.

Sincerely,

Linda Stahnke

LINDA STAHNKE
414 N 4½ ST
MURPHYSBORO IL 62966

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION FRANKFORT, KENTUCKY

JAMES E. BICKFORD
SECRETARY

PAUL E. PATTON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
FRANKFORT OFFICE PARK
14 REILLY RD
FRANKFORT KY 40601

April 23, 1998

Mr. Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Re: U.S. Department of Energy's Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269) dated December 18, 1997.

Gentlemen,

The Kentucky Division of Waste Management (Division) has reviewed the December 18, 1997 *U.S. Department of Energy's Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE/EIS-0269). Since the Paducah Gaseous Diffusion Plant currently store and manage the largest volume of Depleted Uranium Hexafluoride (DUF6) in the nation, the Division is very interested in the decision making process for the long-term storage and management of the DUF6. Attached are the Division's general and specific concerns of DOE's proposed alternative and long-term strategy.

If you have any questions or require additional information, please contact me or Tuss Taylor at (502)-564-6716.

Sincerely,

Robert H. Daniell, Director
Division of Waste Management

RHD/TT/jkg

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1503

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

cc: Robert Sleeman, DOE
Carl R. Freode Jr., USEPA
Jimmie Hodges, DOE
Myrna Redfield, DOE
James Hall, DOE
William H. Timbers, Jr., USEC
Jimmy Massey, BJLLC
John Morgan, BJLLC
KDWM-Paducah
DWM Main File #980

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

Kentucky Division of Waste Management's General and Specific Comments on the DOE's Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DOE/EIS-0269) dated December 18, 1997.

General Comments:

1. DOE's Preferred Alternative: DOE's preferred alternative, as repeatedly mentioned in PEIS is to use the entire inventory of DUF_6 as metal or oxide. However, no evidence has been documented in the PEIS, which suggests that the market demand exists or will be found for all or even a significant part of DUF_6 inventory in the near future. Moreover, two independent studies (*"Integrity of Uranium Hexafluoride Cylinders", DNFSB/TECH-4, May 5, 1995, and "Affordable Cleanup?: Opportunities for Cost Reduction in the Decontaminating and Decommisstioning of the Nation's Uranium Enrichment Facilities", Board on Energy and Environmental Systems, Commission on Engineering and Technical Systems, National Research Council of the National Academy of Sciences, February 9, 1996*) also report that the market demand doesn't currently exist for the DUF_6 or its conversion products, nor is the demand anticipated in the near future. In light of the present uncertainties in the market demand, the Division therefore recommends that the DOE should consider converting the entire inventory immediately to the more stable form U_3O_8. The long-term storage of this material is much safer than the current storage of DUF_6, and it can also be retrieved if future demand is obtained. *75-1*

2. Time Frame: The PEIS doesn't justify the 40-year time frame considered. Justification is warranted for the same. The PEIS recommends storing the cylinders until 2010, after which 20 years would be required to convert the entire inventory of DUF_6 using DOE's preferred alternative. During these years, there is continued storage of DUF_6 required, which will also necessitate the continued monitoring activities. The Division therefore recommends that the process of conversion should be expedited in order to minimize the risk to the human health and the environment from continued storage of deteriorating cylinders. This would also help in cutting down the cost on the annual maintenance and surveillance activities. *75-2*

3. Management of USEC cylinders: The PEIS doesn't take into account the cylinders (~8000) produced by United States Enrichment Corporation (USEC) since its privatization. The ownership of these cylinders has yet to be determined. It is the Division's understanding that under the current agreement between DOE and USEC, the USEC will be able to return to DOE, any waste not easily disposed of commercially. In this scenario, if these cylinders are considered waste, there is a possibility that they could be returned to the DOE. This represents a significant *75-3*

1504

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

increase in the inventory. Hence the Division recommends that a contingency plan should be incorporated in the PEIS to address the USEC cylinders.

4. Conversion Facilities/Site Selection: It is the Division's understanding that the DOE has not yet come to the conclusion of final selection of the site, as is evident from the PEIS. The PEIS describes the impact on the environment, considering various generic settings. However, the Division believes that site specific impact is also necessary after final selection of the site. For example, it is clear from the PEIS that the DOE has not given enough attention to the earthquake prone regions, and the seismic activities at the sites proposed for storage of the waste. The Division believes that it is critical and the site-specific information should be included in the PEIS. If PGDP is selected as one of the conversion facilities for example, then new facts gathered about this should be considered. The summary of some recently gathered seismic data at Paducah site is given in the specific comments. *75-4*

5. Generation of Secondary Waste: Preliminary calculations performed by Division indicate that if DOE's preferred alternative were used, large amounts of secondary waste could be generated. More specifically, around 70% of the product stream will consist of Uranium (in the metal or oxide form) and 30% will be in the form of other products (anhydrous HF, CaF_2, or MgF_2). The Division believes that the potential exist that all the handling, transportation, and disposal for uranium left at the end of the treatment process will meet Low-Level Waste (LLW) requirements. Moreover, unless the specific technology is available to totally remove all the radioactive contamination from these secondary products (e.g. HF, CaF_2, MgF_2 etc.-), all the disposal, handling, and treatment activities for this waste must follow the (LLW) management guidelines. Please provide a description of all potential anticipated wastes that may be derived from the preferred alternative. *75-5*

Specific Comments:

1. One of the chemicals of potential concern (COPC) identified in the conversion (to oxide or metal) is ammonia. Provide a brief discussion regarding the generation of ammonia. *75-6*

2. DOE has proposed a 40-year time frame for the proposed alternatives. Please provide a detailed justification for the proposed 40-year time frame. *75-7*

3. Consideration of "no-action" alternative should include at a minimum, implementation of Recommendation 95-1 of the Defense Nuclear Facilities Safety Board. *75-8*

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

4. It is clear from the PEIS that DOE has not given enough attention to the earthquake prone regions, and seismic activities at the sites proposed for storage of the waste. The Division believes it is critical that site specific information is included within the PEIS.

   The following is a summary of new information discovered at the PGDP: Dr. Ronald Street of the University of Kentucky, Department of Geological Sciences commenced an investigation of earthquake related features in the vicinity of the PGDP (*Acquisition of Shear Wave Seismic Reflection and Refraction Data in the Area of the Northwestward Trending Contaminant Plume at the PGDP*). The purpose of this investigation is to map geologic contacts between the Mississippian limestone, the McNairy Formation, the lower Continental Deposits, and the upper Continental Deposits. It has been proposed that faulting has created horst and graben features in these units and that these features may affect groundwater flowpaths in the area on the Northwest and Northeast plumes. A pilot study conducted by Dr. Street located a small graben structure north of the PGDP. As part of the current project, Dr. Street has collected 17.3 km of six and twelve fold reflection and refraction data using a 24 bit floating point seismograph unit. Work on this project started in May of 1997 and a final report is due to AIP in May of 1998.

   Preliminary interpretations of the data collected in this study were presented to the AIP in February 1998. These interpretations, which are subject to change, indicate that the PGDP is underlain by a series of northeast trending fault zones exhibiting substantial vertical offset on the surface of the Mississippian Limestone as well as the upper surface of the McNairy formation. *75-9*

   In other work conducted by Dr. John Nelson of the Illinois Geological Survey northeast trending faulting was found in sediments north of the PGDP in Southern Illinois. Dr. Nelson identified faulting in road cuts and railroad cuts. He also identified a graben in the surface of the McNairy formation with a vertical offset of 200+ feet.

   Dr. Tom Hildenbrand (USGS, Menlo Park) compiled magnetic, seismic moment, and gravity maps for the Paducah region. An anomalous feature appeared approximately 5 miles northwest of the PDGP on all three maps, gravity high, a magnetic high, and a cluster of small earthquakes. This feature has been interpreted as a mafic intrusion located near the community of Needmore. Earthquakes in the vicinity of this possible intrusion are thought to be the result of the regional compressive stress field being deflected around the structure.

   This evaluation indicates that the probability of significant seismic activities within this region is high and that further consideration is needed within the PEIS.

5. The PEIS should describe clearly the criteria for choosing the sites for treatment/disposal. The Division believes that such information is crucial. It is the *75-10*

1505

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

   Division's understanding that several options will be available for the conversion process of UF_6 to either oxide or metal and production of anhydrous HF. Because there are varying chemical products and potential waste products generated with different conversion methods; DOE must provide a general description of waste products and waste which are anticipated to be generated. If a method has been selected, please state the method. *75-10 (Con't.)*

   Additionally, DOE must address the management and disposal of miscellaneous wastes that will be generated during the conversion process. This would include management and disposal of potentially large volumes of low-level wastes from the neutralization of HF; also various filters and filtered materials. *75-11*

   Finally, discussion is needed for the management of "cylinder heals" from the bottom of the DUF6 cylinder. This material contains a variety of radionuclides (i.e. daughter products and other contaminants) that are not suitable for conversion into uranium oxides or uranium metal. *75-12*

6. While evaluating the alternative "conversion of UF_6 to oxide or metal form", different steps have been delineated as is the case with the other alternatives. In this particular case, the facilities for conversion process, storage of converted uranium form, and the manufacturing of the casks (which is the end use for this alternative, and this is DOE's preferred alternative) are all planned to be located at separate locations. There will be transportation required between these locations. The PEIS should address the impacts of the transportation, including the potential impacts on the environment, human health. However, the transportation impacts could be minimized if DOE would integrate the conversion and manufacturing plants in one complex. This would reduce the amount of land required thereby decreasing possible habitat loss. It is not clear whether DOE has considered this alternative. If not, we recommend that this option be considered. *75-13*

7. A correction is needed on page 3-7, Section 3.1.4.1; the reference to the earthquake magnitude of 7.3 should have been referenced as the "Nuttly Scale" and not as the "Richter Scale". Although, the Nuttly Scale does converts to 8.0 on the Seismic Moment scale sometime referred to as the Richter scale. *75-14*

8. Section 3.1 Paducah Site; U.S. EPA has authorized the Commonwealth of Kentucky for the Resource Conservation and Recovery Act (RCRA) Program. Therefore, when references are made to the U.S. EPA RCRA program, the Kentucky Hazardous Waste should also be referenced. *75-15*

9. Pages2-60 and 2-61; 2-64 and 2-65; 2-68 and 2-69; 3-2 and 3-4; Figure 3.1 of Volume I of the Draft DUF6 PEIS are missing. A comprehensive review could not be performed due to the lack of these pages. Provide the missing pages. *75-16*

COMMENTOR NO. 75: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) FRANKFORT, KENTUCKY

10. Page 5-108, Section 5.8.2.1 Paducah Site; the last paragraph states that 11 pollutants have been detected in the groundwater effecting quality. This statement is incorrect. Numerous pollutants have been detected at the PGDP. In fact, one of the most predominant contaminants at the site is omitted, Technetium 99. Other radionuclides and organic contaminants have been detected in groundwater throughout the PGDP.

75-17

1506

COMMENTOR NO. 76: STATE OF OHIO ENVIRONMENTAL PROTECTION AGENCY COLUMBUS, OHIO

OhioEPA
State of Ohio Environmental Protection Agency

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April 21. 1998

The Honorable Federico Pena, Secretary
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 30585

RE: " Draft PEIS for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride," DOE/EIS-0269 dated December 1997.

Dear Secretary Pena:

Ohio EPA has long been interested in the management of depleted uranium hexafluoride (DUF6). Ohio's concerns result from the 13000+ cylinders of DUF6 which have been stored for decades at the Portsmouth Gaseous Diffusion Plant in southern Ohio. As you may know, management of DUF6 at the Portsmouth site was the subject of recent judicial and administrative consent orders signed by the U.S. Department of Energy ("DOE") and the State of Ohio. The State of Ohio is working to support an appropriate lawful alternative for the long term management and use of DUF6. We have reviewed the above-referenced document and offer the following comments:

1. **There is no evidence to suggest that market demand exists or will be found for all or even a large part of DOE's DUF6 inventory in the near term or the foreseeable future. Therefore, conversion should begin as soon as possible and be completed by 2018 or earlier. DOE should begin now to seek funds from Congress for conversion, and should consider the immediate conversion of all the DUF6 to U3O8, and long-term above-ground storage of this material.** According to the draft PEIS, the preferred alternative for long-term use of DUF6 is conversion of 100% of stockpiled DUF6 to oxide (i.e., U3O8 and/or UO2) and depleted uranium metals. Conversion would not begin until 2010, and would occur over a twenty year period on the basis of market demand. However, in the Draft PEIS, DOE states that "the actual percentage of depleted UF6 inventory for which uses will be identified within the time frame assessed in the PEIS (i.e., up to the year 2040) will be determined as uses develop and conversion begins." In other words, this market demand is uncertain.

76-1

The National Research Council of the National Academy of Sciences (NSF)[1] conducted

[1]"Affordable Cleanup?: Opportunities for Cost Reduction in the Decontaminating and Decommissioning of the Nation's Uranium Enrichment Facilities", Board on Energy and

George V. Voinovich, Governor
Nancy P. Hollister, Lt. Governor
Donald R. Schregardus, Director

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COMMENTOR NO. 76: STATE OF OHIO ENVIRONMENTAL PROTECTION AGENCY (CONT'D.)
COLUMBUS, OHIO

a review in 1996 of possible uses for depleted uranium in shielding applications, as a fluorinating agent, and for re-enrichment by Atomic Vapor Laser Isotope Separation (AVLIS). According to the NSF, market demand does not currently exist for DUF6 or its conversion products, nor is demand anticipated in the near future. This is corroborated by the DNFSB who stated in a 1995 report[1] that according to DOE, only a "small fraction" of depleted uranium has a use in the "foreseeable future". *76-1 (Cont'd.)*

We recognize that market demand is, at best, uncertain. DUF6 can be stored more safely in a converted state. Therefore, rather than wait for market demand to drive conversion, DOE should begin now to seek funds from Congress for conversion, and should consider the immediate conversion of all the DUF6 to U3O8, and long-term above-ground storage of this material, which can be retrieved if demand is established. If a market exists for a small percentage of DUF6, only those cylinders in the best condition should remain unconverted for use by the market.

2. **The draft PEIS provides no assurance that DOE will fund and implement an adequate long-term program of inspecting and coating cylinders throughout the life of the DUF6 cylinders, prior to conversion.** Safe cylinder management requires an adequate inspection program combined with an aggressive cylinder coating program. Several times throughout the PEIS, it is indicated that funding for a cylinder coating program is "uncertain". However, DOE states in the PEIS that coating is expected to be successful and therefore, minimal releases of DUF6 from cylinders to air and groundwater are expected. It is unclear how DOE can assume coating will be successful if funding is uncertain and the success rate of coating cylinders is unknown. Even if funded, there is no assurance that coating will be adequately applied and renewed frequently enough to prevent or slow corrosion. DOE must comply with all DNFSB recommendations for management of cylinders and yards, and with the DUF6 management plan contained in Ohio orders. *76-2*

3 **DOE should ensure that the PEIS addresses the management of DUF6 in compliance with RCRA and state hazardous waste law. The February 28, 1998 Director's Findings and Orders reiterated Ohio EPA's view that DUF6 is a mixed waste regulated under RCRA and state hazardous waste law. These Findings and Orders provide an exemption from state hazardous waste requirements for a 10-year period to allow DOE to identify and implement an appropriate and lawful strategy for use, reuse, or conversion of this material. The Findings and Orders require compliance with a safe management plan for the DUF6 during the 10-year period. Ohio has also reserved legal rights to reassert state hazardous waste requirements. Thus, it is imperative that the PEIS address the management of** *76-3*

Environmental Systems, Commission on Engineering and Technical Systems, National Research Council of the National Academy of Sciences, February 9, 1996.

[1]"Integrity of Uranium Hexafluoride Cylinders", Defense Nuclear Facility Safety Board Technical Report, May 5, 1995.

1507

COMMENTOR NO. 76: STATE OF OHIO ENVIRONMENTAL PROTECTION AGENCY (CONT'D.)
COLUMBUS, OHIO

DUF6 as a mixed waste under RCRA and state hazardous waste law.

4. **A variety of independent and DOE estimates regarding breached cylinders are available but not considered in the draft PEIS.** The draft PEIS estimates that 59 breaches and releases from cylinders could occur over the next forty years, assuming control of external corrosion by painting cylinders. Assuming no control of corrosion, the draft PEIS estimates that 731 breaches and releases could occur. However, according to the Defense Nuclear Facility Safety Board (DNFSB)[1], it has been stated by DOE and the former MMES that 200 cylinders are expected to breach if no corrosion control is undertaken, and more than 1000 cylinders have the potential to breach in storage within 22 years (by the year 2020). *76-4*

5. **DOE's estimate of three to four cylinder spill accidents from breaches due to corrosion appears unrealistically low.** The draft PEIS estimates that as a result of all activities associated with the preferred alternative, three to four spill accidents will occur by 2038 as a result of cylinders that will breach due to corrosion. However, DOE records show that from 1990 to 1992, seven cylinders stored at the DOE three gaseous diffusion plants have breached due to corrosion. In light of DOE's own predictions mentioned in comment #2 above, as well as the current age of the cylinders, unknown cylinder corrosion rates, and the uncertainty of a long-term, ongoing cylinder coating program, a more realistic estimate of cylinder spill accidents due to corrosion must be made. *76-5*

6. **If cylinder breaching rates have been underestimated, all other calculations made in the draft PEIS that were based on this breach rate, such as the impact of a release of DUF6 to soil, groundwater, human health, etc., have also been underestimated. These estimates should be revised accordingly.** *76-6*

7. **Conversion of DUF6 to U3O8 should be expedited in order to minimize the risk to human health and the environment from continued storage of deteriorating cylinders.** In order to implement the preferred alternative in the Draft PEIS, DOE recommends storing cylinders until 2010. Then, a period of twenty years, at a cost of $200 million per year, would be required to convert the entire DUF6 inventory to either depleted metals or oxide at one conversion plant, the site of which has not yet been determined. During conversion, aqueous HF would be generated and marketed. According to the National Research Council, a twenty year conversion rate and was chosen to reduce the cost of plant investment (spread the cost out over twenty years) and to render the HF production rate less disruptive to the market. The rate at which HF would be generated over twenty years is equal to approximately 2% of the estimated annual market in North America. It is recommended that conversion be completed by 2018 or earlier. Expediting conversion will minimize the risk of continued storage and defray the annual cost for cylinder maintenance and surveillance, which is estimated by DOE at $12 to 15 million. *76-7*

[1]Recommendation 95-1 to the Secretary of Energy pursuant to 42 USC 2286a(5) Atomic Energy Act of 1954, as amended.

COMMENTOR NO. 76: STATE OF OHIO ENVIRONMENTAL PROTECTION AGENCY (CONT'D.)
COLUMBUS, OHIO

8. **Rather than construct a conversion plant at a single location and transport all cylinders to the conversion site, DOE should evaluate the feasibility of on-site conversion of DUF6 to U3O8.** According to DOE, 50% to 95% of the DUF6 cylinders have corroded to the point that they are not capable of being handled and transported without undue risk. The draft PEIS states that cylinders would be over packed or their contents transferred into new containers prior to transporting them to an undetermined conversion plant. If cylinders can be converted onsite without transporting them, this will minimize the number of times they are handled, therefore, limiting the risks associated with transferring cylinder contents and transporting them to conversion sites. In addition, the time required for over packing, transferring contents, and transporting cylinders could be saved. The use of a mobile treatment unit that could be transported to each GDP site should be considered. In the alternative, DOE could construct a plant onsite at each GDP (if seismic conditions allow), within an existing, unused gaseous diffusion building. *76-8*

9. **Seismic and flooding concerns were not adequately discussed in the draft PEIS.** For example, Paducah, Kentucky is located approximately 60 miles from the New Madrid fault. Earthquakes of a magnitude of 8.4 to 8.8 on the Richter scale have been measured in the region. These have the potential to damage stored cylinders. The majority of cylinders are stored at Paducah. Seismic issues for Ohio, Kentucky and Tennessee must be adequately considered in the PEIS, especially in light of continued storage of cylinders until at least 2010, and conversion at an unknown site. *76-9*

10. **DOE should evaluate a long-term strategy for DUF6 that would include DOE's entire cylinder inventory including heel and small cylinders as well as the current inventory of 10,000+ cylinders of DUF6 generated by USEC since it's 1993 inception.** When privatization occurs, these USEC-generated cylinders will become the responsibility of DOE. Pursuant to the federal privatization legislation, funds have been accrued for each kilogram of DUF6 generated by USEC in order to pay for future treatment of tails. Currently, this fund may now hold as much as $480 million. When USEC is privatized, this fund will be turned over to the federal treasury. DOE should take steps to secure these funds to offset the cost of conversion of the DUF6 to be acquired from USEC, as well its existing inventory of DUF6. *76-10*

Ohio EPA is willing to work closely with DOE on this issue. We suggest forming a workgroup that includes representatives of Ohio, Kentucky and Tennessee that can work with DOE to find a solution that meets the needs of all three states as well as DOE. Please contact Donna Goodman of my staff at (740)385-8501 if you have any questions or wish to discuss this further.

Sincerely,

Donald R. Schregardus
Director

1508

76

COMMENTOR NO. 77: WATKIN, MARY ELLEN & MONTEITH, JERRY
COBDEN, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. *77-1*

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. *77-2*

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. *77-3*

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. *77-4*

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. *77-5*

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. *77-6*

Thank you for considering these comments.

Sincerely,

Mr. Mel Watkin
Jerry C. Monteith
417 Oak St.
Cobden, IL 62920

(MARY ELLEN WATKIN)

(Jerry Monteith)

* PADUCAH IS 25 minutes from our home in Southern Illinois.

COMMENTOR NO. 78: BELLETIRE, KATHY
MARION, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 78-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 78-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake dvmage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 78-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 78-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 78-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 78-6

Thank you for considering these comments.

Sincerely,

Kathy Belletire
6710 Wards Mill
Marion IL 62959

1589

COMMENTOR NO. 79: COOTS, LOU
PADUCAH, KENTUCKY

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 23, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 79-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 79-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 79-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 79-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 79-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 79-6

Thank you for considering these comments.

Sincerely,

Ms. Lou Coots
Ms. Lou Coots
330 N. 38th St.
Paducah, KY 42001

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY MCDERMOTT, OHIO

Portsmouth-Piketon
Residents for
Environmental
Safety and
Security

P.R.E.S.S.

Vina K. Colley, President
3706 McDermott Pond Creek
McDermott, Ohio 45652-8932
Telephone (614) 259-4688
Fax (614) 259-3912

Hello,

My name is Vina Colley a former worker who suffers form a disabling illnesses as the result of U235 in my lungs and toxic exposures from working at the Portsmouth /Piketon Uranium Enrichment plant located here in Piketon.

I am here today representing PRESS Portsmouth/Piketon Residents for Environmental Safety and Security. Press is am member group of several national organizations representing communities living in the shadows of the U.S. nuclear weapons complex such as the Alliance for Nuclear Accountability (formerly the Military Production Network),Military Toxic Project, Reclamation & Conversion Project, and Task Force on Radiation and Human Right.

Press doesn't represent the union body of the Piketon plant but workers like my myself that have been effect from this facility. PRESS represents the interests members of the directly affected.

We are her today to speak about one of the biggest problems facing the public from the DOE/DOD programs the Uranium Hexafluoride tails (UF6) DU cylinders. A hazardous materials specialist, David Kozlowski was quote as saying " Uranium Hexafluoride is highly corrosive ", its effect to those hydrochloric acid. Sites such as Piketon, he said are regarded as potential "general emergency" sites by the DOE, meaning if there were gas formation it could require evacuation of nearby areas. While in D.C. last year with the national groups we were told by another top person for the DOE that painting, these cylinders was like putting lipstick on a corpse. Slightly contaminated DU cylinders become a problem equal to high level radioactive waste as they age because of the decay daughter product to radium. — 80-1

I would like to remind you of the 1978 spill here at the plant when over 21 thousand LBS left this site by air, ground and water many workers where effected. In September of 1996 another airborne plume went off site in between the lithuim storage building and the national guards bulding. This airborne plume headed toward Wakefield. I have been told that workers were paid over time and told to stay inside, I also called a reporter when this was happening, he called the plant and they lied about the release and two days later put there own story in the paper. I would like someone to tell me why we have alarms and run through drills and when there is an actual potential — 80-2, 80-3, 80-4

15/10

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

dangerous releases there is no sound of alarms to warn the citizens of the surrounding communities. Residents didn't know about the situation so therefore didn't know to stay inside. — 80-4 (Con't.)

Charles Bradley you didn't seen to believe me about the airborne plume from the DU cylinder could form,you though it would suck back inside the cylinder like the video that was show here. That video is misleading in ways. B Removed tape as update — 80-5

I would like to view another picture of children standing around DU cylinders, This should not be allowed with all the information about the hazard of this product,and the problems with on site hazards threat Piketo — 80-6

PRESS considers a decision that there is little effect to the public and it's worlore to be a serious environmental justice concern and and was not address adequately in the draft PEIS.

PRESS along with the Military Toxic Project is asking for the comment period be extended to six months to give folks the opportunity to meet with you in a roundtable meetings, much like the Federal Facilities Restoration Dialogue meetings. We need to have the opportunity to discuss the strategies that have been proposed. — 80-7

I am putting in records the letter form the Military Toxic Project.

PRESS an other viewer should see in writing all agreement between the states of all three facilities OakRidge, Paducah, and Piketon.

All agreements between CONGRESS the USEC,DOD, DOE, and any others involved. — 80-8

The EPA was to fine this facility I believe over the DU clinders, we would like to know how much, and why.

I would like to remind you that Piketon has never been licensed to accept or store Radioactive waste and we have broken many laws by doing so. You have consistenly withheld information from the citizens about radioactive release whether planned, routine, or accidently. PRESS feels that there is a number of cylinders no long inventory and would like to know who is hidding them or where they stolen,or is some one all ready doing conversion? — 80-9

PRESS is worried that a earthquake would create multiple cylinder failures at all the sites,also worried over the possibly of airoraft wrecking and hidding the cylinders. — 80-10

Press feels we need to look at some real problem that the National Research Council as put on the table. — 80-11

We feel that untill we find a safe way to handle these cylinders they should be put in earthquake proof containers or maybe find away to neat them up in the place where stored, then put then in new cylinder untill new safe technology comes along. — 80-12

I have a Report from Geore Hoffman To put in Record

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

I would like to put in record a report from Gene Hoffman. At request, I will make a copy for people here that would like one. Also a letter sent to NY TIMES BUREAU from Leonard A. Dietz. [redacted] about the DU issue.
I would like to thank you for this time to speak.

80-13

Vera Calley
PRESS

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

SCIENCE FOR DEMOCRATIC ACTION
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Worker Radiation Dose Records Deeply Flawed

BY ARJUN MAKHIJANI AND BERND FRANKE

As part of its responsibility for the production and testing of nuclear weapons, the Department of Energy (DOE) and its predecessor agencies (the Atomic Energy Commission, 1947–1974; and the Energy Research and Development Administration, 1974–1977) have been responsible for ensuring that workers were not exposed to more than the allowable amounts of radiation. The DOE has also been responsible to adhere to what is called the "ALARA" principle—the idea that radiation exposures should be kept "As Low As Reasonably Achievable" with available technology.

The goal of using radiation dose limits and following the ALARA guideline is to protect worker health by limiting exposure. But if exposure is not properly measured, radiation exposure regulations cannot be enforced, nor can guidelines be followed. Health monitoring personnel may not be aware of instances when workers are overexposed. Diseases that workers may be at greater risk of contracting may go undetected, harming them and their families. Health studies based on worker dose data would produce misleading results because dose records would be incomplete and knowledge of them would be inaccurate.

A worker at the Plutonium Finishing Plant at Hanford, Washington receives a whole-body survey to detect potential radioactive contamination.

From the beginning of the nuclear era until 1989, *radiation doses from radioactive materials inhaled or ingested by workers were not calculated or included in worker dose records.* This was revealed by DOE in a background paper sent to IEER on April 7, 1997.[1] DOE and its predecessor agencies did make measurements of internal exposure to radioactive materials, though often sporadic (see below), mainly by taking urine samples. After the mid-to-late 1960s, there was also selection use of more sophisticated counters that

See Worker Doses, page 4

Editorial

Identify Groups of Workers at Risk

As noted in the accompanying article, the Department of Energy has stated that it did not calculate internal doses for workers, and therefore did not integrate them into dose records until 1989. This single fact means that historical worker dose records for 500,000 to 600,000 DOE workers are open to question and that a large number of them—those belonging to workers at risk of internal exposure—are flawed.

The DOE was not actively required to do such integration of internal and external doses, as we note in the article. Still, in the 1950s it was possible to crudely calculate internal worker doses and enter them into worker dose records (though such estimates would often have underestimated exposures). Relatively certain estimates were possible after the mid-1960s by matching up urine data with direct measurements of lung burdens, as IEER did in the case brought against

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Editorial, *from page 1*

National Lead of Ohio by workers at the Fernald Plant in 1991. (See SDA Vol. 5 No. 3) But the AEC, its successor agencies, and their contractors did not make the effort until 1989, when new regulations required it.

As the case of Iodine 131 in fallout out shows, (see article, p. 1) the nuclear weapons establishment chose not to properly inform the public about the risks and sacrifices that it was imposing upon them. The counterpart for workers of the public relations campaign that accompanied atmospheric testing was constant reassurances that doses were under allowable limits—and vigorous contestation of worker compensation claims even though the DOE and its predecessor agencies had failed to do their homework on what worker exposures actually were, and though relatively accurate estimates were possible after the mid-1960s.

Relatively precise estimates of internal doses were possible after the mid-1960s.

It is time for the DOE to straighten out the mess by commissioning an independent assessment of the state of internal and external dose data. Simultaneously, the DOE must expeditiously review workers' records to determine which *groups* of workers who labored to make and test this country's huge nuclear arsenal were at risk of high internal exposures and/or high lifetime exposures. The reconstruction of individual worker doses would be a very costly and difficult exercise, which would in many or most cases also be frustrating because huge uncertainties will inevitably remain. That is why we advocate the calculation of doses to groups of workers to determine at-risk groups for the purposes of medical monitoring and, if warranted, compensation. That way more resources can be devoted to workers rather than to legal studies.

It is also possible that the DOE and its contractors have used incomplete dose records to argue its case in compensation cases and other lawsuits. It is improper for the government to continue to fight workers' claims based on exposure data that systematically underestimated doses. A review should be conducted to determine if DOE or its contractors have presented any pre-1989 records as accurate data on internal worker doses.

Private industry failed to calculate internal worker doses until the 1991–1994 period. We have not examined any set of data relating to workers in the private sector of the nuclear industry. The industry's failure to measure internal doses needs to be reviewed and an assessment should be made of its impact on workers.

There are two rays of hope in this dismal picture. One is that DOE began in 1989 to incorporate internal dose estimates into worker dose records. The other is that DOE and its predecessor agencies appear to have taken sufficient measurements to enable group worker doses to be approximately calculated, at least in the one instance where IEER has had access to the raw data. Since its inception, the DOE has made some effort to track individual worker exposures, which has undoubtedly resulted in lower overall exposures than would have occurred if no effort were made. But these measures have been grossly inadequate. If the DOE can spend $4.5 billion a year on laboratory testing and computer simulation of nuclear weapons, which we have found to be essentially unnecessary for maintaining safety (See SDA Vol. 5 No. 2), it can find the resources to do justice to the people exposed to radiation while building nuclear weapons.

—ARJUN MAKHIJANI AND BENNO PHANKE

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Let Them Drink Milk

Iodine-131 Doses from Nuclear Weapons Testing

BY PAT ORTMEYER

. . .it seems necessary to adopt a rather conservative attitude toward the involuntary exposure of the general populations. An error on the radical side will not be immediately apparent, but the chickens will inevitably come home to roost at some later date.

-Howard L. Andrews,
National Institutes of Health,
September 13, 1953[1]

The National Cancer Institute (NCI) recently released results of its 14-year study showing that fallout of Iodine-131 from atmospheric tests conducted in Nevada in the 1950s and early 1960s resulted in thyroid doses to virtually all of the 100 million people living in the United States at the time. The estimated 150 million curies of Iodine-131 released from the tests resulted in a cumulative average thyroid dose to the population of 2 rad.[2] Children were particularly affected: their doses averaged 6 to 14 rad, with some doses as high as 112 rad. Prior to this study, the most recent estimates of children's thyroid doses from Iodine-131 in fallout, reported to Congress in 1959 and cited as recently as 1997, gave a dose range for children of 0.2 to 0.4 rad—15 to 70 times less than the NCI dose estimates.[3] (Note: These are estimates of thyroid doses, not whole body doses. See Crutchfield table on dose.)

Some of the highest thyroid doses in the country were in areas far from the test site.

Thyroid irradiation increases the risk of cancer to children. A 1993 peer-reviewed publication says there is "convincing evidence" of increased thyroid cancer risk to children under age 15 whose thyroids are exposed to 10 rad or more.[4] This study mostly concerned individuals exposed to external radiation sources such as X-rays, but the effect on tissues from ionizing radiation from internal sources is essentially the same.[5] (See foot note for full explanation.)

Thyroid cancer is relatively rare, but the NCI estimates that 10,000 to 75,000 thyroid cancers can be expected as a result of these doses, roughly five to ten percent of which will be fatal. (The upper estimate of 75,000 is more plausible, since the lower estimate assumes that internal radiation doses from Iodine-131 are "as little as one-fifth as hazardous" as the same dose of external radiation.[6] This assumption is very dubious, not based on human data, and not protective of public health.) About 40 percent of thyroid cancers due to Iodine 131 fallout have yet to be diagnosed, according to the NCI,[7] and survivors of thyroid cancer require lifelong treatment with a synthetic thyroid hormone essential for metabolism and other physiological functions. Thyroid irradiation has also been linked to other thyroid disorders, such as autoimmune hypothyroidism, autoimmune thyroiditis, hyperthyroidism (nodular or Grave's disease), and thyroid nodules.[8] Estimates of the level of dose at which these effects occur vary considerably.

While NCI has not estimated the number of children who were put at risk due to fallout, simple demographics coupled with the published numbers indicate that millions of people who were under 15 during the period in question may have received over 10 rad. Doses to girls may be of particular significance, as the incidence of thyroid cancer among women is more than twice that of men.[9]

Iodine can be inhaled, or ingested through contaminated eggs, cottage cheese, or leafy plants and vegetables. But the main pathway of exposure was through ingestion of contaminated milk. As fallout settled on fields and pastures after each test, cows and goats would eat the grass and the Iodine would become concentrated in their milk. Children received higher doses because in general they consumed more milk than adults, and their thyroids were smaller and growing more rapidly. The estimated 20,000 people in the country at the time who drank goat's milk also received higher doses—up to 20 times greater than those drinking cow's milk—because goat's milk concentrates Iodine-131 more than cow's milk.[10] Doses to goat's milk drinkers could, in the most affected counties, have been as high as 180 to 316 rad.

High doses were not limited to those areas directly downwind of the tests. Local precipitation or wind patterns in areas far from the test site caused selective deposition of fallout, or "hot spots," a phenomenon understood by the Atomic Energy Commission (AEC) from the time of the first test, "Trinity," in 1945. As a result, some of the highest estimated thyroid doses in the country were in areas far from Nevada, such as in Meagher County, Montana, with an average dose of 15.8 rad, and Custer County, Idaho with 15.4 rad. Other high doses were estimated throughout the midwest: 8.6 rad in Lyman, South Dakota (26 to 60 rad for children), and 8.1 rad in Lewis County, Missouri (24 to 57 rad for children).[11]

The Atomic Energy Commission understood early on that locating the test site in the western part of the

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Worker Doses *from page 1*

directly measure radionuclides in workers' bodies. The DOE was not required by regulations to calculate worker doses, but only to keep records of whether workers were internally exposed to more than certain amounts of radionuclides.

The lack of historical internal dose data in worker dose records has important consequences for public policy on health issues, for scientific investigations of radiation risk, and most of all for the more than half a million workers (and their families) who have been involved since the Manhattan Project in making and testing U.S. nuclear warheads. In 1989, DOE began to correct this historical problem by initiating a program of integrating internal and external worker doses.

Exposure Limits

Limits for allowable exposure have varied over the years, and have generally tended to decline as evolving knowledge about the cancer risks from radiation indicated that the dangers it posed were greater than previously thought. (See Gottlieb.) In order to ensure that workers are not overexposed, the most important routes of exposure must be properly monitored. Consideration must also be given to the fact that ionizing radiation affects people in various ways.

When only external radiation is involved, measurement of worker dose is accomplished by the use of film badges, small photographic plates sensitive to gamma and beta radiation, or thermoluminiscent dosimeters (reusable devices that measure external radiation—also referred to as TLDs). These devices can measure how much radiation a worker has been exposed to, but not the amount of radiation that may have been taken into the body through inhalation, ingestion or other means.

Internal radiation exposure occurs when radioactive materials get inside the body and decay, irradiating nearby tissues. Internal radiation is often more organ-specific than external radiation. If the radionuclides become lodged in particular parts of the body, such as the lungs or bones, for instance, those areas are irradiated far more than others. Risk of internal exposure is high in workplaces where the air becomes contaminated with radioactive materials or dust, as has frequently occurred in various kinds of uranium processing plants and in uranium mines. Workers can also be exposed internally through ingestion of radioactive materials (if the radioactive materials get into the mouth from the air, for example) or by absorption through wounds or cuts.

Internal exposure is less likely in situations where the radioactive materials are sealed or separated in some other way from the work environment, such as in glove boxes. However, if accidents occur in these situations, or if equipment such as a ventilating system or glove box is not efficient or in proper working order, then workers could be exposed internally as well.

For almost the entire period of nuclear weapons production, limits have been imposed on exposure from both internal and external modes. Some current limits apply to combined external and internal exposure, while past limits have applied specifically to particular organs, such as the lungs. For instance, the limit for lung exposure until 1958 was 15 rem per year for workers and off-site populations. It was lowered for off-site populations to 1.5 rem per year in 1959.

Monitoring Doses

Internal dose is monitored in various ways. One common way is to measure radionuclide concentrations in urine. If one knows the rates of excretion corresponding to various body burdens, then it is possible to calculate these body burdens and thereby infer the radiation dose.

Another method is to measure the gamma radiation being emitted by the radionuclide inside the body. Since a portion of gamma radiation penetrates the body, a fraction of the gamma rays emitted by radionuclides inside the body escape outside it. This is measured by putting the worker or part of his or her body into a "counter," which is a chamber that measures gamma radiation. Thus, we have "whole body counters," "lung counters," and so on. Care must be taken to exclude or adjust for other sources of environmental radioactivity in the measurement of internal body burdens, possibly radon and its decay products.

> *From the beginning of the nuclear era until 1989, internal radiation doses were not calculated or included in worker dose records.*

Internal doses can also be assessed indirectly by measuring the concentrations of radionuclides in the air in the plant. In areas where exposure is more likely, workers can wear portable air monitoring devices to measure concentrations of radionuclides in the "breathing zone"—that is, in the air very close to their faces. Internal worker doses can be estimated if breathing rates, efficiencies of protective devices worn by workers (if any), and other factors are known.

It is essential that radiation monitoring be carried out accurately and in sufficient detail. For instance, film badges and TLDs must be stored properly when not in use, so that they are not contaminated between worker exposure times. Also, workers at risk of internal exposures must be monitored frequently enough to accurately determine internal body burdens of radionuclides. This is because over time the body eliminates radionuclides

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Worker Doses *from page 4*

some are excreted in a very short time, while others are eliminated very slowly. (The amount of time it takes to eliminate half of the body burden of a radionuclide is called its biological half-life.) It is also important to know the chemical form of the inhaled or ingested radionuclide because the rate at which it is eliminated from the body depends on the solubility of the particular chemical compound.

Failure to Monitor

The April 7, 1993 background paper sent to IEER by the U.S. Department of Energy Office of Worker Protection Programs and Hazards Management clearly set forth what IEER had suspected for several years, that

> ... [d]uring 1989 to DOE, and 1991-1994 in the nuclear industry (NRC and Agreement States) external radiation doses were not calculated [or] for workers. Radiation activity (worker exposure or percent of body burden) was recorded in the DOE prior to 1989

Thus, while workers were being monitored for internal body burdens, these body burdens were not being translated into radiation dose estimates; nor were any radiation dose estimates corresponding to internal radionuclide body burdens entered into the dose records of workers.

While there was no regulatory requirement to actually calculate worker doses, the lack of internal radiation dose estimates in worker dose records means that the records of workers who were at risk of internal exposures are incomplete, misleading, and inaccurate. The degree of incompleteness and inaccuracy will vary from one worker to the next, from one historical period to the next, and from one facility to the next. But the overall result is that *large numbers of workers have received information about their radiation exposures which systematically understates their actual exposures.*

Another consequence of the incomplete internal dose records before 1989 is that in compensation cases involving workers who had internal exposures, the DOE and its contractors may have based their arguments on incomplete data that underestimated exposures. Many cases may therefore have been unjustly decided against workers. Whether the DOE or its predecessor agencies knowingly omitted internal dose information from some worker compensation cases is, at this time, an open question, but a reasonable one to pose.

While it is not possible to give an accurate estimate of the proportion of the 300,000 to 600,000 workers who have worked for the DOE that were at risk of exposure beyond allowable limits, we note that at the uranium processing plant in Ohio, commonly called the Fernald Plant, most workers were at risk in the early years. In fact, in 1955, the worst year for worker exposure, IEER estimates that almost 90 percent of workers were exposed to more than the allowable dose limit of 15 rem to the lung. (See SDA Vol. 5 No. 1.)

There are a number of other direct consequences of seriously incomplete dose records:

- Internal exposures of uranium workers may also have led in some cases to heavy metal poisoning, notably of the kidneys. Such cases could have been better detected had internal dose information been a part of dose records.
- Improper medical diagnoses may have resulted in some cases because dose records were inadequate.
- Corrective measures to improve working conditions were likely delayed or not implemented in many cases because dose records did not show overexposures.

The problem was most acute in the period before the mid-to-late 1960s for two reasons. First, evidence indicates that this was the period when workplace conditions were the dirtiest and when workers were at higher risk of exposure. This observation cannot be used to arrive at conclusions about specific workers or even specific plants. But to date, most of the evidence we have examined indicates that for various reasons, exposures were generally highest in this period.

Second, this period is prior to the availability of counting techniques that allowed for direct measurement of body burdens. Action levels were set for radionuclides in urine. So long as the content of specific radionuclides was below these action levels, body burdens and worker doses were assumed to be below the maximum allowable limits. After lung and body-counters became available in the early 1960s, there were delays in using them, even after they were brought into use, for example in 1968 at Fernald, urine measurements continued to be the main method for monitoring internal dose.

Unfortunately, the monitoring procedure adopted by the DOE and its contractors was flawed. IEER's analysis of Fernald dose records in 1985 revealed the following problems:

- The lung burden inferred from urine data was consistently underestimated because of improper assumptions about the ratio of urinary excretion per unit of uranium lodged in lung tissues.
- Other was not monitored for all radionuclides.
- Urine monitoring was generally too infrequent to allow for accurate determination of body burdens and their change with time. Since many chemical forms of radionuclides are excreted relatively rapidly, infrequent monitoring was likely to miss doses from accidents and other occasional but high exposures. Further, in many cases, urine measurements were so infrequent that even chemical forms with relatively long biological half-lives would not have been accurately detected. As a result, low urine concentrations may not have corresponded to low exposure, but merely to a long

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Worker Doses, *from page 5*

time lapse between the intake of the radionuclide and the taking of urine samples (or lung counts).

- The solubility of the compound inhaled or ingested was not determined or, if known, was not recorded.
- The relationship of urine sampling time to exposure was, in most cases, unknown.

As a result of all these factors, the assumption that the dose was below allowable limits if the concentration of a radionuclide in urine was below the action level was scientifically unsound. Even when the actual doses were below allowable limits, the internal doses should have been entered into worker dose records and added to external doses in appropriate ways.

Whole-Body and Organ-Specific Doses

Radiation standards limit dose both to specific organs as well as to the whole body. Consider, for example, doses to the lung. The lung may be exposed by external gamma radiation from sources outside the body, resulting in doses essentially equal to those for other organs in the body. It may also be exposed from inhaled radionuclides. In order to ensure compliance with the lung dose limit, which was 15 rem in the 1950s through 1980s, DOE and its contractors only had to consider internal body burdens of radionuclides. (However, as we have indicated, before 1989 internal doses were not calculated from these data.) In most cases, such as at the Fernald plant, lung doses were inferred from measurements of uranium in urine. If these were found to be below allowable concentrations, compliance with the 15 rem/year limit was assumed to have been demonstrated.

In the period since the late 1980s, the regulatory practice has been to use "committed effective dose equivalents."[2] In this model, "effective dose" is calculated by multiplying doses to individual organs or tissues, like the thyroid, bone tissue, or the lung, with a weighting factor that accounts for the relative likelihood of cancer mortality from exposure to a particular organ. This allows exposures to a single organ and exposure of the whole body to be considered together. Further, internal organ doses are calculated on the basis of a fifty-year "committed" dose—that is, the entire dose from a radionuclide to an organ over a fifty year period (in most cases, the majority of the dose is delivered in a few years or less). These two concepts, "effective dose equivalent" and "committed dose" are put together to arrive at "committed effective dose equivalent." For regulatory purposes, the entire committed dose is assigned to the year in which the radionuclide is incorporated into the body. But even in this new practice, the organ doses arising from internal radiation must be known, because without that data, the correct effective dose equivalent cannot be calculated. This change in regulations requiring calculation of effective dose equivalents caused DOE to begin to move to a policy of integrating internal and external radiation doses.

While the unavailability of precise scientific techniques before the mid-1990s would have precluded accurate internal dose assessment, the doses could have been inferred from urine data and integrated into dose records, but were not. After the mid-1990s, the AEC and its contractors could have made relatively accurate worker dose estimates, but still failed to do so. It would appear that the same institutional outlook that put weapons production before environmental protection also relegated sound worker dose records into second place until the Cold War began to wind down.

> *The same institutional outlook that put weapons production before environmental protection also relegated sound worker dose records into second place until after the Cold War.*

Consequences of Underestimating Dose

Underestimation of internal doses is not just poor practice for worker health protection. It also creates problems for epidemiological studies. Accurate epidemiological work is needed to estimate the health risk of radiation exposure, and this requires studies with sound data on doses to various groups of workers.

Cohort studies, for example, compare the health status of people with various degrees of exposure. Such studies are common among worker populations and help to assess the risk of exposure to radiation (or other disease-causing agents). But if worker dose records are distorted by omission of a crucial component of dose, highly exposed workers and workers with low exposures could be jumbled up in ways for which no statistical control is possible.

For instance, studies that consider external exposure only would group workers with low external doses together and those with high external doses in another group. If some or all of the low external exposure group workers had higher internal doses than the high external exposure group, the study would be comparing workers with high exposure to others also with high exposure![3] Such a study would be misleading and lead to underestimate risk estimates. By contrast, if the high external exposure group had even higher internal exposures, the study would also be misleading and would tend to overestimate radiation risk.

See **Worker Doses,** *page 7*

Worker Doses, *from page 6*

The April 1997 DOE background paper also points out that lifetime dose records have not been carefully maintained through the risk to workers is based on lifetime radiation dose. If dose records are not transferred from one contractor to the next at a plant, or from one plant to another when the worker changes jobs, worker health as well as public health is compromised because it becomes impossible to accurately track the health effects of occupational exposure. Of course, this is another complicating factor in doing epidemiological studies and assessing radiation risk.

External Exposure Data

The state of external dose data also needs to be carefully examined. The DOE has admitted the following problems[4]:

- External exposure data are often incomplete and unreliable.
- Raw dose data and electronic versions of the data (which are often used by researchers in studies) do not always agree.
- In some cases, worker dose records contain entries stating that the dose was zero, regardless of what the actual dosimeter reading may have been.

Finally, there were very few measurements made of worker exposure to non-radioactive hazardous materials. But we do know from the nature of work done at nuclear weapons plants that many workers were exposed to or were at risk of exposure to acids, organic solvents, beryllium, fluorine and fluorides, and heavy metals.

As a result of all of these problems we can conclude that knowledge of workplace exposure during nuclear weapons production and testing was poor, and the results of at least some epidemiological studies are likely to be misleading. At present, it is impossible to say what health effects might be revealed by properly conducted studies. But we can say with confidence that the radiation doses for large numbers of workers were higher than those that are apparent from their dose records because internal doses were omitted until 1989, and because there were many deficiencies in other dose records.

▶

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

A CENTERFOLD FOR TECHNO-WEENIES

Exposure and Dose

This Centerfold provides information about dose in rad and how it relates to energy deposited in tissue, as well as a brief history of the evolution of radiation exposure standards and regulations. We also include additional information about Iodine-131 and thyroid doses received by the US public during the years of atmospheric testing.

A rad is defined as the deposition of 100 ergs of energy per gram of tissue. Since the measurement is *per gram*, then the same dose in rad can reflect very different radiation exposures, depending on the mass into which the energy is deposited:

If the dose is:	...and the total mass into which the energy is deposited is:	...then the total energy deposited is:
2 rad	2 grams (weight of an infant's thyroid)	400 ergs*
2 rad	20 grams (weight of an adult's thyroid)	4,000 ergs
2 rad	70,000 grams (the official definition of "standard man" in radiation protection practice; equal to about 154 lbs.)	14 million ergs

Conversely, the same amount of deposited energy can result in very different doses, depending on the mass into which the energy is deposited:

If the total energy deposited is:	...and the total mass into which the energy is deposited is:	...then the dose is:
4,000 ergs	2 grams (weight of an infant's thyroid)	20 rad
4,000 ergs	20 grams (weight of an adult's thyroid)	2 rad
4,000 ergs	70,000 grams (the official definition of "standard man" in radiation practice; equal to about 154 lbs.)	0.0006 rad

* To every day terms, an erg is a very small amount of energy. It takes about 1.3 million ergs to light a 60-watt bulb for one hour. But in the context of the way cells that make up living tissue work, 100 ergs is a large amount of energy. One erg is enough energy to disrupt tens of millions of the chemical bonds that hold molecules together.

For more on rad, rem and roentgen, see "Dear Arjun," page 13.

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Iodine-131

- **General:** its name is from the Greek word "iodeis," meaning "violet colored," after the violet color of iodine in a gas form. As a solid it is shiny, black and nonmetallic. In its non-radioactive form occurs on land and in sea in sodium and potassium compounds, and is necessary for proper functioning of the thyroid.
- **Half-life:** 8.01 days
- **Atomic number:** 53.
- **Decay mode:** beta radiation.
- **Sources:** Fission product created in nuclear reactors and in nuclear weapons explosions.
- **Release of Iodine-131 per kiloton of fission explosive power:** 125,000 curies.
- **National Cancer Institute estimate of Iodine-131 releases from the Nevada Tests:** 150 million curies.
- **Organ most affected:** thyroid.
- **Main pathway:** milk.
- **Other pathways:** ingestion of other dairy products, vegetables, fruits, and eggs; inhalation; and external irradiation.
- **Direct physical effects:** radioactive iodine damages or destroys thyroid cells.
- **Health effects:** Increased risk of thyroid tumors, notably in children. Likely increase of thyroid cancer risk in children exposed before the age of 15 years. Children under five at highest risk. Females have more than twice the risk of males. Linked to other thyroid disorders, such as autoimmune hypothyroidism, autoimmune thyroiditis, hypothyroidism incident to Grave's disease, and thyroid nodules.
- **NCI estimate of thyroid dose from Nevada Tests averaged over entire country:** 2 rad.
- **NCI estimate of thyroid dose to children aged 3 months to five years in high fallout areas:** 27 to 112 rad.
- **Official Iodine-131 release estimate from Chernobyl:** 7.3 million curies - decay-corrected to ten days after the start of the accident.
- **Iodine-131 inventory in the Chernobyl reactor on April 26, 1986, the day the accident started:** approximately 83 million curies.
- **IEER's rough estimate of actual releases from Chernobyl over the course of the ten-day fire:** 10 to 15 million curies (assuming the official estimate of a 20% release fraction is correct).

1931–34	US Advisory Committee on X-Ray and Radium Protection (precursor to the National Council on Radiation Protection and Measurements) adopts X-ray "tolerance dose" of 0.1 roentgen *per day*.
1940–41	US Advisory Committee proposes but does not implement, lowering the X-ray tolerance dose to 0.07 roentgen *per day*.
1942	U. of Chicago Metallurgical Laboratory adopts a "maximum permissible exposure" standard of 0.1 roentgen *per day*. Becomes standard for entire Manhattan Project.
1954	Atomic Energy Commission adopts National Bureau of Standards recommended dose limit of 5 rem *per year*. Sets additional limits for internal exposures at 1/5 rem per year for most organs.
1956	Dose limit for workers remains 5 rem per year. AEC also adopts dose limits for the public equal to one-tenth of those allowed for workers: 0.5 rem for external exposure and 1.5 rem for most organs for internal exposure.
late 1980s -1990	Department of Energy adopts dose limit for the public of 100 millirem (0.1 rem) per year; dose limit for workers remains 5 rem per year. A new model for calculation of internal doses in workers is adopted, the "committed effective dose equivalent." (See main article.)
1991	International Committee for Radiological Protection recommends worker dose limit be reduced to 2 rem per year. Recommendation is not adopted by DOE.

NOTE: [illegible]

IEER Releases New Report on "Clean-up" of Nuclear Weapons Complex

More than half a century of nuclear weapons production in the United States has created tens of millions of cubic meters of long-lived radioactive waste, decontaminating problems associated with thousands of contaminated facilities, and environmental problems involving contaminated land and water. The production of 70,000 nuclear warheads and bombs would have resulted in a problem of environmental remediation and waste management in any case. But the neglect and mismanagement of radioactive and toxic wastes have created problems that are far more costly than they might have been; some appear to be intractable with current technology.

IEER's newly released report, *Containing the Cold War Mess*, looks at the problem of environmental remediation and waste management of the nuclear weapons complex through case studies of three rather different problems, each important in its own way: a) transuranic waste management; b) high-level waste tank farms at Hanford; and c) radium- and thorium-contaminated wastes at Fernald. It also outlines alternatives that could be considered in reforming the environmental management program of DOE. The main findings of this report and a summary of recommendations are given below.

Main Findings

1. Nuclear weapons production and associated activities have created tens of millions of cubic meters of dangerous wastes and roughly two billion cubic meters of contaminated soil and water.

2. Since 1989, DOE has made considerable progress in characterizing many of the crucial problems of environmental remediation and waste management in the nuclear weapons complex, but much remains to be done.

3. DOE is proceeding with the most expensive environmental program in history without national remediation standards to govern and guide the process.

4. Despite about $40 billion dollars in expenditures since 1989, DOE does not have a sound direction, plan, priorities, or implementation strategy for dealing with remediation and waste management problems. Institutional factors are the single most crucial element in DOE's failure to achieve a sound direction.

The principal institutional problems that we have identified are:

- an attachment to Cold War technologies related to weapons research, development, testing, and production
- a tendency toward "environmentalization"—that is, rushing into big projects without proper preparatory scientific and engineering work (this tendency perhaps deriving from a desire to also maximize the flow of funds into the weapons complex)
- a lack of sound internal scientific and technical peer review that actually matters in decision-making, or in approval and implementation of large projects, and a corresponding tendency to ignore inconvenient extra-departmental advice
- a tendency to approve large budget increases for contractors without thorough engineering-based reviews of the problems that led to the budget changes
- a failure to learn lessons from past mistakes
- an attachment to the Yucca Mountain and Waste Isolation Pilot Project (WIPP) repository programs out of institutional, legal, political, and financial inertia even though these are compromising a much larger effort to remediate the weapons complex, manage long-lived highly-radioactive wastes, and develop a scientifically sound long-term high-level waste management program
- a lack of independent regulation of DOE's nuclear activities.

5. The U.S. waste classification system is on unsound basis for implementing waste management or environmental remediation decisions. (See NDA Vol. 6 No. 1.)

6. DOE is not holding contractors sufficiently accountable for project mismanagement and poor technical decisions.

7. A number of problems cannot be satisfactorily solved with presently available technology. Sound research and development and careful project planning will be needed over a long period.

Main Recommendations

The most important single reform that is needed is institutional in nature. DOE can make internal reforms at once. It should:

- create a project review structure for large projects that is both technical and financial in scope
- create a standing advisory committee to review projects from early stages through implementation both as regards their technical aspects and the reasonableness of budgets from an engineering standpoint. The majority of members on this committee should be free of conflicts of interest in regard to contracting with DOE or its contractors.
- reinstate the practice of issuing annual Baseline Environmental Management Reports, and make them more complete by including all sites, whether

See Report *page 10*

MILK *from page 1*

country would result in fallout spreading over most of the country. In a 1948 memo, an Air Force meteorologist advised the committee assigned to finding a test site that "Because the United States is predominantly under the influence of westerly winds, it seems obvious that the eastern coast areas of the United States may provide a suitable site."[12] But the site was located in the west, where the proximity to the weapons laboratories would allow for acceleration of the weapons program.

Doses Avoidable

Iodine 131 is a relatively short-lived radioisotope with a half life of 8 days. (See Centerfold for more information.) Therefore, radioactivity levels in contaminated milk would have decreased significantly several weeks after the time of detonation, making most of the iodine-131 doses to the public avoidable. Contaminated milk could have been dumped or diverted from the market and used for products such as dried milk, butter or cheese, which take longer to process and would allow time for the radioactivity to decay. But the government made no such provisions, though they were aware as early as 1953 of the "milk pathway," the primary source of exposure for iodine-131 in humans. Warnings about iodine-131 in milk were also issued at the 1955 United Nations Conference on Peaceful Uses of Atomic Energy, where researchers suggested that the then-allowable air concentration limits for iodine-131 were ten thousand times too high and should be lowered:

> This limit should be reduced by four orders of magnitude to provide protection solely for grazing animals. Approximately the same reduction is required for the safety of humans eating large quantities of fresh garden produce and drinking milk from cows grazing on some 10[3] contaminated pasture.[13]

An Oxford University delegation to the conference stressed that "human beings whose diet consists largely of milk, notably infants . . . become of their youth may be considered super-susceptible to the effects of radiation."[14] The advice of the UK delegates, while ignored by the AEC, was heeded by British officials in 1957 when, after a reactor accident that resulted in a release of 14,000 to 27,000 curies of iodine-131, ordered that milk within a 200-square mile area around the plant be dumped as a health precaution.

But even as the early 1960s, when the milk pathway was widely understood, the US government refused to acknowledge the risk of iodine-131 contamination or take measures to reduce it. In 1962 officials in Utah and Minnesota diverted possibly contaminated milk from the market when iodine levels exceeded radiation guidelines set by the Federal Radiation Council (FRC). In response, the FRC, whose members included the chairman of the AEC and the Secretary of Defense, declared that they did "not recommend such actions" and that such "countermeasures may have a net adverse rather than favorable effect on the public well-being."[15] Further, the FRC made the remarkable determination that their own radiation guidelines should not be applied to fallout without further detailed studies because "any possible health risk which may be associated with exposures even many times above the guide levels would not result in a *demonstrable* increase in the incidence of disease" (emphasis added). Since thyroid cancers can develop many years after radiation exposure and are therefore not immediately detectable, this reassurance was highly misleading.

While the public was not warned to refrain from milk consumption and was continually reassured that fallout posed no danger, the AEC was providing advance notice of tests, including "forecasts of contaminated areas based on meteorological data"[17] to the National Association of Photographic Manufacturers. This was done so that they could "anticipate local contamination and take preventive action"[18] to protect photographic film from being ruined by radiation exposure. The warning to the photographic industry began in 1951 – the first year of testing in Nevada – as a result of the Eastman Kodak Company's threat to sue the AEC over damaged film from nuclear fallout. The warnings continued throughout the atmospheric testing program but were not extended to the public.

Other Doses from Fallout

The United Nations Scientific Committee on the Effects of Atomic Radiation estimates that globally, iodine 131 doses comprise only about 2% of the overall radiation dose from weapons testing (dose integration time to the year 2000).[19] Ninety-eight percent of the dose is from other radionuclides. These calculations do not take hot spots into account, which may increase the relative share of iodine 131 dose. In addition, in areas of high precipitation both in the US and in other countries, hot spots probably resulted in high concentrations of other radionuclides besides iodine-131. Further work is needed to clarify which populations were most affected by testing throughout the world. So viet and Chinese testing could have affected populations in Alaska, for example, and there may be incidences of hot spots in the Pacific, including Hawaii, from French, British, and US Pacific area testing. There is also evidence from the NCI study that hot spots occurred in Canada and may have occurred in northern Mexico from Nevada tests.

A thorough assessment of the effects of all nuclear testing – not just US tests – is needed so that those at risk of high doses can receive proper screening. Soviet tests, for example,

See MILK *page 12*

Comment Documents 2-114 Depleted UF6 Final PEIS

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Milk, *from page 11*

had a larger total fission yield than US tests (110.9 megatons compared to 72.1 megatons), and the combined fission yield of Chinese, British and French tests was 34.2 megatons. IEER estimates that only a small fraction of the cesium-137 in the soil in the eastern United States is due to fallout from detonations at the Nevada Test Site. In light of the NCI findings, we make the following recommendations:

- An international study should be funded to carry out a global assessment of the effects of nuclear weapons testing and should follow a process that is open to the general public.
- France, Britain, China and the former Soviet Union should make public all their data on fallout.
- Further study should be conducted to assess the risk of cancer and other thyroid disorders from radiation doses.
- The US government should provide thyroid screening for those who were children at the time of atmospheric testing living in high fallout areas in the United States. The Agency for Toxic Substances and Disease Registry has suggested screening for those who received a cumulative dose of 10 rad or more while they were age 15 or younger.[9]
- The results of the NCI study should be made widely available to the public in a format that is accessible and understandable so that those who may be at risk can receive proper screening in a manner that reduces risk of disease.

This article is based on an article that appeared in the November-December issue of The Bulletin of the Atomic Scientists, *entitled "Worse Than We Knew." It is available on the web at "www.bullatomsci.org," and on IEER's webpage, "http://www.ieer.org/latestfindiant.html."*

The full text of NCI's study can be found on the web at "http://www.nci.nih.gov/newsroom/allout/fallout/contents.html."

1 Richard L. Sanders, "Historical Radioactivity Releases From the Storage of Nuclear Power Plant Spent Fuel," Institute for Energy and Environmental Research, August 1989, pp. 7-8 (explaining that the original "Fat Man" bomb dropped on Nagasaki had a yield of 21 kilotons, and the Trinity test bomb had a yield of 19 kilotons, and that "Little Boy" was 13 kilotons).

2 A discussion of the absorption of radiation, especially the importance of 90 Sr, and of the relative risk of exposure to 90 Sr, 137 Cs and 131 I, is found in Chapter 3 of Gofman, *Radiation and Human Health*.

3 E.B. Lewis, "Mortality of Sporadic Effects of Fallout Radiation," statement to Senate Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, 85th Congress, First Session on S. 3, Part 1, May 9, 10, 11, 12, 13, 14, 1957, Washington, U.S. Government Printing Office, 1957, Vol. 2, p. 1111; see also Lewis, Edward B., "Leukemia and Ionizing Radiation," *Science*, Vol. 125, No. 3249, pp. 965-972, May 10, 1957; and Lewis, Edward B., "Leukemia, Ionizing Radiation, and the Biology of Man," *Science*, Vol. 144, No. 3625, pp. 1302-1308, June 12, 1964.

4 Gofman, John W., *Radiation and Human Health*, San Francisco: Sierra Club Books, 1981, p. 312.

5 Gofman, John W., et al., "Preconception Irradiation of Paternal Reproduction: A Partial Analysis of Seven Studies," *Radiation Research*, vol. 101, 1985, pp. 2-3.

6 Gofman, John W., Seven statements, the first on 6 Apr. 1979, several updated reflections in Congressional Record, and a paper on this issue presented to the Senate, the source on this issue being cited here as Gofman. The observational reasons for this upper theory of the cancer-causing effects of low-dose radiation are seen to be produced by the previous properties that, whereas the energy lost by the electrons which are liberated in a region of the irradiation caused by the given ion. Therefore, in the case of photons under 150 kilovolts energy and by ordered X-ray doses, a dose can instead be delivered to every cell in a tissue or organ, so that the previous requirement is not met. Thus a person who goes to a dentist for a chest X-ray, or a woman who goes to a breast clinic for a mammogram, receives a dose that is distributed to all the cells in the organ irradiated. Such exposures are not associated with the cancer-causing effects of alpha particles, which deposit all their energy in a very small region of tissue. Gofman, John W., *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*, San Francisco: Committee for Nuclear Responsibility, Inc., 1990, p. 22. Of course, in principle, some of the cells in the tissue may be hit by both electrons and alpha particles, but since the latter are much more damaging per energy deposited, the overall effect is dominated by the alpha particles.

7 Ibid., p. 3.

8 Jan Beyea, "Related Aspects of Low-Dose Exposure from Nuclear Power Plants," testimony before the Senate Appropriations Committee on Energy, Water, and Related Services, Subcommittee on Energy Research and Development, October 1, 1987.

9 National Cancer Institute Press Release, "Statement and Questions on the NCI Fallout Report," August 1, 1997, pp. 2-3.

10 Ibid., p. 3.

11 Jan Beyea, "Related Aspects of Low-Dose Exposure from Nuclear Power Plants," Testimony before the Senate Appropriations Committee on Energy, Water, and Related Services, Subcommittee on Energy Research and Development, October 1, 1987.

12 National Cancer Institute Press Release, July 28, 1997, p. 3.

13 "Executive Summary, National Cancer Institute Study Estimating Thyroid Doses of I-131 Received by Americans From Fallout from Nevada and Trinity Tests," p. 4. Obtained by National Cancer Institute Press Office, August 1, 1997.

14 NCI Institute Fact Sheet Table Three A, "Estimates of per capita average thyroid dose received from all tests, and estimated uncertainties (geometric standard deviations, GSD), and populations in each county of the contiguous U.S. receiving most of dose," pp. 1-31. Obtained on NCI Press Packet August 1, 1997.

15 Edward B.G. Williams, 1948, Wall Street Journal, Advertisement in Editorial Format, "Subject: On the Atomic Bomb Experiments," April 30, 1948. Atomic Age Citizens, Long Island Committee for a World Government, Inc., Mineola, N.Y. (Proposing to use the US Army "Small Bomb" Experiment to show a 20-mile Radius Atomic Weapons Test Area). The ad stated that the annual Nevada Test Series is supposed to have only resulting in the explosion of the size of the bomb which destroyed Hiroshima, and would not have caused significant problems, but the explosion of the size of the bomb which destroyed Nagasaki would have caused significant problems.

16 U.S. Congress, Joint Committee on Atomic Energy, "Worldwide Effects of Nuclear Explosions," Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, 85th Congress, First Session on S. 3, Part 1, May 9, 10, 11, 12, 13, 14, 1957, Washington, U.S. Government Printing Office, 1957, Vol. 2, p. 1111; see also Lewis, Edward B., "Leukemia and Ionizing Radiation," *Science*, Vol. 125, No. 3249, pp. 965-972, May 10, 1957; and Lewis, Edward B., "Leukemia, Ionizing Radiation, and the Biology of Man," *Science*, Vol. 144, No. 3625, pp. 1302-1308, June 12, 1964.

17 Gofman, John W., et al., "Preconception Irradiation of Paternal Reproduction: A Partial Analysis of Seven Studies," *Radiation Research*, vol. 101, 1985, pp. 2-3.

18 Gofman, John W., Seven statements, the first on 6 Apr. 1979, several updated reflections in Congressional Record, and a paper on this issue presented to the Senate, the source on this issue being cited here as Gofman. The observational reasons for this upper theory of the cancer-causing effects of low-dose radiation are seen to be produced by the previous properties that, whereas the energy lost by the electrons which are liberated in a region of the irradiation caused by the given ion. Therefore, in the case of photons under 150 kilovolts energy and by ordered X-ray doses, a dose can instead be delivered to every cell in a tissue or organ, so that the previous requirement is not met. Thus a person who goes to a dentist for a chest X-ray, or a woman who goes to a breast clinic for a mammogram, receives a dose that is distributed to all the cells in the organ irradiated. Such exposures are not associated with the cancer-causing effects of alpha particles, which deposit all their energy in a very small region of tissue. Gofman, John W., *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*, San Francisco: Committee for Nuclear Responsibility, Inc., 1990, p. 22. Of course, in principle, some of the cells in the tissue may be hit by both electrons and alpha particles, but since the latter are much more damaging per energy deposited, the overall effect is dominated by the alpha particles.

19 U.S. Atomic Energy Commission, "Report by the Director of Military Application, Concerning Relations between the AEC and the Biomedical Industry Supporting Radioactive Commodities Program," Washington D.C., Joint Committee of Atomic Energy, November 17, 1961, p. 8.

20 DOE and predecessors, Physicians for the Prevention of Nuclear War, Radioactive Waste Disposal, New York: Apex Press, 1991, p. 37. Reports are based on whole body measured cancer dose equivalent.

21 Robert Alvarez et al., "Radiological Monitoring Program: Background Considerations Documents and ATSDR Decisions," publication number 1997-100819, 1-A Issue 3.0, Page 47 (Table 3.0-1 and Thorium Data), Public Health Service, Agency for Toxic Substances and Disease Registry, July 1997, p. 47.

Errata

In SDA Vol. 6 No. 1 (on radioactive waste management), the entry in the "Radioactivity" column of the "Uprated Uranium" row on the table appearing on pages 10-11 should read "31.2," to that same table, the entry in the "Rocketdyne States" column of the "Uranium Mill Tailings" row should read "UMTRA and Uranium Mill Tailings Radiation Control Act."

In SDA Vol. 5 No. 4 (on MOX), lines 9 and 10 of the middle column of page 2 should read, ". . . between 8 to 10 million gallons of liquid waste . . ." Our thanks to James C. Ward of Los Angeles, CA for pointing out this error. You win $25! This is a standing offer to SDA readers! IEER will award $25 to the first person sending in a correction of arithmetic errors appearing in SDA, as well as our gratitude for keeping us on our toes!

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Dear Arjun

Dear Arjun:

What's the difference between a rad, a rem, and a roentgen?

—Mixed-up in Margaritaville

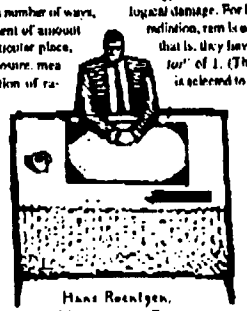
Dear Mixed-Up:

In the 1960s in the United States, individuals who were deeply involved with the so-called counter-culture were sometimes referred to as *radical*, or *"rad"* for short. There were also individuals who didn't want to rock the boat too much, but still liked to be associated with the counter-culture, who were called *"rem,"* short for "regularly enlightened mainstreamers." Everyone else was considered by the rad and rem to be part of the "rank and file," which was later shortened to *"roentgen* file," after a particularly mainstream leader of the time, Hans Roentgen.

But unbeknownst to these radicals, *rad, rem* and *roentgen* had already been used as units to express *doses* from radiation exposure. Radiation dose is calculated in a number of ways, including measurement of amount of radiation at a particular place, measurement of exposure, measurement of absorption of radioactivity, and of relative effect of that absorption on different organs or types of tissue. Dose calculations take into account the type of radiation involved (alpha, beta, gamma, or neutron). Radiation doses can also be expressed in standard international units, sieverts or grays (one sievert equals 100 rem, one gray equals 100 rad).

A *rad*, or "radiation absorbed dose," is a unit of *absorbed* dose equivalent to the deposition of 100 ergs of energy per gram of tissue. (See Clusterfold for more on rad and ergs.) Since a rad measures deposition of *energy per gram of tissue*, a 2-rad dose to a certain organ, like the thyroid (which weighs roughly 20 grams), reflects a very different total deposition of energy than does a 2-rad dose to the entire body (typical weights range from 40,000 to 100,000 grams).

A *rem*, or "radiation equivalent man," is a unit of absorbed dose that takes into account the relative biological damage caused by the various ways that ionizing radiation deposits its energy in tissue (known as the Relative Biological Effectiveness, or RBE). In general the larger the amount of energy absorbed, the larger the biological damage. For beta and gamma radiation, rem is equivalent to rad; that is, they have a *"quality factor"* of 1. (The quality factor is selected to approximate the RBE as it relates to overall risk, and is used in regulatory practice to convert radiation dose measured by energy deposited in radiation dose measured in terms of biological damage.)



Hans Roentgen, Mainstream Guy

For alpha radiation, which involves heavy particles, much more damage is done per unit of energy deposited. Increasing the ratio between damage to tissue and energy deposited. The currently accepted quality factor for alpha radiation is 20, but may change as more is learned about damage due to ionizing radiation. Neutron radiation has a varying quality factor between 5 and 20, depending on neutron energy. Rem is the unit used to express regulatory limits for radiation exposures.

A *roentgen* (abbreviated "R" and pronounced "rent-gen") measures gamma and beta radiation dose based on the amount of ionization in the air. It is the common form of calibration of radiation measuring instruments because the beta and gamma radiation broken up inside the instrument, creating electrically charged particles which can be measured by creating an electric current in the instrument. A roentgen is a unit of radiation dose that causes an ionization charge equal to 2.58×10^{-4} (0.000258) coulombs per kilogram of air.* Because it measures ionization in air and not in tissue, there is no exact, fixed correspondence between roentgen and rad, but an approximate equivalence is that one roentgen equals 0.93 rad for non-body biological tissue. Since the uncertainties in dose calculation are typically far larger than 7 percent, one roentgen is often considered about equal to one rad, for convenience.

* A coulomb is a unit of electrical charge. The charge of an electron is 1.6×10^{-19} coulomb.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

It Pays to Increase Your Jargon Power

by Dr. Egghead

1. body burden

a. The strain felt by writers when they have written introductory and closing paragraphs, but still have to write the rest of an essay.

b. What diet pill companies want people to believe they have.

c. What you feel when you get the bill from the auto body shop.

d. The amount of a radioactive material deposited in the body at a given point in time (in units of mass or radioactivity).

2. whole body counter

a. A specially-designed surface in diners where customers can eat while lying down.

b. Someone not content to do just a headcount.

c. A hospital employee whose job it is to count how many whole bodies came out of the operating room.

d. A chamber equipped with instruments to measure gamma radiation being emitted from anywhere in the body.

3. ALARA

a. The younger, lesser-known sister of Evita.

b. Name of a failed apple harvesting company.

c. Acting in the manner of Ra.

d. Acronym for "As Low As Reasonable Achievable." Usually "ALARA Principle," which dictates that radioactivity released to the environment and radiation doses be not merely in compliance with regulations, but further reduced below the allowable limits, given the technological and financial resources available.

4. effective dose equivalent

a. The number of naps taken during the day by a nuclear plant operator working night shifts to effectively enable him or her to stay awake on the job.

b. The dose delivered by a placebo that works as intended.

c. What a swig of whiskey was back in the days before anesthesia.

d. A dose estimate that takes into account the combined effects of internal and external radiation, the selective uptake and distribution of radionuclides, and their varying effects on different organs. The effective dose equivalent is calculated by multiplying the dose to an individual organ, such as the lung, by a weighting factor which addresses the likelihood of a cancer mortality from radiation exposure to that particular organ.

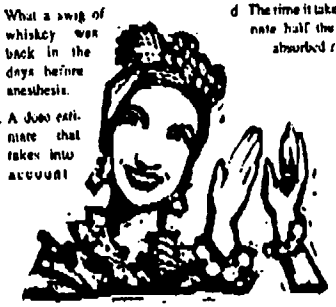
5. biological half-life

a. The time it takes for half a room of biology students to fall asleep.

b. The portion of a soccer player's life spent playing halfback.

c. The time it takes for half a log to decay.

d. The time it takes the body to eliminate half the mass of a given absorbed radionuclide.



ALARA

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

ATOMIC PUZZLER

Gamma dosing on the job...

Back in the late 1980s, when Dr. Egghead's trusty sleuthing dog Gamma was just a pup, the Department of Energy began using a method of worker dose calculation referred to as the "committed effective dose equivalent." Even then, Gamma was interested in such things and would entertain himself by calculating effective dose equivalents for workers (Always the workhound, that Gamma.) He recently fetched his old records and was hoping for some help in completing some unfinished dose estimates. Note that Gamma was at that time learning the Standard International units of becquerels and sieverts, and so was converting from rems and picocuries to sieverts and becquerels. His notes are reprinted below, paw prints, conversions, and all, except for the final dose calculation:

A worker is exposed to an annual average concentration of uranium 238 of 27 picocuries per cubic meter of air—or 1 becquerel per cubic meter of air.

The worker breathes 9.6 m^3 (cubic meters) of air on each working shift (8 hours) and works 200 shifts per year.

The dose conversion factor for the lung is 9.84×10^{-4} rem per picocurie—or 2.66×10^{-4} sieverts per becquerel. (Gamma converted rems to sieverts by dividing by 100. He then multiplied the result by 27 because there are 27 picocuries per becquerel. Try it!)

The weighting factor for the lung is 0.12.

Assuming no other organ is affected, what is this worker's dose in rem? (Note: This dose is called the "committed effective dose equivalent." See main article.) Round to 2 decimal points. What is the committed effective dose equivalent in sieverts?

Hint: The dose conversion factor is used to convert radiation intake into dose. The weighting factor converts the lung dose into the effective dose equivalent.

Gamma the puppy calculating worker doses.

Send us your answers via fax (301-270-3029), e-mail (ieer@ieer.org), or regular mail (IEER 6935 Laurel Ave., Suite 204, Takoma Park, MD 20912), postmarked by Dec. 19, 1997. IEER will award 25 prizes of $10 each to people who send in a solution to the puzzle (by the deadline), right or wrong. There is one $25 prize for a correct entry, to be drawn at random if more than one correct answer is submitted.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Report *from page 10*

closed or operational.

Such internal reforms are unlikely to solve the entrenched problems that we have discussed above. We recommend that President Clinton appoint a commission on Institutional Reform of Environmental Remediation and Waste Management. The commission should hold hearings around the country and make definitive recommendations within a six- to twelve-month period.

Whatever the reform chosen, general technical principles will need to be adopted and reforms implemented to restructure the environmental management program. Specifically, the government should:

1. *Create a new, national, environmentally-protective system of radioactive waste classification* according to longevity and specific activity, so that comparable hazards are managed comparably.

2. *Coordinate waste management and environmental remediation* and make reduction of short-term risks compatible with minimizing long-term risks.

3. *Approach remediation with independently enforced, national, health-based cleanup and waste management standards*, including specific provisions to protect groundwater resources and mandatory guidelines to keep doses as low as reasonably achievable (ALARA) both for workers and for off-site populations. The ALARA guideline for releasing sites for unrestricted use should be to remediate to background levels, if reasonable, or else to keep doses to under 2 millirem per year (which is the British ALARA guideline).

4. *Suspend the politically expedient Yucca Mountain and WIPP repository programs and put in place a scientifically sound program of long term high level waste management*, including repository research, subseabed disposal research, and research on materials to contain radioactivity that are analogues to natural materials that can last for millions of years.

5. *Provide funds and technical support to communities that have residual contamination* so that they can monitor the environment and keep themselves informed. Such funds are needed to protect communities against future known risks and also against risks due to inadequate characterization or present incomplete understanding of risks. The size of the fund should depend on the size and character of the residual radioactive and non-radioactive hazardous contamination of land, remaining structures, surface waters, river beds, and groundwater, as well as the total amount of radioactivity and non-radioactive hazardous material left in disposal areas on site.

6. *Manage non-radioactive toxic components of wastes in ways that do not seriously compromise management of radioactive components.*

7. *Stabilize waste so as to greatly reduce or eliminate the most serious environmental and health threats* and store it on site while sound long-term management strategies are developed.

8. *Provide the states, Indian tribes, and the public (with special emphasis on the affected communities and workers) with timely information* so that they can participate effectively in decision making.

To order a copy of the full 300-page report, see the publication information box on p. 7.

The Institute for Energy and Environmental Research
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Takoma Park, MD 20912

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

The Portsmouth Daily Times
Friday, September 20, 1996
Page A9

Cylinder plug damaged at Lockheed Martin plant

By Martin Poston
Times Staff Writer

The U.S. Department of Energy reported that there was a small release of material at Lockheed Martin Energy Systems in Piketon as a result of a damaged cylinder plug on a 14-ton cylinder, which contained about 18 pounds of uranium-238.

The cylinder plug was replaced, and a precautionary environmental sampling was taken.

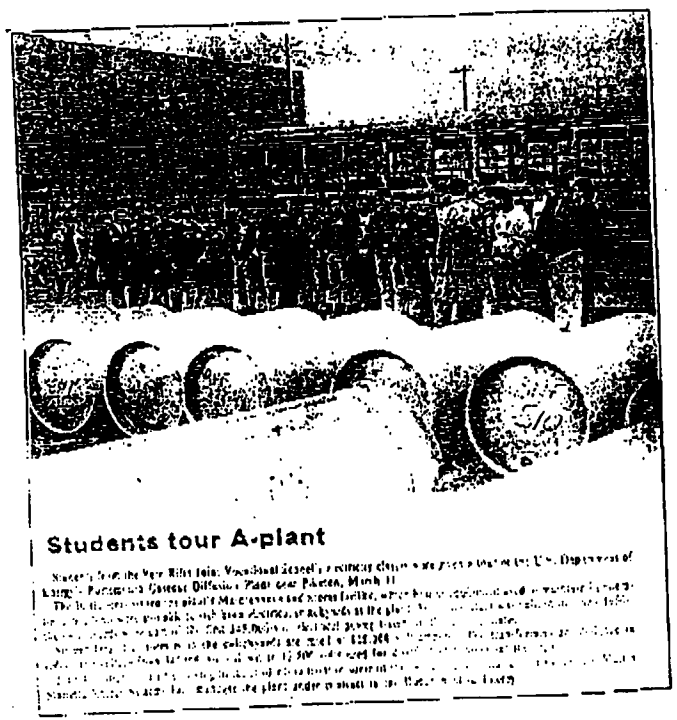
Officials at the plant said that a worker was operating a vehicle to move cylinders in a storage yard, when he accidentally struck a cylinder plug on a cylinder that contained uranium hexafluoride. There were no injuries in the accident, and the cylinder contained no enriched uranium.

As a precautionary measure, traffic on the perimeter road of the plant was rerouted for a brief period between the north and west access roads.

Feb-26-98 10:08A PORTS Environ Info Ctr 614 947-4980 P.05

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

The Waverly News Watchman
April 6, 1993
Page 6
6,200 (Tues. & Fours.)



Students tour A-plant

Students from the Vern Riffe Joint Vocational School's electricity classes were given a tour of the U.S. Department of Energy's Portsmouth Gaseous Diffusion Plant near Piketon, March 11.

[illegible]

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

MILITARY TOXICS PROJECT

471 Main Street, 2nd Floor
Lexington, MD 20510

phone: (207)765-2081
fax: (207)765-2086
e-mail: mtp@tpc.net.org

February 4, 1998

Charles R. Bradley, Jr.
U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
19901 Germantown Road
Germantown, MD 20874

Copy of this Letter into Records with support From PRESS.

Press is a member group of Military Toxics Project

Dear Mr. Bradley

Secretary Pena recently held a press conference in Washington D.C. to tout his Openess Initiative. We hope that this willingness to be open includes efforts to be more inclusive in DoE's outreach to impacted, or potentially impacted communities.

Specifically of concern to the Military Toxics Project and the Indigenous Environmental Network is the Draft Programmatic Environmental Impact Statement For Alternative Strategies For The Long-Term Management And Use Of Depleted Uranium Hexafluoride.

We believe that all of the strategies that proposed have serious environmental justice concerns and potential impacts to communities that you have not adequately reached with the draft PEIS. We also believe that the meetings that the DoE has held in the past, as well as the ones that are beginning on February 19, 1998 in Paducah, are not properly reaching people who are or may be impacted by decisions that your agency will be making regarding the long-term plan for the use of this dangerous material.

Keeping with the spirit and intent of President Clinton's Executive Order on Environmental Justice, and Secretary Pena's Openess Initiative, we feel that it would be reasonable to request that the DoE initiate roundtable meetings, much like the Federal Facilities Restoration Dialogue meetings. We believe that it is necessary and just to bring in grassroots leaders from community, labor and environmental justice groups to further discuss the implications of strategies that have been proposed.

We further request that the comment period be extended to six months to give these folks the opportunity to meet with you. In addition to the hearings that are taken place now, as well as the opportunity to obtain expert technical advice regarding the impact of the various different strategies.

Please respond to our request in writing. We will be happy to suggest participants for a roundtable discussion.

Sincerely,

Cathy Lemar
Cathy Lemar, Director
Military Toxics Project

Tom Goldtooth
Tom Goldtooth, Director
Indigenous Environmental Network

Don Paley
Don Paley
Swords To Plowshares

cc: Energy Secretary Federico Pena

MTP is a project of the Tides Center

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.)
MCDERMOTT, OHIO

1144 Maingate Road
Niskayuna, NY 12309-1315
(518) 377-8203

June 29, 1997

NY Times Bureau
Attention: Mr. Matthew L. Wald
1627 I Street NW
Washington, DC 20006

Dear Mr. Wald:

I am writing to you regarding an article you published in the NY times on March 14, 1997. The title of the article is, "Danger From Uranium Waste Grows as Government Considers Its Fate." Midway through the article you say, "But there was never enough thought given to the final use of the uranium-238, and the leftovers have accumulated like raisin bran with all the raisins picked out. But this leftover is still slightly radioactive because a little of the uranium-235 remains." This statement that the depleted uranium in the storage cylinders at Piketon, Ohio is only slightly radioactive unfortunately is not true. Contrary to public perception, the uranium-235 isotope plays only a very minor role in the radioactivity of either natural uranium or depleted uranium.

I am a retired physicist who worked at the Knolls Atomic Power Laboratory from 1955 to 1983 in Schenectady, NY. On the 26th of June I testified before Congressman Christopher Shays' Sub-Committee on Human Resources concerning the use of depleted uranium munitions during the Gulf War and its potential as one of the causes of Gulf War Illness, also called Gulf War syndrome. On the panel with me was Dr. Asaf Durakovic, former Chief of Nuclear Medicine Service, Wilmington, DE, Veterans Affairs Medical Center. Dr. Durakovic is an internationally recognized expert on the internal contamination of radioisotopes. A copy of his testimony is attached, in which he states that "DU is still very radioactive..."

I would like to illustrate for you the physics reality underlying Durakovic's statement. In Table I I have listed the isotopic compositions of natural uranium and depleted uranium. Using these values I have computed the disintegrations per second of each isotope in one gram of uranium. The results are given in Table II.

Table I. Isotopic composition of natural and depleted uranium in atom percent. The isotopic compositions for uranium-234 (U-234), uranium-235 (U-235) and uranium-238 (U-238) were measured in highly sensitive and accurate mass spectrometers at the Knolls Atomic Power Laboratory, Schenectady, NY.

	U-234	U-235	U-238
Natural Uranium	0.0058	0.7196	99.2746
Depleted Uranium	0.0008	0.2018	99.7947

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MCDERMOTT, OHIO

Table II. The number of nuclear transformations (disintegrations) per second for each isotope in 1-gram of natural uranium and in 1-gram of depleted uranium. These are the alpha particle activities only.

	U-234	U-235	U-238
Natural Uranium	12380	568	12280
Depleted Uranium	1788	160	12325

Theoretically, the disintegration rates of U-234 and U-238 in natural uranium should be identical, because the U-234 is in secular equilibrium with its parent isotope, U-238, the first isotope in the long uranium decay chain. The slight difference results from using only two significant figures in reporting the 0.0055% and small errors in measuring its abundance by mass spectrometry. From Table II we see that the U-235 activity in natural uranium is 568/(12380 + 568 + 12280) = 0.022, or only 2.2% of the alpha particle activity in natural uranium. Similarly, the U-235 activity in depleted uranium is 160/(1788 + 160 + 12325) = 0.011, or only 1.1% of the alpha particle activity in depleted uranium. Clearly, U-235 contributes little to the total alpha particle radioactivity of each kind of uranium.

But this is not even half of the story about the radioactivity of depleted uranium. U-238 decays into thorium-234 (Th-234); thorium-234 decays into protactinium-234 (Pa-234); and protactinium-234 decays into U-234, etc. down the long uranium decay chain. The thorium and protactinium emit energetic beta particles and gamma rays both have short half lives and therefore are in secular equilibrium with U-238, i.e. all three isotopes are decaying at the same rate. See Table III.

Table III. Disintegrations per second in 1-gram of natural uranium and in 1-gram of depleted uranium for U-238, Th-234 and Pa-234 in secular equilibrium with each other. Half lives used: U-238 = 4.47 billion years; Th-234 = 24.10 days; Pa-234 = 1.17 minutes, 6.66 hours (two decay pathways).

	U-238 →	Th-234 →	Pa-234
Natural Uranium	12280	12280	12280
Depleted Uranium	12325	12325	12325

Note that in depleted uranium the U-238 and its decay progeny are decaying at slightly higher rates than the corresponding isotopes in natural uranium. This is because 0.5% of the U-235 in natural uranium has been removed, as is shown in Table I.

You could not have gotten your statement about the low radioactivity of depleted uranium in storage at Piketon, Ohio from any scientific publication, therefore I assume that someone told you this. Whoever it was, he or she did you a great disservice, because it is so far off the mark that it damages your credibility in the scientific community. Furthermore Dr. Durakovic's testimony indicates how easily micrometer aerosol particles of uranium can be inhaled and pass from the lung into the blood stream, from whence they can go anywhere in the body. This makes inhaled depleted uranium particles (or any other kind of uranium) extremely dangerous to health. Furthermore, it is well known that the 2.23 million electron volt beta particles (fast electrons) from

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Pa-234 have a range of 0.5-inch in water. Our bodies are at least 75% water and have an average density close to that of water, therefore one of these fast electrons can penetrate the same distance in body tissue. This means that each Pa-234 beta particle can traverse more than 500 body cells, potentially damaging DNA molecules in the nuclei of cells. A sufficient number of these hits eventually will cause cancer.

I urge you to show this letter to someone you trust, a person with a scientific background who understands the physics of radioactive decay chains and can make independent calculations of the results I show in Tables I through III.

For the latest background information available on the depleted uranium munitions issue and its possible link to Gulf War illnesses, obtain a copy of the recently published book, *Metal of Dishonor*. A copy can be obtained from the International Action Center (Sara Flounders/Frank Alexander Tel: 212-633-6646; Fax: 212-633-2889). It contains a chapter by me entitled, "DU Spread and Contamination of Gulf War Veterans and Others." I submitted it as my written testimony before the Congressional Sub-Committee on Human Resources. Dr. Durakovic can be reached at Tel: 301-681-8258; Fax: 302-633-5490.

A final comment: When are you folks at the New York Times going to stop letting Bill Mesler at *The Nation* run circles around you, scooping you at every turn about the growing scandal surrounding depleted uranium and its use in the Gulf War, and how it is now suspected of causing some of the illnesses being experienced by sick veterans! For example, I testified to the Sub-Committee that in 1979 my colleagues and I at the Knolls Atomic Power Laboratory had measured depleted uranium emissions in air filters exposed at the Knolls site and documented the measurements in a 1980 report. The contamination was coming from the National Lead Industries plant outside Albany, NY, 10 miles east of the Knolls site. We also measured the airborne depleted uranium emissions at another site 26 miles NW of the NL plant. I stated that I had given a copy of my report to the Sub-Committee. Yet, after my testimony, an Army colonel testified that because uranium is dense and heavy, they had measured that it falls to the ground close to a struck vehicle. When Chairman Shays challenged him about my 26 mile fallout statement, the colonel had no answer. At the conclusion of all the testimony, another Army colonel from the Armed Forces Radiobiolgy Research Institute (AFRRI) made the following statement, "I want to go on record that it is AFRRI's position that depleted uranium is not dangerous." Incredible!

Sincerely,

Leonard A. Dietz

Attachment.

Copy to: Philip Shenon, NY Times, 1627 I Street NW, Washington, DC 20006.

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

TOUCHING BASES

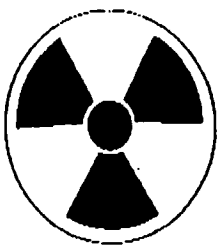
Newsletter of the Military Toxics Project
First Quarter 1993

National Grassroots Networking Toward Pollution Prevention and Environmental Justice

How Depleted Uranium Effects Each of Us

The Department of Defense (DoD) has known since at least 1960 that human exposure to depleted uranium (DU) could result in serious, long-term health disorders. Yet, it refuses to acknowledge publicly the growing list of maladies exhibited by veterans and public citizens alike who have come in contact with this substance.

As investigations heat up concerning Gulf War Syndrome and the many horrible chemicals to which soldiers were exposed in the Persian Gulf, DU is noticeably absent from public discussion. The US Government appears to be burying the story in the sands of the Middle East.



Some opponents of DU manufacturing have characterized the radioactive material as the "Agent Orange" of the 90's, citing the far-reaching, negative effects that DU has on human health and the environment throughout its entire life-cycle. DU harms not only troops and rescue workers on the battlefield, but also the communities near uranium mines, the workers who process uranium and manufacture DU weapons, the communities whose land is contaminated by DU weapons testing and warfare, and the communities who ultimately serve as DU waste repositories.

This issue of *TOUCHING BASES* describes many of the slices of the DU pie. It is MTP's hope that when the DoD finally admits to the severity of the DU crisis, it will address each of these important areas, and provide full disclosure about others we may have missed.

In This Issue...

Message from MTP's Director
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Gulf War Vets Post the Effects of DU
Indigenous Communities
Exposure in the Workplace
Local Communities
Creating Needs for DU
Recent Concerns from Japan
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[illegible]
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US Destruction of Philippines Bases Lingers on
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Georgia Legislature Votes to Delay Construction
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EPA Rules on Chemical and
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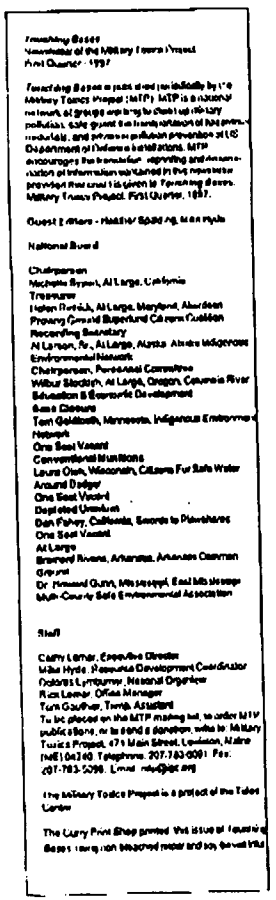
COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.)
MCDERMOTT, OHIO



Newsletter of the Military Toxics Project
First Quarter - 1997

Touching Bases is published bi-monthly by the Military Toxics Project (MTP). MTP is a national network of groups working to clean up military pollution, safe guard the health of base personnel, residents, and promote pollution prevention at US Department of Defense installations. MTP encourages the broadest reprinting and dissemination of information contained in this newsletter provided that credit is given to *Touching Bases*, Military Toxics Project, First Quarter, 1997.

Guest Editors - Heather Sidell, Helen Hyde

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The Military Toxics Project is a project of the Tides Center

The Cherry Pond Shop printed this issue of *Touching Bases* using non-bleached paper and soy based inks

A Message From MTP's Director

As we come into Spring, there is a lot of activity in the MTP office, as well as in MTP campaigns. We are glad that we have the opportunity to work with all of you and look forward to continuing that relationship.

This issue of *Touching Bases* is long overdue. All of us are excited about the new look and all the good news that is being reported by all of you. This issue is dedicated to the problems associated with Depleted Uranium (DU). What we hope to do is to show the *full picture* of DU -- from cradle to grave -- and the many lives it has affected. We hope that after you read the information provided, you will get as angry as we are that, thanks to Uncle Sam, these weapons still are being produced, tested, used and disposed of in this country and in others. The Pentagon would prefer that we all just go away and leave this particular subject alone. But, the continued production, testing and use of these weapons has the potential to affect the health of many generations to come. We are going to bring together each piece of the DU pie, so that readers will have the total picture. We hope that you get mad enough to let your Congressional Representatives know what you think of DU munitions.

MTP also is gearing up for Board Elections once again. This is the time to get in your nominations for at-large elections. For members of MTP network campaigns, it is time to start thinking of what member in your network you want to have representing your concerns on the MTP Board. Nomination ballots will be mailed out soon to all network members.

This summer, MTP will hold its annual Board Meeting, which will be open to all MTP members and allies. At this meeting, the Executive Committee will be elected. This will also be the first meeting that new board members will be attending.

Finally, we are so proud of those of you out on the front lines in communities, workplaces and veterans organizations that have done so much for so many. Keep up the good work!

Cathy Lerner
Executive Director

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.)
MCDERMOTT, OHIO

What is Depleted Uranium?

The *Handbook of Chemistry and Physics* states, "Uranium is a silvery metal, which is pyrophoric [i.e., capable of igniting spontaneously] when finely divided. It has fourteen isotopes, all of which are radioactive." Naturally existing uranium refined from ore is made up largely of U-238, a relatively stable isotope of the element, from which the highly fissionable isotope U-235 is extracted for nuclear weapons and power uses. After the U-235 is partially extracted (reduced from approximately .7% to .2% of the natural uranium), the remainder is misleadingly called "depleted uranium." It still can be used for nuclear weapons and energy programs by being transformed into plutonium in a breeder reactor, and it is still radioactive and toxic. Recent studies indicate there is no threshold level of radiation below which an exposed person is safe from radiation damage, and though DU is less radioactive than U-235 or plutonium, it remains an extremely harmful substance with the chemically toxic properties of many heavy metals.

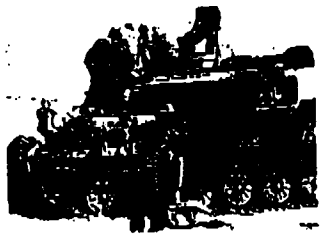
Because of uranium's extreme density, DU can be used to make munitions and armor of great density. The penetrators made with DU have great range and velocity -- velocity that gives them an ability to penetrate most kinds of armor (including otherwise virtually impenetrable DU armor, as Gulf War friendly fire casualties demonstrated).

DU burns on impact, spreading into the atmosphere and creating a small-scale fallout of aerosolized uranium particles which can be inhaled or ingested from the air or by contact with contaminated materials and sites. The particles can travel anywhere that dust goes.

Gulf War Vets Feel the Effects of DU

by Dan Fahey, Swords to Plowshares

Armor-piercing projectiles and tank armor made of DU proved highly effective in their first combat test during Operation Desert Storm. However, military commanders blatantly ignored the serious health and environmental impacts of shooting bullets made of radioactive waste. As a result, tens of thousands of soldiers and civilians were exposed to more than 600,000 pounds of DU contamination, which still remains on Gulf War battlefields. Though the proliferation of DU weapons since the Gulf War threatens to accelerate the spread of DU around the world, the impacts of DU weapons can be prevented if action is taken now.



FIRING TEST OF THE KOREAN [illegible] EXPOSED WITH PARTICLES

When a DU round strikes a target, up to 70% of the round burns, scattering radioactive and chemically toxic dust in and around the target. DU poses its greatest danger to human health when its dust is inhaled or ingested. An Army report on DU completed six months before Desert Storm noted that "aerosol DU exposures to soldiers on the battlefield could be significant with potential radiological and toxicological effects." The same report also stated that "short term effects of high doses can result in death, while long term effects of low doses have been implicated in cancer." Despite these warnings, military officials failed to inform soldiers about the use and dangers of DU weapons during Operation Desert Storm.

During and after the ground war, tens of thousands of soldiers climbed on and entered destroyed vehicles -- many of which were covered in uranium dust -- to look for hiding Iraqi soldiers, to remove any usable equipment, or just to examine the shattered tanks. It was not until a week after the cease-fire ending Desert Storm

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.)
MCDERMOTT, OHIO

that a message was sent to Army commanders warning that "any system struck by a DU penetrator can be assumed to be contaminated with DU." Yet, even after this message was sent, information about the presence and dangers of DU contamination was never passed on to soldiers in the field.

A 1993 General Accounting Office report, aptly titled *Army Not Adequately Prepared to Deal with Depleted Uranium Contamination*, revealed that even the soldiers of the 144th Supply Company of the National Guard, who were tasked with recovering DU vehicles contaminated by DU in friendly fire incidents, were never told of "the existence of DU contamination or radiation hazards," and that they worked on contaminated vehicles for several weeks "without any protective gear."

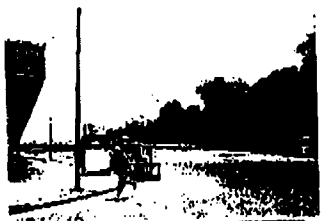
Mark Parsons, who served an active tour of duty for nine months with the 144th Supply Company, reported that more than twenty soldiers worked for five months at the King Khalid Military Camp in Saudi Arabia cleaning tanks contaminated with radioactive dust. For the first month and a half, the soldiers had no idea that they were dealing with radioactive dust.

In March 1991, the Pentagon sent civilians in the camp to take measurements of the radioactivity. Dressed in full protective gear with rubber gloves, respirators, dosimeters and Geiger counters, the civilians went about their work. After two weeks, they concluded that the soldiers had been exposed to hazardly radiation.

The soldiers got no relief, when their commanding officer ordered them back to work with no additional protective equipment.

When GAO investigators inquired about the widespread lack of awareness among US troops about the use and dangers of DU munitions, Army officials stated that "DU protective methods can be ignored during combat and other life-threatening situations because DU-related health risks are greatly outweighed by the risks of combat." The line of military logic was also used to justify exposing soldiers and civilians to poisonous herbicides such as Agent Orange and radiation from atomic testing and fallout.

In July 1991, a fire broke out at a US Army Base at Doha, Kuwait. Nearly $40 million in equipment and ammunition was destroyed, including 860 DU tank rounds and four fully loaded Abrams tanks. The 860 tank rounds destroyed represented more than 7,000 pounds of highly toxic, radioactive uranium that was spread around the Doha base and ejected into the atmosphere during more than 4 hours of explosions.



Explosion at the U.S. Army base at Doha, Kuwait on July 11, 1991. Photo courtesy of Michael Hines.

At the time of the fire, nearly 3,000 troops were at the base. After the fires burned themselves out, explosive safety personnel returned to identify and clear out unexploded ordnance, followed by other soldiers detailed to clean the area. Soldiers approached burned DU armored tanks, carried debris and shrapnel with their bare hands, inhaled the toxic DU dust -- and never knew it. Soldiers involved in the cleanup of the fire area were not provided any radiation protection equipment, and no contamination cleanup of areas was apparently done.

Several of the National Guardsmen exposed to DU in Saudi Arabia have developed serious health disorders since Desert Storm. Symptoms include headaches, cold sweats, hypertension, numbness in the extremities, diarrhea, insomnia, bronchitis and renal disorders. Some have had children with birth defects.

Because troops were exposed to many potentially hazardous substances in the Gulf War, it is difficult to determine how much of a role DU had to play in the cumulative health disorders of ailing soldiers. However, Dr. Asaf Durakovic, one of the military's top medical contamination experts, recently stated, "Every piece of evidence I have from my studies of amputees and autopsies has led me to the conclusion that DU is the cause."

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.)
MCDERMOTT, OHIO

Dr. Durakovic treated two dozen of the soldiers from the 144th Division who cleaned the DU-contaminated tanks in Saudi Arabia. He accuses the Department of Veterans Affairs of terminating his position with the VA, and harassing him "for pursuing the proper medical management of veterans exposed to depleted uranium." He also claims that medical records of the soldiers he had examined have mysteriously disappeared, an allegation the VA flatly denies.

Since the Gulf War, the Pentagon has downplayed the dangers of DU and the significance of DU exposures in the Gulf War because it does not want to draw negative attention to a prized weapon system. The Department of Veterans Affairs (VA) has accepted the Pentagon's assurances obediently, and denied testing and treatment to other veterans suffering from kidney problems and cancers which may be related to DU exposure. Both the Pentagon and VA have expressed, in writing, a desire to avoid the costs of medical care and disability payments for veterans who develop DU-related health problems.

Dan Fahey works closely with ailing Gulf War Veterans as the Legal Assistant for Swords to Plowshares, a San Francisco-based non-profit organization that helps war veterans meet their basic needs. He is also serving Veterans for Peace, Mr. Fahey also serves on MTP's Board of Directors. He recently released a report entitled The Silence is Deafening: A Report on Exposures of Persian Gulf War Veterans and Others to Depleted Uranium Munitions, *which is available from MTP headquarters. For more information about Gulf War Veterans' Illnesses, contact Swords to Plowshares at 995 Market Street, 3rd Floor, San Francisco, CA 94103. Phone: 415-247-8777.*

The Military Toxics Project organizes activities of the Depleted Uranium Citizens' Network. On November 12, 1994, in Jonesborough, Tennessee, the DU Citizens' Network adopted the following mission statement:

In response to the latest form of military radioactive pollution, the mission of the Depleted Uranium Citizen's Network is to provide outreach and unite people affected by the production, testing, and use of depleted uranium for military purposes; and to demand cleanup, health care, compensation and the end of depleted uranium munitions use worldwide to help ensure the survival of future generations.

For more information about DU weapons and efforts to help Gulf War veterans and civilians impacted by DU, contact:

Depleted Uranium Citizens' Network, Military Toxics Project, 411 Main Street, 2nd Floor, Lewiston, Maine 04240.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Going to the Source:
How Uranium Mining Destroys Indigenous Communities

By Philippa Winkler, Desert Concerns

Against the Rainbow Serpent, sleeper in the earth guarding those monumental powers that lie outside of mankind's control. Any attempt made to steal these underworld powers will disturb the serpent and bring destruction and death upon the Earth. -- An Indigenous People's Belief, Australia

When evaluating the need for different materials in modern-day life, it is imperative to go to the beginning of a product's life-cycle. For DU, the life-cycle begins with uranium mining, often on Indigenous lands.

Uranium is mined in many countries around the world, with Australia, Canada, Kazakhstan, Namibia, Niger, Russia, south Africa, the US, and Uzbekistan leading world production. US uranium mining began in earnest in New Mexico, right after World War II, when the US government realized the capabilities of the metal.

Uranium mining in the desert Southwest, has left open and permanent scars on the land, which many Indigenous communities hold sacred. Pollution from the mining has resulted in an epidemic of cancer cases.

Since the 1970s, tourism has exploded in the American Southwest. The rivers, washes and canyons, the sandstone and shale, the mesas and the spectacular red "cathedral" rocks are familiar to us from countless magazine photographs, advertisements, and films. But, no tourist brochure mentions the following scenarios:

> Since World War II, the Navajo Nation and developers of uranium mines have been engaged in a continuous power struggle. The Navajo Nation has called for an international ban on uranium mining, while the uranium industry has fought such resistance. A moratorium on uranium mining on Navajo lands has been in effect since 1983.
>
> Of more than 2000 Navajo uranium miners who worked in the Four Corners (Navajo) Area, Northwest New Mexico, Southeast Utah, and South-west Colorado) mines from 1947 to 1971, in all have died of lung cancer and other illnesses linked to radiation exposure. Yet, only fifty Navajo widows have been compensated under the 1990 Radiation Exposure Compensation Act.
>
> Cancer clusters have been found in Indigenous Navajo -- especially among children and the elderly -- living downwind and downstream of uranium mines.
>
> In one community, at Shiprock, New Mexico, the Special Olympics Games take place annually because of the high number of disabled children.
>
> Church Rock, New Mexico, part of the Checkerboard Area of the Eastern Navajo Agency, was the site of a 1979 radioactive waste spill, the largest in US history.
>
> Church Rock is one of the communities targeted by Hydro Resources, Inc., of Dallas, Texas, for involvement in the construction and operation of two uranium mines and related processing plants in the Checkerboard Area. This is the equivalent of recommissioning the nuclear power plant at Three Mile Island.
>
> From 1946 to 1968, more than 13 million tons of uranium ore were mined on the Navajo reservation to make atomic bombs. More than a thousand abandoned, yet highly radioactive, mines have not been cleaned up or reclaimed.
>
> Despite evidence that cancer is ravaging the Navajo communities, the US Government has routinely denied funding for a complete epidemiological study. According to Arizona Department of Health Physiologist Al Gossman, "the highest birth defect rate in the state -- equal to seven times the national average -- was in the Common-Gray Mountain area of the Navajo Reservation north of Flagstaff. The area is dominated by numerous open pit uranium mines."

In the mid-eighties, the Federal Government began efforts to remove Indigenous Peoples from their ancestral homes in the mineral-rich land of Northwest Arizona. The government intended to mine coal and uranium for further industrial and military uses.

In 1993, the World Uranium Hearings convened in Salzburg, Austria to call for worldwide protection of indigenous peoples and lands and the end to nuclear technology. Despite all these efforts, Navajo communities face continual threats. Yet the struggle of indigenous communities continues.

The Havasupai People, living at the bottom of the Grand Canyon in Colorado, are currently fighting uranium mine developments, while the Navajo are struggling against planned uranium mining operations in New Mexico.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Philippa Winkler, works for Desert Concerns, a project of the World Survival Foundation. The group examines the health effects of uranium mines of the Southwestern US and uranium battlefields of the Middle East. Contact Desert Concerns at PO Box 1148, Clarkdale, Arizona, 86324. Phone 520-634-4327.

Activists Raising Funds For New Video on DU

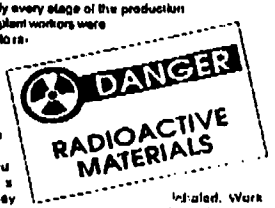
Three organizations, including Desert Concerns, World Survival Foundation, and Southwest Indigenous Uranium Forum, seek funding for a 30-minute documentary on the environmental and human health hazards of uranium mining and depleted uranium. The video will address the entire life-cycle of depleted uranium, and is provisionally titled, *Radioactive Mines -- Radioactive Bullets*. If you would like to contribute to this effort, or assist in fundraising for this important resource, please contact Daniel Robicheau or Philippa Winkler at Desert Concerns, PO Box 1145, Clarkdale, Arizona 86324. Phone: 520-634-4327.

DU Exposure in the Workplace

One of the manufacturers of DU is Aerojet, formerly TNS, Inc., located in Jonesborough, Tennessee. In 1991, employees walked out of their work place, in protest of hazardous working conditions.

The plant uses DU to produce armor-piercing projectiles, primarily for the US Air Force. Prior to the employee walk-out, the US Department of Energy had been sending a powdery substance known as *green salt* to the contractor in 55-gallon drums. The green salt was actually uranium tetrafluoride which was used to manufacture DU.

At virtually every stage of the production process, plant workers were exposed to radioactive substances, often in the form of contaminated dusts which they inhaled. Workers moved the drums from the warehouse to the plant foundry with a forklift. Often, the forklift pierced the drums, spilling green salt onto the plant floor. When the workers tried to clean up the mess with shovels and brooms, they dispersed it into the air. The weighing and blending stages further spread the hazardous substance around the plant, and onto employees. The exhaust system did little to vent the dust and fumes away from the workers who complained of having green salt in their ears, nostrils and mouths. Workers also described violent furnace blow-outs which expelled contaminated material into the workplace.



Many employees began to complain of discharging black mucus from their noses, having chronic nose bleeds, lower back pain and difficulty in urinating. TNS refused to acknowledge that DU was potentially responsible for the health problems, despite their own records indicating airborne contamination in the plant.

In 1980, more than 8% of the workforce sustained whole body doses of radiation ten times as great as the average exposure for workers in the nuclear industry nationwide.

After the workers' walkout, employee exposure to radiation declined significantly. The plant upgraded the blending and weighing equipment to remote-controlled devices, disposed of the old equipment in a landfill, and installed a new dust collector.

The Oil, Chemical & Atomic Workers International Union (OCAW) represented roughly 100 TNS employees in a 1994 legal suit in the United States Court of Appeals. Although the workers won their suit, the company challenged the ruling, and it was overturned. Since then, OCAW has appealed and is awaiting a final decision.

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

DU Weapons Threaten Local Communities

by Judy Scatchell

In 1994, the American public learned that the U.S. government had secretly exposed to radiation its own citizens including pregnant women, teenagers, sick people, atomic plant workers, military and civilian populations - all without their consent during a period from the 1940's to the early 1970's.

Now in the 1990's another involuntary human radiation experiment begun years ago during the Cold War era continues. It is the production, manufacture, development, testing and use of depleted uranium as a military weapon. In the Persian Gulf War the depleted uranium projectile, a weapon made from the nuclear fuel enrichment cycle, was used for the first time. Even though the uranium metal weapon is highly toxic, both chemically and radiologically, it is currently classified as a conventional weapon.

The Army Environmental Policy Institute (AEPI) "Health and Environmental Consequences of Depleted Uranium Use in the U.S. Army: Technical Report" of almost 200 pages does not really tell us much about the health and environmental consequences of DU use. There are no long-term health studies of DU production or manufacturing workers and their offspring. Nor are there health studies of residential populations that have been exposed to radiation from aerosol or ingested DU from DU production, manufacturing or testing. There are no health studies of Gulf War Veterans who were exposed to DU through inhalation or ingestion, and there are no studies of these veterans' children born after the Gulf War. How then can there be the following finding in the AEPI report Executive Summary:

> *"After an exhaustive review of weapons systems containing DU, AEPI concluded that the Army has done an excellent job attending to the environmental and health impact of these systems."*

The AEPI report reports specific action on the effects of DU on the environment consists of three paragraphs on pages 145 - 146. In these, only two sources are cited on the effects of DU on plant life. One, Hanson and Miera in 1978, (almost 30 years ago), concluded that in DU contaminated soil most injury occured in the roots of plants. In the other study at Eglin Air Force Base, Florida in 1980, 25 vegetation samples were collected and yucca roots were found to have "the highest apparent radiation concentrations." Is this a scientific basis for concluding what DU's impact is on plant life in the environment? In the report, there is very limited and superficial discussion of the effects of DU on animal life. An ongoing monitoring of plants and animals should be integral to assessing the effects of DU on the environment.

There are 50 different sites in the United States where DU has been produced, developed, manufactured tested and stored. A major shortcoming of the AEPI report is the lack of consideration given to the health and environmental consequences on the adults and children at the 50 sites.

In Concord, Massachusetts, near Nuclear Metals, Inc. (NMI), there are two middle schools and one elementary school. NMI has been a manufacturing site using uranium metals for 37 years. It is currently one of the two manufacturers in the U.S. of the DU penetrator.

Citizens' Research and Environmental Watch (CREW) has found DU contaminated soil as far away as nine-tenths of a mile from NMI. Among the contaminated areas on NMI's 40.4 acre site is an unlined pit that has 400,000 pounds of uranium wastes which are leaching and migrating.

The State of Massachusetts has designated the NMI property as a Superfund site.

A November 1984 internal memo from the Nuclear Regulatory Commission states, *"migration [of the uranium plume in the groundwater under NMI] might have already reached the site boundry, or at any rate will reach it soon at the projected rate of movement in [bedrock fissures]."*

NMI is but one example of contamination on and off site, caused by the U.S. Army's use of DU that is not revealed in the AEPI report. How many other examples similar to NMI can be found at the other 49 sites? And what about their nearby neighborhoods, schools, public lands and waterways?

And what of the health of all the people living near those sites? In August 1995, CREW researcher Bill Smith completed a statistical study of cancer in Concord. Using the Massachusetts Cancer Registry data available (1982-1990), Smith found that Concord had a higher incidence of six types of cancer relative to state averages. Concord had the second highest incidence of thyroid cancer in the state, nearly two and a half times the state average. The reason for this higher incidence of cancer is not known.

For more information, contact: CREW, 82 Prairie Street, Concord, MA 01742. (508)369-7146

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

TOXIC SHOTS HEARD ROUND THE WORLD

Sunday, April 27, 1997
3:00 p.m.
First Parish Church
20 Lexington Road
Concord Center, MA

Radioactive Weapons and Waste in Concord

Panelists from Massachusetts, New York, Tennessee and Louisiana will discuss:

* The hazards of radioactive contamination from the manufacture of the depleted uranium penetrator at Nuclear Metals Inc. in Concord, MA and at other sites in the US.

* Clean-up of the toxic and radioactive wastes generated by DU.

* Gulf War veterans' exposure to DU contamination.

Co-sponsored by Grassroots Actions for Peace and the Social Action Council of First Parish Church. Supported in part by the Military Toxics Project Community Exchange Program.

Recent Concerns from Japan

The latest DU weapons incident to hit the news happened on an uninhabited island in Japan in late 1996 and early 1996. The US Marine Corps publicly stated that it accidentally fired 1,520 DU bullets on the island of Tori Shima near Okinawa. While the rounds had been labelled "armor-piercing," they were not specifically marked "depleted uranium."

While the Marine Corps apologized to Japan for firing the rounds and cleaned up 192 of the bullets, it downplayed the likihood that any health or environmental threat remained in the area.

Dan Boyd, a US Air Force spokesman in Japan told Reuter news service that the amount of radiation released on Tori Shima was "absolutely insignificant," and likened it to that of early television sets.

Yet, Japanese officials, citizens and local fishermen are skeptical. Last month, a staffer for a Japanese Parliament member contacted the MTP office asking for information on DU as they try to determine the extent of contamination [illegible]

While the incident on Tori Shima raises concerns about how US military use of DU threatens Japanese communities, it is important to keep the situation in perspective. During Operation Desert Storm, when DU bullets were first introduced, US forces fired 940,000 small-caliber and 4,000 large-caliber DU rounds in combat. Six years after the war, none of the more than 600,000 pounds of DU has been cleaned up, and no apologies have been issued to exposed Gulf War veterans or the populations of Kuwait and Iraq who live amidst this contamination. A classified United Kingdom Atomic Energy Authority report warned in 1991 that depleted uranium contamination on Gulf War battlefields could cause 500,000 deaths among soldiers and civilians.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

A Global Ban on DU The Only Solution

By Chris Larson, Patriots for Peace

The first international conference on DU was held at the United Nations (UN) in New York City on September 12, 1996. People from around the world crowded into the standing-room-only hall to learn about the complex DU issue and initiate a global ban on DU weapons through public education.

One conference participant raised the following question: "What would you do if you owned a portion of the US nuclear waste?" The answer, "Essentially, each of us does." Virtually all of us are taxpaying citizens on the grid (using electricity via nuclear power) and thereby own a portion of the waste created. As shareholders in the nuclear waste crisis, each of us has a responsibility to stop the use of waste uranium for further destruction, and to demand environmentally safe and renewable power supplies.

Conference keynote speaker and former US Attorney General Ramsey Clark stressed the need to create a worldwide ban against the use of DU, and many other speakers described their personal experiences with DU. Native Americans, war veterans, scientists and activists all agreed that DU has no place in modern society.

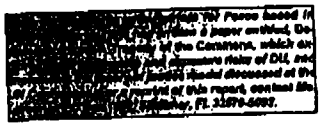
International efforts to curtail the DU problem were evident throughout the forum. Dr. Jay Gould, former Environmental Protection Agency Science Advisory Board member, announced a "tooth fairy" grant that he had received from the United Methodist Church to analyze New England children's baby teeth for proof of DU exposure. A London physician distributed DU fact sheets to the UN delegations. Kenk van der Kaur, a Dutch participant, presented information on LAKA, a data collection and research center in the Netherlands that gathers and shares information on nuclear energy issues internationally with interested parties. A film crew from Japan Broadcasting Corporation attended the conference and developed a 60 minute documentary on DU.

Conference participants pondered a Thomas Jefferson decree that citizens hold their government accountable for its actions, and considered a model for constructive, patriotic participation to address the DU problem. The model contains the following three levels of awareness: personal understanding and conviction; interpersonal cooperation, and omni-personal respect for the Commons, or the life-sustaining ecosystem we all share.

Many people at the conference characterized the mainstream media as a major obstacle to accurate information about the DU crisis, and agreed to develop alternative information sources for public education. Conference-goers stressed the importance of seeking alternative news and information sources, and encouraged others to join the Military Toxic Project's DU Citizen's Network, which works to ensure that prompt, accurate information about DU is disseminated by grassroots organizations. Participants gathered more than $1800 to begin a comprehensive DU book that will be written in lay terminology.

Nuclear physicist Dr. Michio Kaku, delivered perhaps the most inspiring statement of the conference when he proclaimed, "There is one power stronger than plutonium, the power of educated people."

MTP's DU Citizens' Network currently is developing a resolution for global action on DU. The Network seeks to strengthen an August 1996 UN resolution which urges all States to "curb production and spread of weapons of mass destruction or with indiscriminate effect, in particular nuclear weapons, chemical weapons, fuster bombs, napalm, cluster bombs, biological weaponry and weaponry containing depleted uranium." The stronger resolution would ban, not just curb, the production and spread of DU weapons.



Dan Fahey and Chris Larson at the September UN conference on DU

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Metal of Dishonor: How the Pentagon Radiates Soldiers & Civilians With DU Weapons. Published by the International Action Center (IAC), with selections by Dr. Hosain Rahek, Dr. Helen Caldicott, Ramsey Clark, Dr. Leonard Dietz, Pat Brandy, Carol Picou, Dan Fahey, Dolores Lymburner, Dr. Michio Kaku, Manuel Pino, and Dr. Victor Sidel. Focuses on the environmental and health effects of depleted uranium. Book and companion video to be released in late April 1997. $12.95 plus $4.00 shipping and handling for the first copy. $1.00 for each additional copy. Available at discounted bulk rates for organizing, educational, or fundraising use by community organizations. The companion video - 45 minutes. $20.00 for individuals, $40.00 for institutions plus $4.00 shipping and handling for first copy. $1.00 for each additional copy. All mail orders must be pre-paid. Send check or money order to:

IAC, 39 West 14th Street, Room 206, New York, NY 10011. Phone: 212-633-6646. Fax: 212-633-2889.

Project CENSORED Honors MTP For DU Research

MTP's Depleted Uranium Citizen's Network report, "Radioactive Battlefields of the 1990s: A Response to the Army's Unreleased Report on Depleted Uranium Weaponry," took honors as the ninth most "censored" or "under-reported" story of 1996. Project Censored, based at Sonoma State University in California, identified twenty-five issues to be reviewed in the organization's annual yearbook. Of those issues, the top ten ranked stories will become the primary focus of public discussion on more than 125 radio and television talk shows during the spring and summer. MTP will receive a small cash award from Project Censored for its efforts in educate the public about the environmental and health threats of DU.

Creating Needs for DU

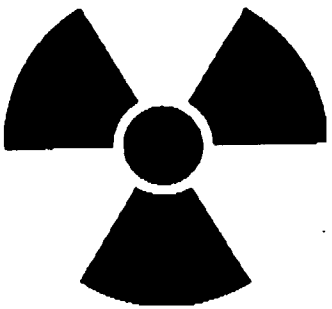
By Dolly Lymburner
National Organizer, MTP's DU Citizens' Network

Depleted uranium has been licensed for a new use by the Idaho National Engineering Laboratory (INEL) as containers for spent nuclear fuel.

The US Department of Energy currently has an estimated 555,000 metric tons of DU that it is trying to dispose of or use. The production of containers for spent nuclear fuel will use large quantities of DU. Originally, the plan was to convert DU into a metal, but this was considered very costly. A cheaper course evaluated by INEL was using a DU rock-like aggregate as an ingredient in concrete. This material is called "DUCRETETM". INEL has completed initial testing and Lockheed Martin Idaho Technologies Company is obtaining patents here in the U.S. and in other countries.

DUCRETETM will replace the concrete and steel casks currently being developed. According to INEL, DU, because of its density, will better shield radiation from spent fuel. They also state that these new casks will be thinner and lighter in weight, making handling and transportation at the storage sites easier.

Teton Technologies, Inc. has formed a partnership with Nuclear Metals, Inc (NMI) to further develop the process and marketing strategy. Initial production will be at NMI's facilities in Barnwell, South Carolina with production starting this year.



ONCE AROUND THE BASES

Wisconsin Community Rejects Army Base Conversion Plan

By Laura Olah, Citizens for Safe Water Around Badger

Environmentalists, local government officials, and regulatory agencies alike rejected a recent Army base conversion proposal in Wisconsin.

At issue is the Badger Army Ammunition Plant (BAAP), a defunct 7,400-acre facility which has been on stand-by since 1975. BAAP has become the focus of a county-wide battle to preserve the area's rural quality of life, its endangered natural resources, and its local economic health.

Opposition to the reindustrialization plan, spearheaded by Citizens for Safe Water Around Badger (CSWAB), arose in response to a September 18, 1996 announcement by Olin Corporation and the US Army to initiate an aggressive marketing scheme which would bring the pulp and paper industry; varnish, paint and lacquer manufacturers; ethanol and cosmetics industries; and nitrogenous fertilizer plants to BAAP by 1997.

BAAP identified the target industries in a Strategic Planning Process which excluded nearby communities, local town, village and county boards, planning and zoning authorities, and other stakeholders. Through a nine-month planning process -- costing 275,000 taxpayer dollars -- BAAP hosted no public meetings.

The reindustrialization proposal is the result of the 1992 Armament Retooling and Support Act (ARMS). The ARMS initiative encourages private firms to use Army ammunition facilities (specifically government-owned, contractor-operated facilities) for commercial purposes. The US Government authorized ARMS to create jobs at facilities like Virginia's Radford Army Ammunition Plant, where a recent lay-off resulted in the loss of thousands of positions. Opponents of the BAAP conversion proposal noted that, by contrast, BAAP had not had a significant job loss since the mid-1970s, and today employs only about 100 people.

Under the ARMS program, the Department of Defense makes contracts available to private industry for one or more years. Companies receive *Facilities Use Contracts* to develop and implement a reuse plan and, in return, receive part of the rent from new industries brought on-site. At BAAP, the operating contractor is Olin Corporation.

One of the objectives of the ARMS program is to perpetuate Badger and other Army ammunition plants as military facilities, avoiding closure and allowing deferral of cleanup efforts. This tactic contradicts a February 20, 1997 report from the Government Accounting Office which concludes that BAAP and three other military plants could be eliminated because alternative sources exist to provide the capabilities that these plants provide.

In the Community around Badger, there is a strong sentiment that the ARMS program is neither applicable nor appropriate for the BAAP facility and Sauk County. A flat labor market, housing shortages, overflowing schools, and other stressed infrastructure are all signs that additional development in the area is not warranted. Community members maintain that other possible uses for the site have not yet been evaluated. The other options may, in fact, provide much greater benefits to the Community than rendustrialization.

One of the assets cited by the Strategic Plan is open, currently undeveloped land. Local residents are very concerned that reindustrialization may promote uncontrolled development of agricultural lands within the plant for new industry. Contrary to statements in the Strategic Plan, there is a paucity of available farmland in Sauk County, which is reflected by local farmland preservation ordinances. Moreover, the value of farmland and small farms is highly prized in the area.

BAAP itself lies primarily on the terrain of the former Sauk Prairie, a bioregion which hosts remnants of many diverse ecosystems including prairie, oak savanna, dry forest, southern hardwood swamp and sandy meadow.

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MCDERMOTT, OHIO

ONCE AROUND THE BASES

The base is also home to a wide variety of animal species including some that have been classified as rare, endangered and threatened. BAAP is surrounded by the Baraboo Range -- a National Natural Landmark. Composed of quartzite, the hardest rock on Earth, it covers 144,000 acres in parts of Sauk and Columbia counties. The 25-mile Range extends from Rock Springs in the West to just west of the interstate highway in adjoining Columbia County in the East. It stands as high as 799 feet above the Wisconsin River and is one of the largest and most ancient rock outcrops in North America.

The Range includes 55,300 acres of forest -- the largest tract of southern upland forest remaining in an ecoregion which covers 40,000,000 acres in parts of five states (central Minnesota through southern Wisconsin, northeastern Iowa, northern Illinois, and northwestern Indiana.) Although the Range covers less than 0.5% of this area, it supports 68% of all breeding bird species, 44% of all mammal species, and 37% of all reptile species found in the ecoregion. This ecoregion is home to more than 16,000 species of plants and animals, including 138 species of breeding birds alone. Seventy-seven of these plant and animal species are rare or imperiled in Wisconsin, and 25 are on the State or Federal lists of threatened or endangered species.

Reindustrialization of the region has met broad opposition at local, state, national and federal levels.

The Town of Merrimac, the Village of Merrimac, the Town of Sumpter, the Town of Honey Creek, the Town of Spring Green, and Sauk County all have passed resolutions opposing the proposed conversion plan. Local business organizations, including the Baraboo Economic Development Council, have drafted resolutions opposing BAAP's proposal citing unfair competition from new industries coming into the plant which would be exempt from real estate and property taxes. The Spirit Prairie School District Administration also has written to the Army objecting to the negative financial impact on the district.

At least sixteen environmental groups, including the Rural Alliance for Military Accountability, the Sierra Club, the Madison Audubon Society, the Aldo Leopold Chapter of the Society for Conservation Biology, the Baraboo Range Preservation Association, and several chapters of Physicians for Social Responsibility have co-signed a letter opposing the proposed reindustrialization.

The Wisconsin Department of Natural resources, the US Department of Interior, and the US Environmental Protection Agency all have written letters forewarning potentially negative primary and secondary impacts on the adjacent Baraboo Range ecosystem. The Ferry Bluff Eagle Council, a non-profit organization whose mission is to protect wintering American Bald Eagles, has documented serious concerns about the potential harm to this endangered species and its habitat.

In response to the proposed reindustrialization of BAAP, CSWAB hosted a series of four public meetings to encourage and solicit community input and consensus. Public meetings averaged 60 participants. CSWAB has collected more than 600 signatures from local residents opposing reindustrialization.

CSWAB has called for the closure of BAAP, citing that maintenance of the plant -- although out of operation since the 1970s -- costs taxpayers millions of dollars each year. In 1991 alone, maintenance costs exceeded $17 million. Built in 1942 in response to World War II, the BAAP production facilities are obsolete and would require more than $119 million in upgrades to meet current state and federal environmental standards. Environmental damage continues to plague the facility -- since 1975, there have been more than 56 chemical spills and incidents.

Environmental cleanup of the Badger plant, operating intermittently since 1942, is expected to exceed $250 million. Of the 40 contaminated military sites in Wisconsin, the Defense Environmental Restoration Agency has cited BAAP as the most contaminated -- 32 areas within the plant are polluted with high levels of solvents, toxic metals and explosive wastes. Groundwater beneath the plant is saturated with cancer-causing chemicals, including carbon tetrachloride, trichloroethylene and dinitrotoluenes. An area know as the Propellant Burning Grounds is the source of a three-mile long plume of contaminated groundwater that has migrated several miles offsite, polluting private drinking water wells in its path and dumping into the Wisconsin River.

CSWAB was organized in 1990 when the community learned that private drinking water wells near BAAP were polluted with high levels of cancer-causing chemicals. The founders believed that community involvement could have prevented this tragedy and consequently organized CSWAB both to empower and to protect nearby residents and plant workers from further harm. For more information, contact CSWAB at 212629 Weigand's Bay South, Merrimac, Wisconsin. Phone: (608) 643-3124; Fax: (608) 643-0005, Alternate Fax: (608) 643-2662; Email: olah@speagle.com.

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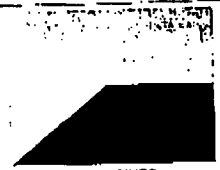
COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

ONCE AROUND THE BASES



PHILIPPINES

Toxic Threat at Former US Bases in the Philippines Lingers On

By Myrla Baldonado

Almost five years have passed since the US Military agreed to terminate operations at Subic and Clark Bases in the Philippines. Despite findings of a 1992 report from the US General Accounting Office which stated that "the costs for environmental cleanup and restoration could approach Superfund proportions," there has been no comprehensive investigation nor cleanup.

To date, the US Government's only act regarding the bases is the release of incomplete Drawdown Reports which were supposed to have been turned over to the Philippines Government prior to the pullout.

During President Clinton's official visit to the Philippines in 1994, base clean-up advocates managed to put the issue on the discussion agenda, despite the reluctance of both governments to touch the issue.

At a joint press conference of Presidents Ramos and Clinton at Malacanang, President Clinton was asked about the toxic contamination at the former Clark Air Base and Subic Naval Station, his Government's offer of financial and technical assistance, and his willingness to accept the moral and financial responsibility for any necessary cleanup.

President Clinton responded by stating that the U.S. was "continuing to work with the Philippine government on this and will continue to do so." He added, "it is very important not to let the general policy pronouncements or the rhetoric outrun the facts we have on the case, so we decided we should focus on finding the facts now, and when we find them, deal then with the facts as they are."

A few months later, the Philippine Health Department asked for a consultation from the US Center for Disease Control (CDC) to help test the drinking water of wells in an area inside Clark that used to be a motor pool. The official response was that the agency adhered to a US State Department policy of "no responsibility," and that they would send a technical person if the Philippine Government could pay for his transportation and per diem.

During the November APEC Summit in Manila, delegates of the 1996 International Forum on US Military Toxics and Bases Clean-up lobbied for the inclusion of the toxics problem in the bilateral talks between the two governments. As a result, former Secretary of State Warren Christopher and Philippine Foreign Affairs Secretary Domingo Siazon discussed the matter. Secretary Christopher assured US willingness to help with the clean-up, but a quick follow-up by supporters in Washington, DC revealed that the State Department would not confirm what Mr. Christopher said, nor admit knowing anything about it.

The current policy of the US Department of Defense (DoD) requires host countries to demonstrate "imminent and substantial danger" at former overseas bases used by the US Military before it provides further assistance. The People's Task Force for Bases Clean-up, with headquarters in Manila, is targeting DoD's reckless scheme, hoping to shift the burden of proof back to the entity that created the mess in the first place.

The requirement to technically demonstrate imminent and substantial threat is beyond the capacity of the Philippines and many other Third World countries. Thus, the US must responsibly assist its former host countries with the task of meeting this requirement.

Myrla Baldonado is the coordinator of the People's Task Force for Bases Clean-up in Manila. For more information about the ongoing campaign to fight US military pollution in the Philippines, contact the group at: Room 511, J & T Building, 3884 R. Magsaysay Boulevard, Sta. Mesa, Manila, PHILIPPINES. Phone/Fax: 632-716-1084. Email: mbaldonado@ibc.apc.org. The US Working Group for Philippine Bases Cleanup is assisting the Task Force, and can be reached at: PO box 5644, Hercules, CA 94547. Phone/Fax: 510-799-2551.

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

ONCE AROUND THE BASES

Chemical Weapons

Activists Call For Permanent Shutdown of Tooele Incinerator

The Kentucky based Chemical Weapons Working Group (CWWG), the Sierra Club and the Vietnam Veterans of America Foundation have joined forces and filed suit in federal Court to permanently close the chemical weapons incinerator in Tooele County, Utah.

The US Army owns the Tooele facility, while the defense contractor EG&G Defense Materials, Inc. operates it.

The controversial incinerator has suspended operations six times since it opened in August 1996. The latest shutdown occurred in late January, when lethal nerve agents leaked inside the plant to areas often occupied by unprotected workers and visitors.

According to an Army "Unusual Occurrence Report," air pressure adjustments being made to stabilize flame strength in the liquid agent incinerator resulted in agent leaking into two observation corridors. Personnel donned gas masks and evacuated the building. Utah state officials asked the Army to close the facility until they determined the cause of the problem and corrected it.

"Yet another dangerous incident illustrates this plant's defective design, poor operating procedures, and lack of safety culture," said Craig Williams, national spokesman for the CWWG. "Instead of suggesting that the plant should be closed for a couple of days, the State should protect the workers and local residents by suspending the Army's permit until a safe approach can be implemented."

Craig Williams, Sergeant Turnbo, Peter Hille of the Chemical Weapons Working Group

Since a leak-burn in July 1996, two former employees of the Tooele incinerator have come forward with evidence of numerous major safety and environmental problems at the plant. The new evidence supports charges made by Steve Jones, the plant's former chief Safety Officer who EG&G fired in 1994 for refusing to approve the plant's level of safety and environmental compliance.

Former General Plant Manager Gary Miller, also fired for raising concerns about incineration operations, likens the safety mind-set at the Tooele facility to that which preceded the Three Mile Island and Chernobyl disasters.

On January 8, 1997 former plant employee John R. Hall made similar accusations and filed a wrongful termination suit against EG&G with the Department of Labor. Mr. Hall claims retaliation and eventual termination due to raising concerns about the incinerator's safety and environmental compliance.

An estimated 180 million Americans live downwind of proposed chemical weapons incinerators, and face the risk of agent contamination.

The Pentagon admits that small amounts of the kinds of nerve agent that may have contributed to Gulf War illnesses are emitted in smokestack exhaust at the Tooele incinerator, yet it claims that the amounts are so low that citizens downwind should not be concerned.

Gulf War illnesses researcher, Howard Urnovitz, Ph.D., a leading researcher on immune system damage caused by low-level chemical agent exposure said, "Study after study indicates that there is a link between low-level exposure to chemical agents and chronic health problems. There is no proven acceptable level of exposure to these chemicals."

Due to public opposition to incineration, cost overruns, and technical problems at facilities in the Pacific and Utah, the Army announced its recommendation to abandon incineration in Maryland and Indiana to pursue non-incineration technologies. Through the 1997 Defense Appropriations Act, the US Congress has funded and mandated demonstration of safer, non-incineration technologies for assembled munitions, such as those stored in Utah.

"The CWWG advocates the use of alternative technologies," said Mr. Williams. "The Army has demonstrated effective use of such technologies in Maryland and Indiana, so there is no excuse not to do the same in Utah and at all chemicals weapons storage sites."

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

As this issue of *Touching Bases* goes to press, the Toodle chemical weapons incinerator is back up and running, and the Oregon Environmental Quality Commission has issued a permit to begin construction of a similar facility in that state. The CWWG remains committed to shutting down all chemical weapons incinerators, and preventing the permitting of all new chemical weapons incineration facilities.

Georgia Legislators Stall Construction of Alabama Incinerator

In February, the Georgia House of Representatives passed a unanimous resolution calling for a federal hearing on Pentagon plans to build a chemical weapons incinerator in Anniston, Alabama. The proposed facility would be located less than two miles from a school in the community.

The resolution, H.R. 174, includes the following language, which other communities may wish to use when fighting permitting of chemical weapons incinerators:

> Urging the Georgia congressional delegation to urge Congress to request the Environmental Protection Agency to hold public hearings in northwest Georgia; and for other purposes.
>
> Whereas, the Alabama Department of Environmental Management, the United States Army, and Westinghouse plan to construct a chemical weapons incinerator in Anniston, Alabama; and
>
> Whereas, the operation of such a facility has the potential to affect the air quality, health, quality of life, and economy of the residents of northwest and west central Georgia; and
>
> Whereas, other states, including Maryland, Indiana, and Kentucky, have passed legislation precluding the construction of such a facility within their boundaries; and
>
> Whereas, nonincineration and chemical neutralization methods are being studied by the United States Army which may prove to be safer alternatives for the destruction of chemical weapons; and
>
> Whereas, Georgia residents have expressed concern about the construction of such a facility because of toxins that might be released into the air and harmful genetic repercussions:
>
> NOW, THEREFORE, BE IT RESOLVED BY THE GENERAL ASSEMBLY OF GEORGIA that the members of this body urge the Georgia congressional delegation to encourage Congress to take steps to initiate public hearings conducted by the Environmental Protection Agency in northwest Georgia prior to the construction and operation of the chemical weapons incinerator in Anniston, Alabama

> BE IT FURTHER RESOLVED that the Clerk of the House of Representatives is authorized and directed to issue one appropriate copy of this resolution to the members of the Georgia congressional delegation.

For more information about the incineration of U.S. chemical weapons, contact: Chemical Weapons Working Group, PO Box 467, Berea, Kentucky 40403. Phone: 606-986-7565. Fax: 606-986-2695.

MTP To Sue EPA Over Munitions Rule

On February 11, the US Environmental Protection Agency (EPA) released its final rule clarifying when conventional and chemical military munitions become a hazardous waste under the Resource Conservation and Recovery Act (RCRA). After reviewing the Rule, the Military Toxics Project (MTP) decided to sue EPA.

Attorney Rena Steinzor, with the University of Maryland Environmental Law Clinic in Baltimore, Maryland, is representing MTP.

Members of MTP's Conventional Munitions Network who reviewed the Rule were outraged by EPA's failure to promulgate legislation that "shall assure protection of human health and the environment," as the directive from Congress clearly states.

"The EPA has proposed that the DoD regulate itself," stated Laura Olah, MTP member and Director of Citizens for Safe Water Around Badger, in Wisconsin. "The EPA has failed to meet its obligation as defined by law, and has let down both communities and Congress by proposing self-regulation."

On December 3, 1996, the Conventional Munitions Network adopted a position on EPA's proposed rule. EPA failed to address most of the concerns that the Network raised more than two years ago.

While States and Tribal Governments will retain their right to adopt and enforce more stringent requirements than those adopted nationally, EPA's final rule:

allows the DoD to determine whether to do anything about the environmental damage caused by munitions scattered over hundreds of thousands of acres of active military ranges;

postpones action on unexploded ordnance and explosive wastes on closed and transferred ranges in part because the DoD has not yet issued its range rule currently under development; and

flagrantly disregards the environmental and cultural impact of military munitions activities on indigenous lands, communities of color, and poor rural communities.

In December, 1995, MTP testified before the National Environmental Justice Advisory Committee (NEJAC) on how the proposed rule did not follow the Presidential Executive Order on Environmental Justice in Minority Populations and Low-Income Populations.

"The review of problems associated with military facilities suggests that military munitions activities heavily impact many communities of color, other poor, rural communities, and particularly the lands of Native Americans, Native Alaskans, and Native Hawaiians," stated Al Larson, Sr. who represents the Indigenous Environmental Network (IEN) from Chickaloon Village, Alaska. "EPA Administrator Carol Browner signed the final document that fails to protect the health and way of life of my people."

In February, 1994, MTP filed a *Notice of Intent to File Suit of EPA Failure to Act*, and subsequently sued the EPA because it was in violation of the Federal Facilities Compliance Act, which amended the Solid Waste Disposal Act, in which Congress required that the EPA Administrator propose the Munitions Rule by April 1993. MTP brought legal action against the Administrator of the EPA for failure to perform a non-discretionary duty imposed by Congress. MTP filed a consent decree in the US Court of Appeals for the District of Columbia.

MTP has decided to do a special reprint of citizen testimonies submitted to EPA more than a year ago regarding the EPA's ruling on when conventional and chemical weapons become hazardous waste. In light of the recent ruling which allowed the Department of Defense to regulate itself, it is clear that EPA ignored the valid concerns of these and many other citizens. The testimonies reprinted below were originally submitted to the Environmental Protection Agency's Resource Conservation and Recovery Act (RCRA) Docket #F-94-MMP-FFFFF.

From Mary Grisco, Chair, Military Accountability Committee, Sierra Club, Alaska Chapter -- January 8, 1996

...We of the Alaska Chapter of the Sierra Club, 1300 Alaskans, add our voice of strong concern about the proposed rule on military munitions. We know that if adopted in its current form particularly with the options that allow increased self-regulation by the Department of Defense, our public health will be endangered and our environment more damaged...

...Ft. Richardson, within the Anchorage municipal area, has been "training" at Eagle River Flats for years -- exploding munitions that were killing migratory waterfowl and lowering water quality as recreational hunter safety. We spent many years forcing the US Fish and Wildlife Service to force the Army to comply with environmental standards. Only recently did the Army finally announce that it is working to protect our water and wildlife. Ft. Greely, outside of Fairbanks contains many unexploded ordnance as well as storage vaults of unmanned weapons. Neighbors complain of headaches and nausea and wildlife (their subsistence) testing "funny." Ft. Greely continues training while issuing statements that public health is not being threatened.

These two small examples of the way the Department of Defense conducts business throughout our state lead us to support the critique of the proposed rule adopted by the Military Toxics Project's Conventional Munitions Network. In the Federal Facilities Compliance Act, Congress clearly legislated that the military cannot be allowed to regulate itself. External oversight, including the constitutional right of states to set more stringent standards than those established nationally, are basic for protecting our health and environment. The growing partnership of regulatory agencies and public stakeholders that is emerging in the cleanup of federal facilities requires that the military not be allowed to continue its cold war "announce and defend" mentality. We are the owners of these facilities and expect a level playing field for decision making.

From Bruce K. Gagnon, State Coordinator, Florida Coalition for Peace & Justice -- December 14, 1996

...We write to express our deep concern and outrage that the EPA is even considering allowing the Pentagon to regulate themselves in your proposed rule on military munitions.

We have several munitions impact ranges and disposal sites in our state and know that the military has a poor record of maintaining the health and safety standards at these locations.

In Florida, where our water table is so vulnerable, we are sure that allowing the military to "do as they please" will endanger our drinking water quality as toxic wastes from munitions leaks into the aquafer.

The Pentagon should not be allowed to regulate itself under any circumstance. If the EPA won't stand up to protect the American people then who will?

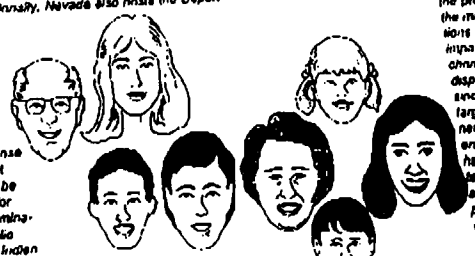
External oversight, from the EPA and the states must be strengthened, not eliminated.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Please make it known that our organization demands that the final rule preserves the intent of Congress to fully protect our communities. EPA should not back down to the Pentagon for one moment...

From Grace Bukowski, Military Land and Airspace Program Director, Rural Alliance for Military Accountability (RAMA), Reno, Nevada -- January 12, 1996

Today, Nevada hosts 20% of our nations military lands (over 4 million acres) including the largest military installation in the western hemisphere, Nellis Air Force Base. The Hawthorne Army Weapons Depot is the site of our nation's largest munitions stockpile nationally. Nevada also hosts the Department of Energy Nevada Test Site, and Fallon Naval Air Station...



...The Defense Department should not be rewarded for their contamination of public lands and Indian lands. Nevada has experienced first hand the hazards associated with off-range bomb contamination of public and Indian lands. Currently, 25,000 acres of public lands surrounding bombing ranges at Naval Air Station Fallon are closed to the public. Five thousand six hundred acres of the Walker River Paiute Reservation are contaminated with live munitions. Instead of cleaning up the land, the Navy is trying to take it over and the proposed rule would allow it. We note that Naval officials knew of this contamination for over a decade and failed to notify the State of Nevada or the Walker River Paiute Tribe.

The Defense Department view that withdrawal is the only solution to their careless contamination of public lands, is a bygone concept. We consider rewarding mismanagement a very serious policy issue. The off-range ordnance problem is wholly the Defense Department's doing and the magnitude of the problem points to a record of decades of [illegible] of public lands. To [illegible] withdrawal of these lands from the public domain as the only solution to contamination exacerbates the known problem. The proposed rule would permit, with EPA blessing, the deliberate contamination of public lands. How will the Defense Department acquire lands in the future? The answer is simple: largely bereft the perspective lands they request a withdrawal for public health and safety protection...

From Suzanne Marshall, Chair, SAFE (Serving Alabama's Future Environment) -- January 2, 1996

I am writing as Chair of SAFE -- Serving Alabama's Future Environment, an organization of citizens in Alabama who work to end toxic pollution, especially the military toxics generated by Fort McClellan and the Anniston Army Depot. We are very concerned about the proposed rule on the military munitions and how it will impact the US chemical weapons disposal program since we are a site targeted for a nerve gas incinerator. We also have weapons testing ranges and non-stockpile chemical weapons at Fort McClellan, which was recently added to the base closure list. Our comment is:

States, such as Alabama, that have chemical weapons stockpiles must keep their right to make and enforce laws regarding chemical weapons disposal that are stricter than federal laws. The incineration of chemical weapons is not acceptable to people in Alabama because it is an unsafe, unproven, out-dated, dioxin-producing technology. The proposed rule could stop our state from passing the stringent, necessary laws to regulate the disposal of chemical weapons and protect the health and safety of our communities...

...We advocate the research and development of closed-loop treatment and disposal technologies for chemical weapons and other munitions. The DOD has agreed to look into some of the alternatives [illegible] The EPA rule should reflect the need for the development of innovative, [illegible] disposal technologies.

COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

We support cooperation among the DOD, the EPA, and the public in creating good solutions to military munitions disposal problems. We know that the best solutions come when all affected groups -- especially citizens near disposal sites -- take part in making decisions.

We wholeheartedly support the critique of the proposed rule adopted by the Military Toxics Project's Conventional Munitions Network of December 3, 1995. In the Federal Facilities Compliance Act, congress decided that the military should not be permitted to regulated itself -verynnvious,fair,and logical decision. We believe that external oversight, mandatory citizen participation, and state ability to pass tougher laws than those passed nationally, are crucially important if we are truly going to protect the health of people and the environment.

We hope that the final rule will coincide with the intent of Congress -- that the Army should not regulate itself -- and that we can all work together to clean up our world...

Resources

All resources listed below are available from the national headquarters of the Military Toxics Project unless otherwise noted. Checks should be made payable to "Tides Center/Military Toxics Project." California residents should add 8.6% sales tax.

Covering the Map: A Survey of Military Pollution Sites in the United States. Co-published by Physicians for Social Responsibility and The Military Toxics Project. May 1993. 116 pp. $15.00.

Fighting Military Toxics: A Citizen's Organizing Manual. Published by the Military Toxics Project January 1991. 48 pp. $10.00.

Citizen's Guide to Military Base Cleanup & Conversion. Co-published by The Center for Economic Conversion and The Military Toxics Project. 1993. 75 pp. $15.00

Chemical Weapons Disposal and Environmental Justice. Published by the Kentucky Environmental Foundation. 13 pp. Free. Contact Kentucky Environmental Foundation, PO Box 467, Berea, KY 40403. Phone: 606-986-7565.

Smoking Guns: The Environmental, Economic and Cultural Impacts from Conventional Munitions. A fact sheet published by the Military Toxics Project. 2 pp. $1.00.

Depleted Uranium: A Tragedy of the Commons. Written by Christina E. Larson, Department of Psychology, University of West Florida. Published in *Peace and Conflict: Journal of Peace Psychology.* 2(3). 217-232. 1996. Lawrence Erlbaum Associates, Inc. Requests for reprints should be sent to Christina Larson, PO Box 1002 Shalimar, FL 32579-1002.

Friendly Fire: The Link Between Depleted Uranium Munitions and Human Health Risks. Co-published by The New Mexico Progressive Alliance for Community Empowerment (PACE) and The National Depleted Uranium Citizens Network of The Military Toxics Project (MTP). Second Edition. March 1995. 12 pp. $5.00.

Radioactive Battlefields of the 1990s: The United States Army's Use of Depleted Uranium and its Consequences for Human Health and the Environment. Published by the Military Toxics Project's Depleted Uranium Citizens' Network. January 16, 1996. 7 pp. $3.00.

The Silence is Deafening: A Report on Exposures of Persian Gulf War Veterans and Others to Depleted Uranium Munitions. Written and published by Dan Fahey of Swords to Plowshares. February 20, 1997. 19 pp. 415-247-8777

Angels Don't Play This HAARP: Advances in Tesla Technology. By Jeane Manning and Dr. Nick Begich. This book looks at the Pentagon's $30 million HAARP (High frequency Active Auroral Research Program) which is designed to beam more than 4.7 gigawatts (billion watts) of radiated power into the ionosphere. The authors explain how HAARP could not only lead to a new class of military weapons, but also manipulate global weather patterns; damage the earth's ecosystem; knock out electronic communications; and change human moods and mental states. Published by Earthpulse Press. 1995. 233 pp. $14.95. Available from Dr. Nick Begich, PO Box 201393, Anchorage, Alaska, 99520. To order by VISA or Master Card, call 907-249-9111.

Deadlines for Submissions to 1997 issues of *Touching Bases.*

Second Quarter - May 16
Third Quarter - August 8
Fourth Quarter - November 7

Direct all submissions to:
Military Toxics Project
471 Main Street
Lewiston, ME 04240
Fax: 207-783-5096
Email: mtp@igc.org

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COMMENTOR NO. 80: PORTSMOUTH-PIKETON RESIDENTS FOR ENVIRONMENTAL SAFETY AND SECURITY (CONT'D.) MCDERMOTT, OHIO

Coming Soon!!

MILITARY TOXICS PROJECT'S

Homepage

The Military Toxics Project is pleased to announce it's upcoming World Wide Web Homepage. Visitors will be able to access such information as recent publications, highlights and feature stories from our newsletter and links to other related organizations on the Web. MTP welcomes e-mail of concerns, suggestions and comments.

Military Toxics Project
471 Main St. 2nd Floor
Lewiston, Me. 04240

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COMMENTOR NO. 81: STARMET IDAHO FALLS, IDAHO

STARMET

EIS Comments on Technology Development Needs for Depleted Uranium Metal Applications

Prepared by
W. J. Quapp
April 29, 1998

1. Introduction

These comments are prepared to identify the required research in depleted uranium production that must be funded by the DOE to reduce the production cost. Without such cost reduction, some applications, while technically feasible, will never be economic compared to alternative metal options such as steel, lead, and copper. As will be discussed later, the performance advantage of depleted uranium metal must be very high to overcome the high product cost of metallic uranium components. This paper identifies some opportunities and offers suggestions for reducing the economic penalty of using metallic depleted uranium.

81-1

2. Background

Depleted uranium metal is a unique material. It is slightly radioactive and, thus, possession and use are regulated for all but the smallest quantities. Depleted uranium and its alloys have the undesirable attribute of being easily oxidized at room temperature and machine turnings are pyrophoric. The property of depleted uranium which makes it use most desirable is its high density – 18.95 g/cm^3. The high-density characteristic can be used in selected applications such as radiation shielding and counterweights to provide superior product performance. But the radioactive baggage factor require management as a radioactive material.

In shielding applications, depleted uranium provides an efficient gamma shielding material and can allow designers to create smaller and frequently lighter shielded casks. This is particularly important in transportation casks where shipment weight or size restrictions cannot be met with alternative materials such as steel and lead. In counterweight applications, the high density allows for the manufacture of heavy components occupying a small volume. Depleted uranium aircraft counterweights have been used on military and commercial wide body jets for over thirty years but recently the industry has been shifting to tungsten because of the radioactive stigma of depleted uranium and the counterweight maintenance requirements.

The primary direct performance competitor to depleted uranium for both shielding and aircraft counter-weight applications is tungsten with a density of 19.3 g/cm^3. The main advantage of tungsten is its non-radioactive attribute. Its disadvantage is both cost and fabrication difficulties. However, there are also several other metallic alternatives to depleted uranium in applications where space is not a critical premium – industrial equipment such as forklifts and excavators. Most commonly, these alternatives are steel, lead, and, occasionally, copper with densities of 7.87, 11.35, 8.96 gm/cm^3, respectively. Heavy concrete with steel chips is used in excavator counterweights.

STARMET

3. Metallic Uranium Applications

2.1 Radiation Shielding Applications

Depleted uranium is an excellent gamma shield having 2.4 times the density of steel and 1.7 times the density of lead. Depleted uranium offers a significant advantage over lead in transportation casks during the postulated fire accident scenario due to its much higher melting point – 1135°C compared to 327°C. Depleted uranium offers advantages over steel in radiation attenuation in proportion to its density efficiency for spent fuel shielding applications. For some specific isotopes (specific photon energies), uranium is much more efficient than the density ratio alone would imply. However, depleted uranium alloys have never been established as an ASME code material so that no structural credit for depleted uranium is given by the NRC in cask applications regulated under 10CFR Part71. Consequently, the surrounding steel, which is also required to preclude oxygen from reaching the depleted uranium, must provide the structural requirements even though some depleted uranium alloys have very high strength and toughness.

81-2

Given that selected depleted uranium alloys have been used by the US Army for penetrators and tank armor, it appears that that there is ample precedent for using depleted uranium metal in high technology and demanding applications where corrosion protection can be assured.

3.2 Counterweight Applications

As stated previously, aircraft counterweights have been in use in wide-body aircraft for about 30 years. These counterweights are generally very small and are used to adjust the center of gravity and to balance loads on various aircraft components. Modern aircraft design techniques have reduced the need for counterweights. In addition, some aircraft owners are switching to tungsten to avoid issues associated with radioactive materiel. For example, Japan prohibits any aircraft using depleted uranium counterweights. Consequently, this market is relatively stagnant and little future use is projected.

81-3

Other potential counterweight applications include equipment such as fork lifts which require massive (several ton) counter weights to balance lifting loads. This market does not currently exist but if economic issues could be overcome (as well as regulatory and public acceptance issues), a large market might develop. One promoter of this application has sugested major warehouse cost savings and forklift safety improvements associated with forklifts using depleted uranium counterweights. The claimed cost savings come from more compact warehouses. The safety benefits come from a lower center of gravity. If all forklift production was converted to using depleted uranium counterweights, the entire inventory of depleted uranium could be consumed in a few years.

However, regulatory and public acceptance issues aside, the major barrier to commercial depleted uranium counterweight use is the cost of production. This is addressed in the next section.

STARMET

4. Depleted Uranium Metal Production Costs

3.1 Current Production Costs

The method used commercially for uranium metal production is the Ames process. In this process, UF_6 is reacted with hydrogen to produce UF_4 or "greensalt" and HF. In a separate step, the greensalt is mixed with magnesium metal chips and is ignited in a graphite lined retort (a high temperature chemical reactor) at about 800°C. The magnesium reduces the UF_4 to uranium metal and forms MgF_2. This solid phase reaction liberates tremendous heat and the entire mass of uranium and MgF_2 become molten. Due to density differences, the U metal liquid phase separates by gravity from the MgF_2 salt to form a "derby" which takes the shape of the crucible. After this material is cooled, the uranium metal derby is manually separated from the MgF_2 salt. The MgF_2 salt is disposed as a radioactive waste as it typically contains 1% to 2% uranium by weight. The metal is then cleaned and alloyed, as required, in a vacuum casting furnace. The metal is then shaped via extrusion, rolling or casting into its product form.

The Starmet CMI facility in Barnwell, SC, is the only remaining commercial US producer that manufactures uranium metal from UF_6. Some DOE conversion capability exists at the Y-12 and Los Alamos weapons facilities. Starmet CMI uses the Ames process. This facility has converted UF_4 to metal since 1983 for use by the US Army (as well as the British and French) for depleted uranium penetrators. The UF_6 to UF_4 capability was added in about 1987. These are the same processes that were employed at the DOE Fernald site prior to its shutdown.

81-4

Uranium derbies are shipped from Starmet CMI in South Carolina to the Starmet facility in Concord, MA, for alloying, casting and forming into products. After alloying, the uranium is cast into either ingots or slabs. Ingots to be used for penetrators are extruded into rods for subsequent machining operations. Starmet also casts slabs that are sent to the DOE INEEL facility in Idaho for use in fabricating armor for the Abrahms tank. These uranium slabs are fabricated at the Concord facility in vacuum melters from scrap uranium being recycled from prior operations at the INEEL facility.

The biggest non-regulatory impediment to the use of depleted uranium metal in commercial applications is the high cost of converting from UF_6 to uranium metal. In a survey performed for DOE in 1993 by Technics Corporation, the cost was identified to be about $11.70 per kg-U ($5.30 per lb-U) for conversion of UF_6 to metal and casting into a shape. Any forming or machining cost was additional and was priced at $4.40 to $22 per kg-U. Some cost reductions could be forecast through larger conversion facilities but these would not be expected to be sufficient to dramatically reduce the costs below those cited.

3.2 Market Production Cost Requirements

In a recent meeting between Starmet personnel and a Japanese forklift manufacturer, the manufacturer stated that the counterweight must not cost more than its steel equivalent. Thus,

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STARMET

unless the performance advantage of forklifts designed with uranium counterweights justifies the higher costs, none will be sold unless the cost of uranium metal production is reduced.

3.3 Cost Reduction Opportunities

3.3.1 Continuous Metallothermic Reduction

This process was developed at Oak Ridge National Laboratory in support of the AVLIS Enrichment process that uses a uranium-iron eutectic as feed material. The process uses a bath of molten magnesium into which uranium tetrachloride is injected. The magnesium reduces the uranium tetrachloride and forms magnesium chloride that can be recycled to recover the magnesium. The molten uranium is alloyed with iron during this process to reduce the melting point from 1135 C to about 700 C. This reduces the uranium vapor pressure and simplifies subsequent operations. The potential cost reduction for this process, compared to the AMES process, is not known due to proprietary restrictions associated with the AVLIS technology. *81-5*

Conceptually, this process might be adapted to uranium hexafluoride however, the process has not yet been successfully demonstrated at production scale. Furthermore, the advantages of using the eutectic mixture for AVLIS would probably be unavailable for counterweight applications since the metallurgical properties of the uranium-iron alloy are very poor. During cooling, shrinkage cracks develop and the alloy is very brittle at room temperature. By casting the alloy in a steel sheath, these metallurgical property deficiencies might be made irrelevant.

3.3.2 Direct Plasma Conversion of UF_6 to Uranium Metal

Technology Description

This technology was conceived at the INEEL as a possible method for a lower cost production of uranium metal from UF_6. Conceptually, the process operates as shown in Figure 1. The UF_6 is injected as a gas into the center of a hydrogen-rich plasma operating at about 5000°C. At this temperature, the UF_6 dissociates to Umetal and elemental fluorine. The fluorine combines with the hydrogen to form HF. As the gas exits the plasma reactor, it must be cooled rapidly to avoid the back reaction of HF with U. At the exit of the reactor, the gas (HF and unreacted H_2) with the entrained Umetal vapor enters a cyclone where the cooled metal particles are separated from the gas stream. The system operates with excess hydrogen and to maximize conversion of the fluorine to HF. This excess hydrogen must be separated from the HF gas and recycled. *81-6*

Advantages of this direct conversion approach must be contrasted with the traditional method for uranium metal production – the Ames process. The INEEL plasma conversion process consumes only hydrogen and liberates only anhydrous HF and H_2 as byproducts. The H_2 is extracted from the HF and recycled. The HF gas is comparably easy to purify of uranium using filtration techniques. The metal formed from this process is nanometer sized particles that are very pyrophoric. A method must be developed to solidify the uranium particles into an ingot before exposure to air.

COMMENTOR NO. 81: STARMET (CONT'D.)
IDAHO FALLS, IDAHO

STARMET

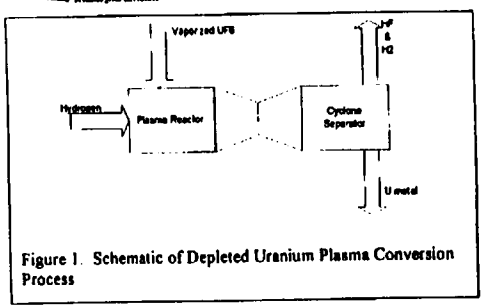

Figure 1. Schematic of Depleted Uranium Plasma Conversion Process

In all past uranium metal production operations, because of the relatively small production, the HF was captured in a scrubber to form aqueous HF that was subsequently reacted with CaOH to form CaF_2 and water. The water was evaporated and the CaF_2 was disposed as a radioactive waste. The greensalt reduction reaction to produce uranium metal consumes magnesium and produces MgF_2 as a radioactive by-product waste. Method to separate the uranium contamination from the MgF_2 have been considered but not deployed. *81-6 (Con't.)*

The INEEL process was successfully demonstrated at the small bench scale under a program funded by DOE EM 50 in 1994. The major challenge with the plasma reduction process is associated with the design and maintenance of a plasma reactor operating at such high temperature. INEEL researchers identified methods for designing such plasma reactors but further demonstration was beyond the scope of the funded program.

Estimated Cost Savings

After the proof-of-concept, bench scale test was successfully completed, an engineering conceptual design was performed for INEEL by Morrison Knudsen to estimate the total lifecycle cost of this approach. In summary, this report identified that a reasonably sized facility could produce uranium metal at about $3.00 per kg-U. This compares to estimated commercial costs from the Ames process of about $8.80 per kg-U.

To achieve this production cost reduction, substantial research support will be required and probably at least ten years of effort will be needed before large-scale production could be achieved.

5. Conclusions

Applications for depleted uranium metal have been identified. These applications include radiation shields and industrial counterweights.

Barriers to using radiation shielding applications are minimal as numerous precedents have been set for use in transportation casks. Barriers to industrial counterweight applications are institutional and economic. The institutional barriers are public acceptance and legal possession limits. Such regulatory barriers may be resolvable, as the real toxic health effects of depleted *81-7*

1534

COMMENTOR NO. 81: STARMET (CONT'D.)
IDAHO FALLS, IDAHO

STARMET

uranium are less than for lead. The radiation issues from depleted uranium are miniscule provided the material is not ingested into the lungs. Resolution of public acceptance issues are difficult to predict but in an industrial setting, but they must be solved.

Thus, the largest barrier to the use of depleted uranium metal is production costs. Unless the forklift industry can sell the concept of substantially increased performance for the depleted uranium counterweight forklift designs, then the counterweight must have a similar cost to a steel counterweight. With steel casting costing in the range of $1.54 per kg versus uranium casting costing over $12 per kg, it is clear that reduced manufacturing costs are needed for commercial applications.

The direct plasma conversion of UF_6 to uranium metal offers significant cost reduction potential but will require substantial research investment to demonstrate commercial feasibility. Even then, assuming success and that the economics are as predicted, the estimated costs are still over a factor of two greater than a cast steel counterweight. *81-7*

Consequently, wide scale application would be contingent upon either 1.) justifying to forklift buyers that the increased performance of a forklift with depleted uranium counterweights justifies a higher price, or 2.) alternatively, DOE could subsidize the conversion cost to neutralize the cost differential as a preferred action to managing the UF_6 for disposal. If the direct plasma conversion process were successful, the DOE subsidy would be less that the currently expected disposal costs – assuming the counterweights remained continuously in commerce and ultimately did not require disposal.

In summary, large scale industrial use of depleted uranium metal in applications such as counterweights will require development of a lower cost production technology for economic deployment. The INEEL process is one potential process which comes close to the needed production cost point.

1535

COMMENTOR NO. 82: STATE OF OHIO, LIEUTENANT GOVERNOR, HOLLISTER, NANCY P.
COLUMBUS, OHIO

STATE OF OHIO
OFFICE OF THE LIEUTENANT GOVERNOR
COLUMBUS, OHIO 43215

NANCY P. HOLLISTER
LIEUTENANT GOVERNOR

May 7, 1998

The Honorable Federico Peña
Secretary
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 30585

RE: "Draft PEIS for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafloride," DOE/EIS-0269 dated 12/97.

Dear Secretary Peña:

Thank you for the opportunity to comment upon the draft PEIS pertaining to future management plans for depleted uranium hexafloride (DUF6) being stored at the Portsmouth Gaseous Diffusion Plant in Southeastern Ohio. As a lifelong resident of Appalachian Ohio who has represented the area in a number of roles and as someone who has been closely involved with other issues regarding Portsmouth, my primary concerns are the safety, economy and environment of the region.

With this in mind, I support the near-term conversion of the significant stockpile of DUF6 to U308 at the Portsmouth plant. Under "normal" circumstances, one would wait until a market for a given product develops before engaging in such an activity. However, the DUF6 is stored in canisters of somewhat questionable integrity, and for which funding for long-term maintenance is noted in the PEIS as "uncertain." Thus, converting the DUF6 to a "safer" product as soon as possible is the more prudent option. *82-1*

Assuming that conversion is chosen as the preferred option, USDOE should carefully reassess the status of these cylinders and the practicality (safety) of transporting them through the region to a central conversion site. The deteriorating condition of the cylinders may make on-site conversion at each plant a safer, preferred alternative. On-site conversion may also serve to maintain employment in each region. *82-2*

DOE should work with Congress now to ensure that funds presently accrued by the US Enrichment Corporation to offset DUF6 conversion are maintained for that specific purpose, and to lay the groundwork for the on-site conversion efforts. *82-3*

COMMENTOR NO. 82: STATE OF OHIO, LIEUTENANT GOVERNOR, HOLLISTER, NANCY P. (CONT'D.) COLUMBUS, OHIO

The Hon. F. Peña 2 May 7, 1998

My comments are intended to augment and support those filed on this matter by Governor George Voinovich and Ohio EPA Director Donald Schregardus, and are included by reference herein. Once again, thank you for the opportunity to comment.

Sincerely,

Nancy S. Hollister

Nancy P. Hollister
Lieutenant Governor

xc: G. Voinovich, Governor
D. Schregardous, OEPA
C. Bradley, Jr., USDOE
J. Hall, USDOE
W. Timbers, USEC

1536

COMMENTOR NO. 83: MILLER, JANE E. MURPHYSBORO, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874 April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 83-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 83-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 83-3

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem. 83-4

Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 83-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 83-6

Thank you for considering these comments.

Sincerely,

Jane E. Miller

Jane E Miller
[illegible]

COMMENTOR NO. 84: BAILEY, SUSAN
NASHVILLE, TENNESSEE

Dear Mr Bradley
I sent deadline listed as Apr. 23 • April 27. Since Nashville's tornado really slowed me down, I hope April 27 was accurate.

Comments on PEIS for Alternative Strategies for the Long Term Management • Use of Depleted UF_6:

I am concerned that the draft PEIS does not include the alternative of disposing of depleted uranium per the rules of 40CFR191. Long-term storage of uranium poses serious risks which make the no action alternative • the new containers (for long term storage) option inappropriate • unacceptable. The waste classification of depleted uranium should be re-examined • should be put in the same category as transuranic waste. The scientific basis for this concern was well-documented in the comments of the Institute for Energy • Environmental Research. 84-1

Susan Bailey
2113 7th Ave N
Apt B-5
Nashville TN 37209

1537

COMMENTOR NO. 85: CAVAZOS, ALBERTO, SGT.
ADDRESS UNKNOWN

Forward Header
Subject: DUF6 Web Site Comments
Author: <web@bugs (Internet developers)> Date: 4/29/98 5:46 AM

Date Sent: 4/29/98

••••• Comments:

MY QUESTION IS, IF SOME ONE COMES IS EXPOSED TO DEPLETED URANIUM...WHAT ARE SOME OF THE SYMPTOMS??? I AM CURIOUS TO KNOW....I READ AN ARITCLE IN THE ARMY TIMES, RECENTLY AND ALSO I SERVED IN THE PERSIAN GULF WAR FROM 901216 TO 910427....THANKS IF YOU CAN PROVIDE THAT INFO..IF NOT, THANKS ANYWAY AND HAVE A GOOD DAY!! 85-1

Name: ALBERTO CAVAZOS SGT
Organization: US ARMY
emailAddress: ALBRTO@HOTMAIL.COM

COMMENTOR NO. 86: RUSTIN, FRANK; RUSTIN, RUTH & CASTEEL, NATHAN
BROOKPORT, ILLINOIS

Charles Bradley
US DOE (NE-40)
19901 Germantown Rd.
Germantown, MD 20874

April 13, 1998

Dear Mr. Bradley,

These are the comments of the undersigned on the Depleted Uranium cylinders DPEIS. There are some 50,000 plus cylinders of the DUF6 containing from 10 to 14 tons of material apiece currently stored in the three sites, Paducah, Portsmouth, and Oak Ridge.

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF6 will have to be defluorinated, which is a highly dangerous activity. The converted material and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF6. 86-1

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored - Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft. 86-2

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed. 86-3

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Although it appears that the best alternative is converting the material from the reactive UF 6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods. 86-5

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating such huge amounts of toxic waste, it should strongly consider ceasing production. 86-6

Thank you for considering these comments.

Sincerely,

Ruth Rustin

Frank Rustin

Nathan Casteel

1538

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON
NASHVILLE, TENNESSEE

STATE OF TENNESSEE

DON SUNDQUIST
GOVERNOR

May 1, 1998

Mr. Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
US Department of Energy
19901 Germantown Road
Germantown MD 20874-1290

Dear Mr. Bradley:

As the Governor's Lead Contact for State of Tennessee's National Environmental Policy Act (NEPA) reviews, I am providing comments in response to the **"Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride," DOE/EIS-0269**. The attached comments from state agencies represent the complete and official response of the State of Tennessee.

We prefer conversion of the entire inventory of stored Uranium Hexafluoride (UF_6) material which is recommended by the proposed alternative, however, the time line presented for the proposed alternative is unduly long considering the questionable condition of the stored inventory and potential health and environmental risks associated with leakage. As Governor Sundquist emphasized in his joint letter with the Governors of Kentucky and Ohio, the State of Tennessee urges the DOE to "consider the immediate conversion" of UF_6. The proposed alternative will provide the most rapid reduction of hazard to the environment and public if the time line for conversion is shortened . This recommendation applies only to the current scope of alternatives presented. 87-1

Up to this point the DOE has not fully funded the proper storage, inspection, testing and maintenance of stored cylinders of material nor does the PEIS address this pressing need for funding. Previous DOE documents have underscored its importance. Current inventories, however, remain in improper storage conditions and inspections of these inventories are limited Improperly stored cylinders are at risk to natural catastrophes such as earthquakes and tornadoes In order to fully assess the hazards associated with long-term storage versus conversion of UF_6, the DOE must address these funding concerns in the PEIS. 87-2

State Capitol, Nashville, Tennessee 37243-0001
Telephone No. (615) 741-2001

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

Beyond the condition of stored cylinders, issues concerning the handling of cylinders for transport have been insufficiently addressed or neglected in the PEIS. DOE's inspection of stored cylinders has been limited raising the concern that breaches in corroded cylinders may exist. Handling such corroded cylinders as well as cylinders that have been overfilled or cylinders containing "heel" materials—conditions which do not meet Department of Transportation's specifications for transport—will require costly training of personnel to repackage materials. The DOE cannot adequately assess alternatives for long-term management of stored inventory without realistically assessing these hazards and costs in the PEIS. *87-3*

We further request that the PEIS address the Inventory of the United States Enrichment Corporation (USEC) which may come into DOE possession. Omission of this significant inventory represents an incomplete analysis. *87-4*

In addition to these general comments, I request that the enclosed comments be given your full consideration. As always, your timely consideration of the interests of the State of Tennessee is appreciated. If you have any questions, please contact our staff policy analyst at (615)532-4968 (fax 615-532-0740).

Sincerely,

Justin P. Wilson
Deputy to the Governor for Policy

JPW:emw

Attachments

cc: Mr. Milton H. Hamilton, Jr., Commissioner
Mr. Rick Sinclair, Deputy Commissioner
Mr. James Hall, US Dept of Energy
Mr. Tom Winston, Ohio Environmental Protection Agency
Mr. Tuss Taylor, Kentucky Department of Environmental Protection
NEPA coordination file/Mr. Dodd Galbreath
NEPA contacts

1539

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY ROAD
OAK RIDGE, TENNESSEE 37830-7072

April 21, 1998

Charles E. Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
US Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Mr. Bradley

Document Review: "Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride," DOE/EIS-0269, December, 1997.

The Tennessee Department of Environment and Conservation, DOE Oversight Division (TDEC/DOE-O) has reviewed the subject PEIS in accordance with the requirements of the National Environmental Policy Act (NEPA) and associative regulations of 40 CFR 1500-1508 and 10 CFR 1021.

After review, the Division would like to express its support of the preferred alternative of converting uranium hexafluoride to oxide and/or metal. Tennessee has joined with Kentucky and Ohio in challenging DOE to begin the conversion immediately and complete the conversion by 2018. The PEIS has not properly addressed the need to provide adequate funding for the safe maintenance of the cylinder yards and implement requirements that protect the workers, public, and environment at and adjacent to the sites. *87-1 (Con't.)*

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

Charles E. Bradley, Jr.
April 21, 1998
Page Two

Additional comments, for DOE's consideration in preparation of the Final Programmatic Environmental Impact Statement, are attached.

If you have any questions regarding the Division's review, please contact John Owsley or Jim Harless at (423) 481-0995.

Sincerely

Earl C. Leming

Earl C. Leming
Director

el381.99

1540

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

Tennessee Department of Environment and Conservation /DOE Oversight Division

Comments on Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride, DOE/EIS-0269, December, 1997

General Comments:

The State agrees with the preferred alternative as stated in Section 2.5, Page 2-54 of converting uranium hexafluoride to oxide and/or metal. Given, however, the numerous reports that cast doubts on the integrity of uranium hexafluoride cylinders and their environmental safety, the State, as shown in a recent letter from the Governors to Secretary Pena on the same subject, would prefer that fabrication and conversion facilities be sought as early as possible and not wait until the year 2005 as stated in the PEIS. *87-1 (Con't.)*

In order for Tennessee to effectively evaluate the potential impacts of the preferred alternative, the PEIS must provide information on the location of the sites where conversion might occur and how waste and materials generated from this process will be managed. *87-5*

More than 50% of the cylinders were not constructed to Department of Transportation (DOT) specifications. After thirty years in storage, a much higher percentage of the cylinders may not meet DOT specifications for transportation purposes and may need to be overpacked if they are moved for processing. Also, deteriorated cylinders may require cold extraction of the contents. The personnel needed to handle the cylinders will need to be trained for extreme conditions. The costs of recruiting and training appropriate personnel for the duration of the processing operations will have to be factored in the cost-benefit analysis. *87-3 (Con't.)*

Funding must be addressed in the PEIS to provide for regulatory compliance and the continued storage of cylinders, including the heel and smaller cylinders. The "Draft Preliminary Report-DOE Independent UF6 Cylinder Assessment Team" dated 03-25-92, still in draft form, states the primary issues with cylinder management is funding to properly store, inspect, and maintain. Site visits by the State in July 1997, confirmed that funding has not been fully appropriated to maintain the yards or the cylinders. *87-2 (Con't.)*

The Draft PEIS fails to address two major issues. The first is the treatment, recycling, or reuse of Uranium Hexafluoride (UF_6) in a timely manner. The second issue is the final safe disposition of the "heels" component of the UF_6 cylinders, containing a high energy (gamma emitting) RCRA mixed waste like material. The Division estimates there to be 120 million pounds of this material in cylinders stored on the Oak Ridge Reservation. Of paramount concern under the No Action or Long-Term Storage alternatives, is the slow migration of the "heel" material into the groundwater/surface water and the release of UF_6 into the air, due to the corrosion and failure of the cylinders. The Draft PEIS is unclear on the criteria used for hazard modeling. The PEIS must identify the "worst-case" cylinder conditions and explicitly use this information in the hazard modeling descriptions. The PEIS must describe the modeling parameters such as total wall area found to be less than minimum thickness, age of the cylinder, manufacturing requirements (ASME or other design/construction), denting/bulging, and if the cylinder is in an "overfilled" condition. *87-6*

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

These conditions then must be coupled with the natural phenomenon hazards in determining the risk. The PEIS must accurately identify the cylinder population with these conditions.

The PEIS does not address storage and maintenance of the overfilled cylinders. The K-25 site has determined there are approximately 2300 14-ton and two 10-ton cylinders that contain more UF6 than is allowed for off-site shipment by DOT regulations. Although the cylinders are determined to be overfilled for transportation, they also must be properly evaluated for long-term handling and storage. 87-7

The document does not address potential waste issues arising out of leaks (breach or rupture) in the cylinders and/or leaks caused by the handling of the cylinders. Prolonged storage of the UF_6 in outdoor yards can and has been shown to cause corrosion events. The products of corrosion include radioactive and hazardous wastes. In so far as the products of corrosion are not collected and recycled, they are wastes. With age, the probability of corrosion and external breach for the cylinders increases. Thus leakage from the long-term storage of Uranium Hexafluoride cylinders could result in hazardous waste violations and non-compliance with applicable DOE Orders. 87-8

The PEIS has not presented supporting evidence that mines, shallow earthen trenches, and other underground sites are suitable for long-term storage. The State cannot continue to rely on "later determinations," "future treatments," or other vague options for storage and/or disposal. DOE has failed to approve long-term storage and disposal sites for other materials/wastes thus the State could expect the same lengthy time period for decision making on UF6. Placing any of the UF6 material for long-term storage or disposal in shallow earthen structures, below ground vaults, and/or underground mines should not be an alternative consideration. 87-9

United States Enrichment Corporation (USEC) since its privatization, has produced about 8000 cylinders (now reported to be upwards of 10,000) and is estimated to be currently producing 2 to 4 cylinders daily. The exact number of cylinders in question must be identified in the PEIS. The ownership of these cylinders has yet to be determined. The decision regarding USEC's 8000 cylinders should be made now, not as described in a "future Memorandum of Agreement between the USEC and the Office of Management and Budget." If the 8000-10,000 cylinders were considered part of DOE's inventory, it would represent a significant increase in total cylinder inventory. 87-4 (Con't.)

A long-term strategy for DUF6 must include DOE's entire cylinder inventory, including heel and small cylinders as well as the 10,000+ cylinders of DUF6 generated by the USEC since 1993. The USEC cylinders will revert to DOE ownership upon privatization of USEC. DOE might consider partnering with the future owner of USEC in a long-term strategy for managing and converting DUF6 in order to avoid redundancy of efforts, so long as the partnering does not slow progress toward conversion. An estimated $480 million has been accrued by USEC since 1993 in order to offset the cost of future conversion of the DUF6 generated. DOE should take steps now to ensure that this fund is not diverted into the federal treasury for an unrelated use.

The PEIS must give a clear definition for "heel" and list the word in the definition section. 87-10

1541

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

Specific Comments:

Page S-3, Section S.1.1, Background
"Under the current management plan, if alternative uses for the depleted uranium have not been found to be feasible by approximately the year 2010, steps would then be taken to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020." Conversion to an oxide should be completed by 2018 whether the material has a useful purpose or not. 87-1 (Con't.)

Page S-6, Section S.2, Description of Alternatives
This section describes an alternative for "long-term" management. DOE has defined long-term in previous NEPA documents as storage for up to 50 years. This document does not identify any time frame in its definitions. The continued storage of these cylinders under the No Action alternative has already reached the long-term storage definition. 87-11

Page S-8, Table S.1
The No Action and Long-Term Storage alternatives state *"...cylinders would be subject to a comprehensive monitoring and maintenance program..."* Describe how this program differs from those already proposed. The document *"Draft Preliminary Report-DOE Independent UF6 Cylinder Assessment Team,"* dated 03-25-92, made specific observations and recommendations for UF6 cylinder management, but is still in draft form. DOE has proposed many plans, but has failed to appropriate the funding to fully carry out those plans. The PEIS must take into consideration historical management plans and DOE's failure to fund or comply with its own requirements. 87-2 (Con't.)

DOE continues to state there is to be maintenance and monitoring plans, but the PEIS state that funding is questionable for some cylinder activities, such as coating. Current cylinder conditions leave no question that funding has been less than adequate. DOE must take aggressive action to ensure whatever alternative is selected and there will be no reduction or elimination of necessary maintenance and inspection activities due to lack of funding.

Page S-13, Section S.3.3, K-25 Site on the Oak Ridge Reservation
"Which consists of three major facilities..." The K-25 site contains more than three storage yards. 87-12

Page S-32, Section S.4.1
"...exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations." The K-25 facility is no longer in normal operation status, and yet poses a significant gamma exposure risk to members of the public and to "reindustrialization workers." The Division has recorded the annual radiation dose (by method of thermoluminescent dosimetry monitoring) at the fences of K-1066-K Yard to be 1240 mrem, B Yard to be 950 mrem, and J Yard to be 260 mrem. Members of the public have access to the fence line at the K-1066-K area. The Division questions the methods DOE used for the estimated radiation exposures of "workers and members of the public." 87-13

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

Page S-38, Section S.4.5, Water and Soil
"...(based on the U. S. Environmental Protection Agency (EPA) proposed maximum contaminant level (MCL) of 20 µg/l for drinking water, and on the EPA health-based guideline of 230 µg/g for residential soil)." This is not the spirit or the letter of environmental and nuclear regulatory limits and the laws that codify these regulations. The spirit or the letter of environmental and nuclear regulatory limits and the laws is to minimize contaminant migration at its earliest and most effective point. 87-14

Page S-42, Section S.5, DOE's Preferred Alternative
The State supports DOE's Preferred Alternative of simultaneously implementing both use as uranium oxide and use as uranium metal as described in this section. Disposal as Oxide should be retained as an option as these uses progress, since it may be necessary to pursue the disposal options for some of the material. 87-15

Page 1-5, paragraph 2, Section 1.1, Background Information
The Division concurs "The DOE has responsibility for continued management of the depleted UF_6 cylinders generated by DOE and stored at the Paducah, Portsmouth, and K-25 sites." However, the proposed time table does not adequately address the safety and environmental concerns of the State of Tennessee. It has been estimated that there are an additional 12 undiscovered breached cylinders in the inventory, in addition to 7 already identified, and that the number may be as high as 200. Since some cylinders (with approximately 3 curies per cylinder) have experienced a 1/3 to 1/2 wall thickness loss due to corrosion, the continued storage of cylinders does not seem prudent or reasonable. The timetable should be accelerated to convert the UF_6 to triuranium octaoxide (U_3O_8) as soon as possible. The U_3O_8 or metal form of depleted uranium represents "safe" storage of depleted uranium. 87-2 (Con't.)

Pages 2-54 and 2-55, Section 2.5, DOE's Preferred Alternative
"...(1) continuing the safe, effective management of the cylinders and (2) beginning conversion of the depleted UF_6 into depleted uranium oxide and/or metal products as uses for these products become available."

This document should address the safety concerns raised by the National Defense Facilities Nuclear Safety Board (DNFSB) in 1995 on the integrity of Uranium Hexafluoride Cylinders.

In its conclusions, DNFSB noted in 1995 *"DOE has stored depleted UF_6 in transportation cylinders for more than 40 years and may continue to store them for an additional 30 years. The analysis of the adequacy of the existing cylinders for use as storage systems over this extended time period has not been systematic and has not addressed all the pertinent concerns. Specifically, the following areas need further assessment:*
1. the potential for failure by accelerated corrosion mechanisms needs to be better characterized and then quantified;
2. the inspection program, used to characterize the condition of the cylinder population and monitor continued adequacy for storage, needs significant overhaul to achieve these purposes;
3. cylinder handling procedures need to be analyzed and then revised to incorporate precautions for handling degraded cylinders; and 87-16

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4. the safety analyses for the cylinder storage yards need to be upgraded to: include insights gained through the above reviews; investigate the unique problems presented by a breach in the vapor space; investigate the hazards associated with moving degraded cylinders; and incorporate structural analyses of the cylinders." 87-16 (Con't.)

The PEIS does not include the DFNSB report in its Reference section. In the absence of effective management reactions to these recommendations, storage of the cylinders in their present location and present condition may not be continued safely. Continued safety is questionable as the probability of loss of container integrity and external corrosion increase with time.

Also continued long-term storage of the cylinders is in conflict with the accelerated clean up program of DOE. The availability of skilled and trained workers for the extraction and treatment of UF_6 ten or twenty years beyond 2006 will be more expensive. If the present conditions of storage persist, a greater population of the containers will be structurally unsound and the risk of release by rupture will be compounded. 87-17

Page 3-42, Section 3.3.1, Cylinder Yards
"The four breached cylinders have been patched to restore their integrity, segregated from other cylinders in K- and E-yards, and placed under temporary awnings. No estimates of material loss are available for these cylinders."
Appendix B-2: Breached cylinders and material loss - conflicts with the statement above. The following information has been obtained from the *"Investigation of Breached Depleted UF6 Cylinders at the K-25 Site"* dated 10-94:

Cylinder Number	Hole Diameter	Total Weight of Material Collected External to the Cylinder	Uranium Content of Material
101244	6 inch	Not Available	0.160
114951	8-12 inch width by 15-17 inch length	11.8 Kg	1.8 Kg
7953	9 inch	9.8 Kg	2.2 kg
116797	2 inch	----	----

87-18

Breach of the Cylinder 116797 is presumed to be mechanically induced cylinder breach and the reason for the absence of Uranium containing deposits. Estimated amount of UF_6 lost is 0-4 pounds for cylinder 116797 versus 17 pounds to greater than 109 pounds of estimated loss for Cylinder 114951.

Page 3-46, Chapter 3, Section 3.3.5.1, Surface Water
Monthly sampling plan does not include a means to identify contamination of the storage yards and run-off from the UF_6 material. The timing of the sampling with that objective should be immediately after a precipitation event, since Uranyl fluoride is extremely soluble in water. Thus the discussion of the results of the monthly sampling and the analyses is not relevant to the storage of UF_6 cylinders. 87-19

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Pages 4-2 through 4-5, Section 4.2, Major Assessment Assumptions And Parameters
The reports from the Oak Ridge and Paducah assessment teams on the UF_6 Cylinders, 1992 and 1994 respectively, have noted many deficiencies with regard to cylinder integrity and thinning of walls due to internal and external corrosion. Corrosion has occurred to the extent that special training is required for personnel engaged in the monitoring of the cylinders. Also, the safety analysis performed on the cylinders is incomplete and does not include effects due to high winds, tornadoes, earth movements, and etc. Some of the cylinders have been reported to have thinning of the walls in the middle. Handling of such cylinders may be cause for concern. Under these circumstances, the No Action alternative will be a potentially hazardous alternative. 87-20

In addition, the stated assessment period of forty years is in conflict with DOE's accelerated clean-up plan for K-25. While the cylinder storage yards have not been identified as hazardous waste sites, the fact that breached cylinders exist and have the potential to leak out toxic substances is of major concern to the State of Tennessee. While the release so far may not meet the reportable quantity requirements, DOE has a responsibility for any environmental impact due to the breaches. Also, there is the possibility that future leaks will be of a greater magnitude. In spite of known breached cylinders, DOE has not undertaken any action to determine the degree of contamination to the soil and to the water stemming from the breaches. 87-21

Page 5-69, Section 5.5.1.1.2, General Public
"*...the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million.*" The risk of dying from a radiation-induced latent cancer associated with a total dose of 1 mrem is closer to 1 in 30,000. Please provide a citation or reasoning to support a 1 in 1 million radiation induced latent cancer risk. 87-22

Page 5-72, Section 5.5.1.2.2, Accidents Involving Releases of Radiation or Chemicals
"*All doses would be considerably below the 25 rem maximum allowable dose specified in NRC regulations (10 CFR Part 76).*" The regulation with which 10 CFR 76 refers is 10 CFR 20, which is the regulation with the widest applicability "Standards for Protection Against Radiation." The 10 CFR 20 applies to all activities licensed by the NRC which encompasses all commercial uses of radioactive material. Part 20 provides extensive details on "subsets" of exposure such as hourly exposure and exposure of minors. For comparative purposes, Part 20 limits whole body dose to 5 rem for personnel in restricted areas and 0.5 rem for personnel in unrestricted areas. The term "unrestricted area" is usually interpreted to extend to the site boundary, but not beyond to the "environment." This interpretation keeps 10 CFR 20 from conflicting with 40 CFR 190. It also assumes that the licensee has at least some minimal control over the personnel exposed. 87-23

The 40 CFR 190 regulates doses received by members of the general public in the "general environment" resulting from the nuclear fuel cycle. This is a different scope than 10 CFR 20 since 40 CFR 190 includes all processes and facilities in the nuclear fuel cycle (excluded is any dose due to occupational exposure as part of the nuclear fuel cycle). The "general environment" means the environment outside the boundary of the facility covered by the regulation. This keeps 40 CFR 190 from conflicting with 10 CFR 20. The whole body exposure limit specified by 40 CFR 190 is 25 mrem. The 25 rem "maximum allowable dose" is not really a "maximum allowable dose" at all, but rather, the dose at which notification to the NRC must be made. Section 20.403 states that "*Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause: (1) Exposure of the whole body of any individual to 25 rems or more...*"

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Page 5-76, Section 5.5.7, Waste Management
Generation of "1 m^3/yr of LLMW" seriously underestimates the "heels" component of the UF_6 cylinders containing a high energy (gamma emitting) RCRA mixed waste. The Division estimates there to be 120 million pounds of this material in cylinders stored on the Oak Ridge Reservation.. 87-24

Page 5-108, paragraph 3, Section 5.8.2.1, Paducah Site
The Clean Air Act contains a Particulate Matter $_{2.5}$ ($PM_{2.5}$) standard. 87-25

Page 5-108, paragraph 4, Section 5.8.2.1, Paducah Site
"*...cylinder breaches occurring at Paducah before the year 2020 could result in groundwater concentrations of uranium exceeding 20 μg/L*" is not provided for under the "Clean Water Act." 87-26

Page 5-110, paragraph 3, Section 5.8.2.2, Portsmouth Site
The Clean Air Act contains a Particulate Matter $_{2.5}$ ($PM_{2.5}$) standard. 87-25 (Con't.)

Page 5-110, paragraph 4, Section 5.8.2.2, Portsmouth Site
"*Uncontrolled corrosion until about 2050 before groundwater concentrations of uranium would approach 20 μg/L*" is not provided for under the Clean Water Act or Safe Drinking Water Act (SDWA). 87-26 (Con't.)

Page 5-112, Paragraph 3, Section 5.8.2.1, Oak Ridge Reservation: K-25 Site
The Clean Air Act contains a Particulate Matter $_{2.5}$ ($PM_{2.5}$) standard. 87-25 (Con't.)

Page 5-112, Paragraph 5, Section 5.8.2.3, Oak Ridge Reservation: K-25 Site
"*Uncontrolled corrosion until about 2025 before groundwater concentrations of uranium would approach 20 μg/L*" is not provided for under the Clean Water Act or SDWA. 87-26 (Con't.)

Page 5-115, First bullet, Section 5.9, Mitigation
The Clean Air Act contains a Particulate Matter $_{2.5}$ ($PM_{2.5}$) standard. 87-25 (Con't.)

Page 5-115, Third bullet, Section 5.9, Mitigation
"*Future impacts on groundwater from failure of a disposal facility could be minimized by selection of a site in a dry environmental setting*" should be highlighted and recognized as a major siting factor. The same argument could be made for the storage of "awaiting conversion" cylinders, that are currently deteriorating and corroding. 87-27

Page 5-119 and 5-120, Section 5.13, Pollution Protection And Waste Minimization
This section should address the "heels" component of the UF_6 cylinders. These heels contain a high energy (gamma emitting) RCRA like mixed waste. 87-6 (Con't.)

Page 6-1, Section 6, Environmental, Occupational Safety, And Health Permits And Compliance Requirements
The Clean Water Act/SDWA should also be included as a "potential requirement" 87-28

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STATE OF TENNESSEE
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April 30, 1998

Mr Charles E Bradley, Jr., Program Manager
Depleted Uranium Hexafluoride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U S Dept of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Re PEIS for DOE's Long-Term Management of Depleted Uranium Hexafluoride

Dear Mr Bradley

The Division of Radiological Health has the following comments

- The discussion of the statistical nature of the hazards posed by radiation exposure was a good addition to this report. — 87-29
- The PEIS document considers a number of different options for dealing with the Depleted Uranium Hexafluoride. Several of the options include the conversion of the material from UF_6 to either uranium oxide or uranium metal. In their analysis of this option, they always consider the conversion beginning in the year 2008 (PEIS 2-6, 2-9, 2-12, 2-15) This seems to be an unreasonably long time before starting conversion Even considering that it will take time to decide what to do with the material, and to build the facilities if conversion is the chosen option, it does not seem that 10 years should be necessary before conversion can begin. — 87-1 (Con't.)
- Chapter 5 of the PEIS discusses the environmental impacts of the various alternatives. As support for the discussion several graphs are included On page 5-20 a single graph compares the long term cancer risk (radiation risk) if the material is maintained as UF_6. Pages 5-37 and 5-39 compare the long term cancer risk (radiation risk) for conversion to an oxide and the probabilty of injury (non-radiation risk) if the material is converted to an oxide. While the report states that the chemical hazards of the material in its UF_6 form are greater than if it is converted to an oxide the omission of a graph showing the probability of injury if the material is maintained as UF_6 leads to an unbalanced representation of the hazards of these two options for the disposition of the material. Also, the combination of all non-radiation hazards as "risk of injury" is a misleading representation. — 87-30
- There are a number of questions about the characterization of the hazard from earthquakes at the Paducah, KY location These questions are outlined in an attached memo from a State geologist. — 87-35

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- References to the usefulness of the depleted uranium in either its oxide or metallic forms are unsupported. The document states that changing circumstances have made the specific uses mentioned unlikely for the future and yet no other possible uses are adequately addressed. (PEIS 2-20) This makes the position that this material is a resource as opposed to a waste tentative at best. If there are realistic scenarios for the future use of this material, they should be presented in the PEIS. If there are no realistic future uses, then the material should be treated and disposed of as waste. — 87-31
- Recommendation number 15 of the Draft Preliminary Report – DOE Independent UF_6 Cylinder Assessment Team dated March 25, 1992, states "All cylinders in or near ground contact should be removed from those conditions, ... and ultrasonic wall thickness examinations be performed of all cylinders with significant corrosion to determine the amount of residual thickness remaining." At the time of the PEIS, it is mentioned that ultrasonic testing is now part of the cylinder maintenance. (PEIS 2-56) It is also stated, however, that "Because the ultrasonic tests are time-consuming and costly only a small portion of the entire inventory has been measured." (PEIS B-2) This is a problem for two reasons First, it does not begin to meet the minimum of testing all cylinders with significant corrosion. Second, this brings doubt to statements such as "the cylinder breaches were assumed to go undetected for [at most] 4 years (the inspection interval for most cylinders)." (PEIS 2-5) The inspection for most of the cylinders consists only of a visual inspection. The visual inspection method, as described, does not appear to be adequate since many of the cylinders can not be seen on all sides and cylinders that are leaking may not be detected visually since the color of the paint matches the color of the leaking material exposed to air. — 87-32
- The PEIS states on page 4-3 that "While in storage at the three current storage sites, cylinders were assumed to be inspected and maintained in safe storage consistent with current management practices and plans." Based on the number of breaches detected, the rusting of the cylinders, the improper storage conditions and the documented lack of adequate surveillance of these cylinders, the assumption that material is in safe storage is only true when qualified by the phrase "consistent with current management practices and plans." Essentially DOE is defining their practices and procedures as safe This allows them to say that a process is safe simply because it meets the standards of the procedure, not because an unbiased safety analysis has been performed. — 87-33
- Appendix G of the PEIS, table G.6 compares accident consequences associated with the long term storage of the material in different chemical forms. Why are the accidents considered differently for the different forms. For example, an earthquake or a tornado are considered under unlikely accidents for the uranium oxide but neither scenario is considered for the UF_6. A comparison of this type would seem to be most useful if it compares the same types of accidents. Another difference is that "unlikely accidents" for UF_6 are described as having a possible frequency of "1 in 10,000 to 1 in 1 million years," while under the uranium oxide option the "unlikely accident" is described as having a frequency of "1 in 100 years to 1 in 10,000 years." It is not clear why an "unlikely accident" would have a different probability associated with it for a different chemical composition? — 87-34

Sincerely,

Michael H. Mobley
Director

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DIVISION OF GEOLOGY
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(615) 532-1504, FAX 532-1517

MEMORANDUM

TO: Mike Mobley & Joelle Key, Div. of Rad. Health

FROM: Mike Hoyal, Asst. State Geologist

DATE: February 20, 1998

Subject: Draft DOE PEIS, Earthquake Hazard

Regarding the information you provided on the above referenced document, please refer to the attached information from the Center for Earthquake Research and Information (CERI), at Memphis University.

The draft PIES seems to not only down-play past seismic events but gives very little information on future potential events. By all accounts, the Paducah area is located in a high-risk area for major damage from earthquakes (see attached seismic risk map). In comparison, the Oak Ridge area is located in a moderate-risk area and experiences fewer and less severe earthquakes. The information presented by this document might be more accurate for the East Tennessee area but seems to be an understatement for the Paducah plant area.

87-35 (Con't.)

The article on earthquake intensity gives a good explanation for how we can determine the extent of damage a seismic event can cause to manmade and natural objects in a particular place. The Modified Mercalli Scale describes intensities in physical terms that can be related by personal or observable results, thus more subjective. By contrast, the Richter Scale is a specific measurement of magnitude or energy released during an earthquake and is determined at the time of the event. While every earthquake can have many intensities, depending on distance from the epicenter, it can only have one measurement of magnitude. While magnitude measurements provide useful data for scientific research, including accurate comparison of

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NASHVILLE, TENNESSEE

earthquakes, they give no specific information about the damage or other effects caused by an earthquake.

For specific information on the probability or frequency of significant seismic events, please refer to the CERI attachment.

87-36 (Con't.)

Our Division has several publications available on earthquakes in Tennessee and both Ron Eurewski, Director, and Tom Hart, Geologist, are active in the Central U. S. Earthquake Consortium for this region.

If we can provide further service, please advise.

COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

The New Madrid Fault System

The greatest earthquake risk east of the Rocky Mountains is along the New Madrid fault system. Damaging earthquakes are much less frequent than in California, but when they do occur, the damage can be far greater, due to the underlying geology.

The New Madrid fault system, or the New Madrid seismic zone, is a series of faults beneath the continental crust in a weak spot known as the Reelfoot Rift. It cannot be seen on the surface. The fault system extends 150 miles southward from Cairo, Illinois through New Madrid and Carruthersville, Missouri, down through Blytheville, Arkansas to Marked Tree, Arkansas. It dips into Kentucky near Fulton and into Tennessee near Reelfoot Lake, and extends southeast to Dyersburg, Tennessee. It crosses five state lines, and crosses the Mississippi River in at least three places.

The great New Madrid earthquake of 1811-12 was a series of quakes that happened over a three-month period. The main shocks, the three largest earthquakes, were estimated to be greater than magnitude 8.0 Aftershocks included two events around magnitude 8.0, five magnitude 7.7, ten magnitude 5.3, and eighty-nine estimated at magnitude 4.3. The entire fault system is believed to have ruptured in this series of earthquakes. Aftershocks were felt in the region for more than a year. This was the largest release of seismic energy in the continental United States. The only other larger event was the Great Alaska Earthquake, in 1964

Earthquakes of 5.0 or less are also possible in many other parts of the central and eastern U.S. In addition to the New Madrid seismic zone (NMSZ), earthquakes of magnitude 6.0 and above have occurred at Charleston, South Carolina, and recent research suggests that the Wabash Valley fault system in Illinois and Indiana has produced large earthquakes.

The possibility of a great earthquake happening soon in the New Madrid seismic zone is small. Scientists believe that catastrophic events like those of the 1811-12 happen in the New Madrid region every 550-1200 years. THis means there is roughly a 0.3-1.0% probability of an event greater than magnitude 8.0 within the next 15 years, and a 2.7-4.0% probability within 50 years. Even though the probabilities are small, there is no reason to be complacent, for there have been other damaging earthquakes in the region since 1811 and 1812.

A major earthquake, magnitude 7.0 or greater happens every 254-500 years and has a probability of five to nine percent within the next fifteen years, and a nineteen to twenty nine percent within the next fifty years. An earthquake of this size would be felt throughout much of the central and eastern United States. Damage could amount to several billion dollars.

A damaging earthquake in this area, magnitude 6.0 or greater, happens every seventy to ninety years and has a probability of 40-63% within the next fifteen years, and 86-97% within the next one hundred and fifty years. An earthquake of this size would cause damage to older structures, especially those of masonry construction. There could be serious damage to many schools in the region.

The fault system is active averaging more than 200 earthquakes per year. Of these, eight to ten are large enough to be felt. There are approximately forty six earthquakes in the magnitude 2.0 range, and seven in the magnitude 3.0 range per year. (If your browser does not support HTML Table Tags, please use this link.)

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Magnitude	Expected Rate (yr)
4.0	14 months
5.0	10-12 yr
6.0	70-90 yr
7.0	254-500 yr
8.0	550-1200 yr

Magnitudes are determined by various methods The one of which most people are familier, is the Richter Scale. The Richter Scale is a measure of energy released in an earthquake. It is determined by ground motion on seismograms. An earthquake has only one Richter magnitude.

What do the numbers on the Richter Scale tell us? Each unit of the Richter Scale is a tenfold increase in the relative size of an earthquake. A magnitude 6.0 is ten times the size of a magnitude 5.0, and one hundred times the size of a 4.0. But energy release is a different matter. Each unit up the Richter Scale is around a 32 times greater release of energy. A magnitude 6.0 releases 32 times more energy than a magnitude 5.0, and about one thousand times more energy than a magnitude 4.0

The amount of energy released in a small earthquake is not enough to prevent a large one from occurring. A million magnitude 2.0 earthquakes would release the same amount of energy as one magnitude 6.0 quake. 32,768 magnitude 2.0 earthquakes would release the same amount of energy as one magnitude 5.0

Of greatest concern in the near future, then , are the 6.0 to 6.5 events. Damaging earthquakes in this magnitude range are possible within the lifetimes of our children. Two have occurred since 1811-1812, one in 1843, and another in 1895.

Many things can be done to protect ourselves. Education, preparedness planning, and proper building construction are proven means to minimize the deaths, injuries, and economic losses due to earthquakes. Northern California and Armenia recently experienced 6.9-7.1 earthquakes.Northern California was prepared, Armenia was not. In northern California 62 people died and there were more than $6 billion in losses. In Armenia over 25,000 people died and losses were greater than $20 billion. The central United States is more prepared than Armenia, but not nearly as well prepared as northern California.

The choice is ours. We can get ready and reduce our losses, or we can do nothing, and suffer the full consequences of a damaging earthquake. We need to continue to plan, to build better buildings, and make sure that earthquake preparedness becomes a part of all our lives. We cannot prevent the coming of an earthquake, but we can reduce the effects.

To contact the manager: mevans@cerl.memphis.edu

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COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

http://www.cert.memphis.edu/www/public_info/faultdocs.l

Magnitude	Expected Rate (yr)
4.0	14 months
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To contact the manager: stevens@cert.memphis.edu

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COMMENTOR NO. 87: STATE OF TENNESSEE, GOVERNOR SUNDQUIST, DON (CONT'D.) NASHVILLE, TENNESSEE

2

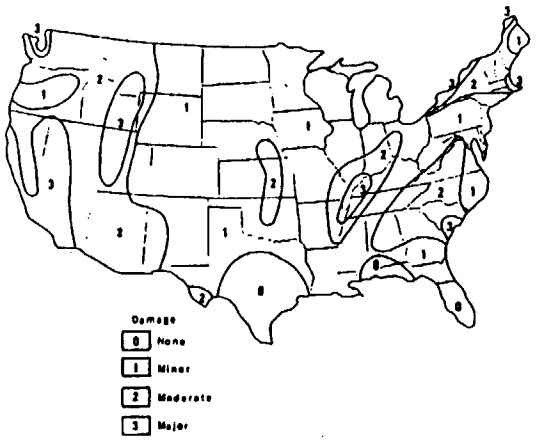

Figure 1. General seismic risk map of the United States. Note that much of Tennessee is in zone 2 or 3, where at least moderate damage is predicted. From Algermissen, Seismic risk studies in the U.S., Fourth world conference on earthquake engineering, January 14, 1969, Santiago, Chile.

CAUSES OF EARTHQUAKES

Most earthquakes are the result of shock waves created by the sudden release of slowly accumulated stress in rigid bedrock. This release of stress results in the rock's sliding along fractures, called *faults* by geologists. On either side of a fault the rock is offset. The sliding relieves the stress for a time, but continued stress accumulation often leads to recurrent sudden slippage on the fault, and more earthquakes are the result. It is for this reason that geologists are so concerned with accurately mapping fault locations, both old faults no longer active and those along which slippage has occurred in the recent geologic past. By studying the actual history of earthquakes along these faults, it may be possible to predict the likelihood of future earthquakes.

Throughout the world many earthquakes occur along precipitous sea coasts or actively rising mountains at the edges of continental plates. These plates are segments of the outer thin "shell", or crust, of the earth. The crust consists of several of these plates moving slowly apart, or sliding past, over, or under each other. It is along the boundaries of these plates that great amounts of energy are released in earthquakes and volcanic activity. It is not surprising, then, that quakes are so common in California and other places (e.g., Japan) at plate edges along the borders of the Pacific Ocean.

One might ask, "Why should earthquakes occur in and near Tennessee, since we are obviously far from

COMMENTOR NO. 88: MILITARY TOXICS PROJECT
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April 15, 1998

Charles E. Bradley, Jr.
U.S. Dept. of Energy
19901 Germantown Road
Germantown, MD. 20874-1290

Dear Mr. Bradley,

Thank you for your response to our letter, regarding the Department of Energy's draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride. As per our phone conversation you agreed to meet with the Military Toxics Project and other interested parties to discuss the P.E.I.S., however DOE could not afford to foot the bill. The citizens and impacted communities we work with simply do not have the money to fly to Chicago or Washington, D.C. to meet. Therefore, I simply wish to have on record the Military Toxics Project's position regarding Depleted Uranium.

As you may know, the Military Toxics Project (MTP) is a non-profit grassroots organization. Our membership is made up of concerned citizens, community organizations, national organizations, physicians, scientists, veterans, environmental justice activists, labor and peace groups from around the country. MTP's mission is "to unite activists, organizations and communities in the struggle to clean up military pollution, safeguard the transportation of hazardous materials, and to advance the development and implementation of preventative-based solutions to the toxic and radioactive pollution caused by the United States military activities. MTP's mission is based on mutual respect and justice for all peoples, free from any form of discrimination or bias".

In 1992, the Military Toxic Project formed the Depleted Uranium Citizens Network. The Depleted Uranium Network provides outreach and education, uniting people affected by the mining, production, manufacturing, testing, sale and use of depleted uranium for military and commercial purposes; and to demand cleanup, health care, compensation and the end of depleted uranium munitions use worldwide to help ensure the survival of future generations.

88-1

recycled paper

1548

COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

The Military Toxics Project adamantly opposes any use of the depleted uranium for military purposes such as in weaponry and munitions. First used in the Persian Gulf War in 1991, U.S. and British forces used depleted uranium as both armor piercing bullets and as tank armor. When uranium weapons burn, when they corrode, and when they are machined, uranium oxide dust is created. The U.S. Department of Defense estimates approximately 315 tons (630,000 pounds) of depleted uranium were fired in the Gulf. This firing resulted in the release of large amounts of DU dust which contaminated thousands of tanks, vehicles and land.

88-1 (Con't.)

Recently, the Military Toxics Project released a report with Swords to Plowshares and the National Gulf War Resource Center called the ***Depleted Uranium Case Narrative***. The report details how hundreds of thousands Gulf War Veterans may have been exposed to DU radioactive dust in the Gulf War. I have enclosed a copy for your review.

88-2

All too often we see industry and government with end of the pipe mentality, redefining waste as a product to be used. For example the paper industry's waste they call fertilizer and spread sludge on unsuspecting communities, further exposing citizens to toxics. Changing the medium doesn't necessarily reduce the risk. We hope the Department of Energy will start working towards more preventative based solutions in the future.

88-3

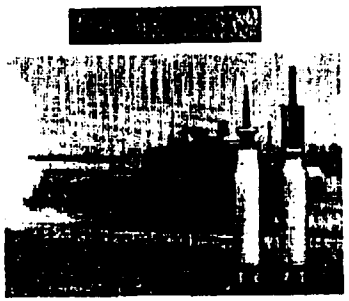
The task you are charged with now is to find the most safe and effective way to manage/use DU. When reviewing the comments for the Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride, we hope you will weigh MTP's concerns on how DU is used. Dealing with the tremendous stockpiles of Depleted Uranium Hexaflouride is a monumental task. We wish you well and if you have any questions, please don't hesitate to call.

Sincerely,

Tara Thornton

Tara Thornton
National Organizer

MILITARY TOXICS PROJECT



DEPLETED URANIUM:

AGENT ORANGE OF THE 90'S
ANOTHER PENTAGON COVERUP

Military Toxics Project's
Depleted Uranium Citizens' Network
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COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

DEPLETED URANIUM WEAPONS
Threaten Nuclear Non-Proliferation Treaty

A Briefing Paper To The Delegations to the 1998 Non Proliferation Treaty Preparatory Committee

Governments concerned about the future of nuclear weapons must be alerted to the dangerous proliferation of a new class of radioactive weapons first used in warfare by U.S. aircraft and U.S. and British tanks in the Gulf War. These weapons are made from Depleted uranium (DU).[1] Depleted Uranium is a radioactive and chemically toxic nuclear waste product that has been manufactured into an armor-piercing projectile known as the depleted uranium penetrator. At least fourteen countries including the U.S., the United Kingdom, France, Russia, Greece, Turkey, Israel, Saudi Arabia, Bahrain, Egypt, Kuwait, Pakistan, Thailand, and Taiwan now have DU penetrators in their arsenal.[2] Other sources assert that the weaponry has proliferated to Iraq, Oman, Jordan, Abu Dhabi and the United Arab Emirates.

The U.S. Department of Defense estimates approximately 315 tons (630,000 pounds) of depleted uranium were fired in the Gulf in 1991. This firing resulted in the release of large amounts of DU dust which contaminated thousands of tanks, vehicles and land. Depleted uranium dust can be transported by wind or water and can enter the human body via wound contamination or injection (as in fragments), inhalation or ingestion. Depleted uranium has a half life of 4 1/2 billion years.

Among the short and long term health effects of inhaled or ingested depleted uranium particles are kidney and liver problems, immune system disfunction, reproductive problems, birth defects and cancers. A March 2, 1998 report released by Swords to Plowshares, the Military Toxics Project, and the U.S. National Gulf War Resource Center details how hundreds of thousand Gulf War veterans may have been exposed to DU radioactive dust in the Gulf War. The Depleted Uranium Case Narrative is available on the Internet at www.miltoxproj.org.

Since the Gulf War battlefields remain contaminated with depleted uranium, the health of today's civilians, as well as that of future generations, is at risk. The United Nations Human Rights commission in Geneva has taken up the issue of depleted uranium weaponry through its Sub-Commission on Prevention of Discrimination and Protection of Minorities. The Sub-Commission adopted resolutions in 1996 and 1997 (resolution 1996/16 and 1997/36), which included depleted uranium weaponry among "weapons of mass or indiscriminate destruction", incompatible with international humanitarian or human rights law. In 1997 the U.N. appointed Mme. Clemencia Forero de Castellanos (Columbia) Rapporteur to take over the study of DU and other weapons of "mass or indiscriminate destruction". The report is due in the Sub-Commission 1998 summer session.

COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

Besides being a threat to human rights, DU weapons may impose on a nation a burden of health care costs and contamination of the environment that is expensive to address. In the United States, the price of clean up of 152,000 pounds of depleted uranium fragments and dust on 500 acres at Jefferson Proving Ground in Indiana has been estimated at $4 to $5 billion dollars.[3]

In addition to causing dire and costly health and environmental damage, depleted uranium can be modified to make an atomic bomb of plutonium 239. Depleted uranium penetrators purchased in sufficient quantities by any country could be disassembled and the DU diverted for breeding weapons grade plutonium in a nuclear power reactor that had been suitably adapted. Therefore, it is critical to the success of the Nuclear Non-Proliferation Treaty, that depleted uranium weapons be considered for their potential to become a plutonium bomb as well as their intrinsic capability of being "weapons of mass or indiscriminate destruction". Thus, depleted uranium weapons' development, production, stockpiling, testing, sale and or transfer, as well as use, must be banned.

---

1 During the process of making fuel for nuclear weapons and nuclear power plants, the fissionable isotope Uranium 235 is seperated from uranium. The remaining uranium, which is 99.8% uranium 238, is misleadingly called "depleted" uranium. As a result of more than fifty years of uranium enrichment, the U.S. Department of Energy currently maintains a stockpile in excess of 1.1 billion pounds radioactive uranium waste.

2 The Depleted Uranium Case Narrative, by Dan Fahey, Swords to Plowshare, March 1998, p. 67. The report is available on the Internet at www.miltoxproj.org, http://www.gulfweb.org/ngwrc, http://www.nsnn-us.org/ or http://www.globalidea.com/~borrelvw/. For copies call the Military Toxics Project in the USA at (207) 783-5091.

3 Depleted Uranium Case Narrative, p 50.

This paper has been prepared by the Military Toxics Project. MTP is a national network of groups working to clean up military pollution, safeguard the transportation of hazardous materials, and advance pollution prevention at US Dept. of Defense installations. Through its Depleted Uranium Campaign, MTP provides outreach and unites people affected by the production, testing, and use of DU for military purposes; and demands cleanup, health care, compensation and the end of DU munitions use worldwide to help ensure the survival of future generations. For more information contact MTP at 60 Pine Street, Suite 2, Lewiston, ME. 04240, USA. Phone: (207)783-5091, Fax: (207)783-5096, E-mail: miltoxpr@lme.net, Website: www.miltoxproj.org.

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COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

International Declaration on Depleted Uranium

Developed at the International Forum on Depleted Uranium held in Washington, DC on November 14 ~ 16, 1997.

In the spirit of universal harmony, with regard for the integrity for all peoples and nations, and for the perpetuity of safe and healthy environments and workplaces for ourselves and future generations;

Mindful that depleted uranium is the largest radioactive/hazardous waste of the nuclear enrichment process, and has accumulated in enormous quantities since the dawn of the nuclear age;

Concerned that depleted uranium is highly toxic and radioactive, with a half life of four and a half billion years, causing cancer, damage to internal organs (especially lung, kidney and bone), and birth defects;

Deeply concerned for the many people who are experiencing illnesses and medical problems because they are or have been knowingly or unknowingly exposed to depleted uranium;

Knowing that depleted uranium weaponry has proliferated throughout the world and that its use is incompatible with international law;

In response to the latest form of military radioactive pollution, namely weaponry made from depleted uranium which was used for the first time in warfare in Operation Desert Storm, which poses a threat to veterans, civilians, and future generations, citizens from the world community hereby agree to:

- **provide outreach and education, uniting people affected by the production, manufacture, testing, sale, and use of depleted uranium for military and commercial purpose**
- **pursue providing information and training for workers and soldiers regarding the hazards of depleted uranium exposure**
- **pursue the establishment of an independent international scientific and medical commission**
- **demand cleanup, health care, and compensation**
- **demand the end of the production and use of depleted uranium munitions worldwide.**

COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

PLEASE SEND ME MORE INFORMATION ABOUT THE MILITARY TOXICS PROJECT.....

NAME:_____

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STATE:_____ ZIP:_____

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MTP RELIES ON GRASSROOTS SUPPORT. PLEASE SEND YOUR CONTRIBUTION TODAY!!!!! MAKE YOU CHECK PAYABLE TO:

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471 MAIN ST. 2ND. FLOOR
LEWSITON, ME. 04240

phone: (207) 783-5091
fax: (207) 783-5096
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website: http://home.cdh.net/~mtp

MILITARY TOXICS PROJECT
471 Main St. 2nd. Floor
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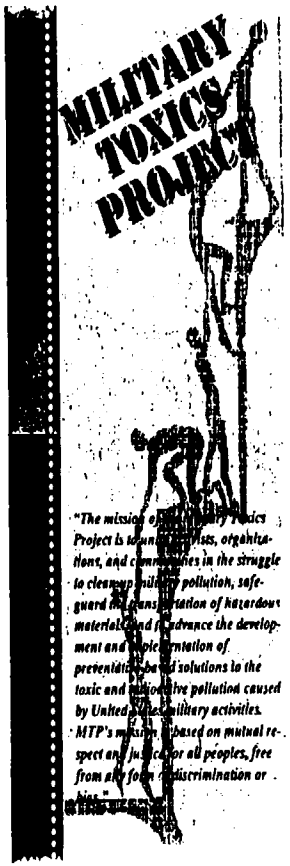

"The mission of the Military Toxics Project is to unite activists, organizations, and communities in the struggle to clean up military pollution, safeguard the transportation of hazardous materials, and advance the development and implementation of preventative based solutions to the toxic and radioactive pollution caused by United States military activities. MTP's mission is based on mutual respect and justice for all peoples, free from any form of discrimination or bias."

COMMENTOR NO. 88: MILITARY TOXICS PROJECT (CONT'D.)
LEWISTON, MAINE

ABOUT THE PROBLEM.....

The Department of Defense(DoD) is the nation's worst polluter. Continuing production, testing, and disposal of weapons threatens communities daily, yet the DoD has managed for the most part to escape existing environmental regulations and reporting. The closing of dozens of bases and other military cutbacks creates the opportunity to make a transition from a polluting military-dominant economy to sustainable peacetime endeavors. Public awareness and involvement are critical at this time, to ensure that communities know the extent of local pollution, facilities are adequately cleaned up, disposal methods are safe, and new military and civilian industry is pollution prevention-oriented to protect the environment and public health.

ABOUT MTP.....

The Military Toxics Project(MTP) unites activists, organizations, and communities to remedy and prevent pollution created by the military. Over the last seven years, the MTP's effective combination of research and public awareness, organizing and technical assistance, and networking has led to a number of accomplishments.

These have included:

- ⇒ creation of a powerful grassroots force.
- ⇒ national issue networks involving over 130 groups from the U.S., Hawaii, and Alaska.
- ⇒ publication of several major research reports detailing the extent of the DoD's toxic burden.
- ⇒ substantive policy actions by the DoD and the U.S. Congress.

The MTP has increased its impact by forming strong working relationships with other groups, including both community and national environmental organizations, and constituencies concerned about military toxics such as physicians, veterans, environmental justice activists, labor and peace groups.

The MTP will continue its work to raise public awareness about the DoD's toxic legacy; increase the effectiveness of local groups working on military toxic issues; build a multi-racial staff, leadership and program; and network groups to advance practices and policies on the national level which increases public knowledge and participation, hold the military accountable and promote safe, sustainable industry.

Its activities will include:

- Organizing Assistance and Training - on-site and phone consultation with grassroots groups; training; distribution of newsletter and organizing material.
- Technical Assistance - - Distribution of reports and fact sheets and other information specific to individual communities.
- Networking - - Continued facilitation of issue networks on base closure, depleted uranium, public participation and conventional munitions; implementation of a collaborative campaign focusing on issues that affect all groups.
- Workshops, Conferences, and Meetings - - Continues to organize and facilitate workshops around the country.
- Multi-racial Effort - - Increasing racial diversity on staff, among groups, and in the program work. MTP has a leadership development program which promotes diversity.

These activities will result in greater public awareness, more effective local leaders and groups, changes by the DoD, and other government agencies and the U.S. Congress.

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION WASHINGTON, D.C.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 1, 1998

Dr. Carol Borgstrom
Director
Office of NEPA Policy and Assistance
Department of Energy
Washington, DC 20585

Dear Dr. Borgstrom:

As requested in your letter dated December 18, 1997, enclosed are the Nuclear Regulatory Commission staff comments on the Department of Energy's Draft "Programmatic Environmental Impact Statement for Alternative Strategies for the Long-term Management and Use of Depleted Uranium Hexafluoride." Please contact Priya Patel (301-415-5757) of my staff with any comments.

Sincerely,

Carl J. Paperiello

Carl J. Paperiello, Director
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: Charles E. Bradley, Jr., DOE

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COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

U. S. NUCLEAR REGULATORY COMMISSION COMMENTS ON DOE/EIS-026, DRAFT "PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE," (PEIS), dated December 1997.

Supporting Documents Reviewed:

UCRL-AR-124080, "DEPLETED URANIUM MANAGEMENT PROGRAM: THE ENGINEERING ANALYSIS REPORT FOR THE LONG-TERM MANAGEMENT OF DEPLETED URANIUM HEXAFLUORIDE," Rev. 2, Volumes 1 and 2, (EAR), dated May 1997.

UCRL-AR-127650, "COST ANALYSIS REPORT FOR THE LONG-TERM MANAGEMENT OF DEPLETED URANIUM HEXAFLUORIDE," (CAR), dated May 1997.

The purpose of the U.S. Department of Energy (DOE) programmatic environmental impact statement (PEIS) is to assess the potential impacts of alternative strategies for managing the depleted uranium hexafluoride at three DOE sites. DOE states that its preferred alternative is to use 100% of the uranium hexafluoride, either as uranium oxide, uranium metal, or both. The following are comments the Nuclear Regulatory Commission believes need to be addressed in the PEIS.

General Comments:

1. Assumption of Future Potential Use

While we agree that the use of UF_6 is desirable, we recommend that DOE include in the PEIS an alternative that addresses UF_6 for which no use can be found. The PEIS does not provide information indicating a market demand capable of consuming 100% of the depleted uranium (DU) inventory and notes that "potential uses that are capable of consuming a substantial fraction or all of the inventory . . . are not yet fully developed . . . ." In fact, very little of the material has been used in the decades over which it has been generated and it is not clear that all of it will be used in the future, as DOE has assumed in its preferred alternative. The existing management plan for depleted uranium described on page S-3 explicitly recognizes that future uses may not be found. In this regard, the Council on Environmental Quality (CEQ) recommends that an environmental impact statement (EIS) contain ". . .all reasonable alternatives. . . . Reasonable alternatives include those that are *practical or feasible* [emphasis in original text] from the technical and economic standpoint and using common sense, rather than simply *desirable* [emphasis in original text] from the standpoint of the applicant." ["Forty Most Frequently Asked Questions Concerning CEQ's NEPA Regulations," 46 FR 18027, March 23, 1981]. An alternative that recognizes that uses may not be found seems appropriate for the PEIS, given this CEQ guidance. 89-1

Furthermore, CEQ recommends that existing management plans be included as alternatives in EISs. One of the two CEQ interpretations of the "no action" alternative is "no change" from current management direction, i.e., continuing with the present course of action. Under the current DOE management plan for UF_6, if alternative uses have not been found to be feasible

ENCLOSURE

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

by approximately the year 2010, steps would be taken to convert the UF_6 to U_3O_8 beginning in the year 2020. The U_3O_8 would be safely stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste. Thus, our concern about future uses not developing as projected in the PEIS would be addressed by following this CEQ guidance.

Also, the discussion does not address regulatory and licensing requirements for the DU applications. It is recommended that (1) DOE identifies the likely market consumption of DU oxides and metals over the timeframe of the EIS, (2) DOE estimates the impacts from these potential DU uses, (3) DOE considers the potential of the converted DU materials becoming a waste, thus, requiring conversion into forms compatible with disposal, and (4) DOE evaluates the likely regulatory and licensing aspects of potential uses. 89-2

In addition, DOE's assumption that all of the depleted uranium can be used in the future appears to mean that the UF_6 would be stored onsite as it is stored now, until uses actually develop. The PEIS states that conversion to metal or oxide would not begin until uses for these products become available, and that safe management of the cylinder inventory in accordance with existing practices would continue until all of it had been converted for use. Thus, if no significant uses were to develop, the PEIS would in effect be endorsing an alternative that continues to spend resources indefinitely on maintaining and monitoring the steel containers, to expose workers to radiation in performing these functions, and to put off a long-term plan for disposal. 89-3

2. Additional Evaluation of Combination of Alternatives

While the combination of 50% use as uranium oxide and 50% use as uranium metal is evaluated in the PEIS, other combinations, assuming DU applications are not forthcoming, would be beneficial. One example would be to assume only 50% inventory use altogether, and the remaining 50% requiring conversion to a more stable form and disposal. Again, this seems appropriate due to the uncertainty of inventory use. 89-4

3. Ranking of the Alternatives

The summary of the results (page S-15 et seq) does not include a ranking of alternatives, and implies that all of the alternatives are acceptable, but that there is one "preferred alternative." DOE may wish to rank or identify those alternative(s) that appear more favorable than others based upon the analysis. DOE may also want to consider and mention if any of the proposed alternatives are precluded by the analysis. For example, page S-84 mentions individual doses from groundwater ingestion of 100 mrem/yr from disposal in shallow earthen structures, far in excess of 10 CFR Part 61 standards of 25 mrem/yr. Page S-84 also mentions a scenario for a hypothetical future resident living on the disposal site and receiving radiation doses as high as 10 rem/yr. These limitations should be included in the summary. 89-5

4. Use of the Term "Uranium Oxides"

The PEIS generally combines all uranium oxide compounds, U_3O_8 and UO_2, under the title "uranium oxides" for consideration in the alternatives and strategies (see page S-6 et seq). 89-6

1553

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

This seems too all inclusive, as uranium oxides have significantly different chemical and physical properties that produce a wide range of environmental health and safety impacts. For example, U_3O_8 is a high porosity powder, with a low density and a significant respirable fraction. UO_2 powder is also porous, and can spontaneously ignite in air. On the other hand, when UO_2 is sintered, a process involving high temperatures to reduce porosity, increase density, and decrease volume, it has the highest density of the uranium oxides and is essentially pore free. The presence (or absence) of pores also has significant implications for the potential disposal of the material, either as a management option or as an end-use item; a denser, essentially pore free material would appear to be advantageous due to lower leaching potential. Thus, a dioxide material sintered to a lower density (i.e. 4-5 g/cm^3) would not be expected to perform as well in a disposal environment as a uranium dioxide sintered to a high density (i.e. 9-10 g/cm^3). It is recommended that more qualifiers are given to the term "uranium oxides," perhaps including low and high density as the principal discriminator. 89-6 (Con't.)

5. Equivalent Bases and Life-Cycle Effects, the Cradle-to-Grave Approach

The text does not seem to incorporate a life-cycle approach to the different management alternatives and compare them on an equivalent basis (see pages S-7 et seq). For example, even if a market exists for potential uses of the depleted uranium (DU), at the end of the product's useful life it is still radioactive ($t_{1/2}$ = 4.5 x 10^9 years) and will require disposition. Thus, disposal would seem to be the logical endpoint for all of the alternative branches shown in Figure S.2, instead of only for the disposal as oxide alternative. Following the DU product from cradle to grave thereby influences the impacts and potentially the alternative(s) selected. It would seem that the "manufacture and use" alternatives will ultimately result in impacts from the DU component; for example, the material (perhaps as itself or in a product) could be shipped to a disposal facility. Such potential impacts do not appear to be included in the analysis, and may even preclude some options or require additional conversion and conditioning. For example, without supporting analyses, it is unlikely that significant quantities of DU metal can meet the regulatory requirements of disposal sites due to high solubility and the formation of hydrides. Thus, pursuit of use as a metal option may require another conversion facility to convert the DU metal into a form compatible with disposal. In addition, the long-term storage alternative also appears to lack the realization of ultimate disposal in the future. The PEIS should consider and analyze the alternatives on an equivalent basis with the same/comparable endpoints and include life-cycle effects. 89-7

Other examples of the need for equivalent bases include the oxide conversion routes, due to fundamental differences in the uranium oxide forms. One of the specific oxide conversion routes (gelation) appears to be manufacturing UO_2 with properties comparable to high density nuclear fuel. This process would be anticipated to have improved stability and related properties as compared to the other oxides. The gelation route detailed in the PEIS appears to include two plants - one for U_3O_8 production and one for dissolution/UO_2 production:

$$UF_6 \rightarrow U_3O_8 \rightarrow UO_2$$

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

This appears inconsistent with literature reports on the process which maintain that no production of U_3O_8 is necessary. The process described in the PEIS would cause double the impacts by performing a two step process when the same result is achievable in a one step conversion from $UF_6 \rightarrow UO_2$. 89-7 (Cont.)

6. Results of the Analyses

Pages 8-15 et seq summarize and compare the results of the impacts for the alternative management strategies. Some of these results seem inconsistent and are not intuitively obvious. For example, it is not clear why the use as uranium oxide results in higher impacts than the use as uranium metal (see pages S-20 and S-49) - the opposite would be anticipated. A more rigorous analysis of the assumptions made in the Engineering Analysis UCRL-AR-124080 is recommended (see specific comments #20). In V2, Section 8.11, Potential Shielding Applications, a large disparity is evident between the damage fractions assumed for uranium metal (1%) and those assumed for uranium dioxide(100%). Again, this seems questionable based on the pyrophoricity of uranium metal upon heating. Furthermore, the airborne release fractions are orders of magnitude lower than what is recommended in the DOE Accident Analysis Handbook 3010-94. These calculations should be examined more closely to confirm DOE's conclusion. 89-8

Furthermore, it is unclear whether or not the disposal analyses include all of the potential long-term impacts and doses from uranium leaching from the disposal area. It is recommended that DOE consider greater consistency in the results and clarify the summary.

7. Waste Management

In Section S.4.8 on page S-40, waste management impacts are discussed. DOE should consider briefly highlighting the potential uranium content of the secondary streams (i.e. CaF_2, MgF_2), along with a brief assessment of acceptability for either reuse/nonradioactive disposal or disposal as radioactive waste. The uses and demands for the by-products of conversion (HF, CaF_2) should be explored and discussed. DOE should expand the discussion in the last paragraph about uranium disposal as low-level waste (LLW). 89-9

Furthermore, the DOE may wish to cite the Louisiana Enrichment Services (LES) Final EIS (NUREG-1484) analysis. The NRC documents provide analyses supporting DU disposal as a LLW, but note that its disposal could require a mine or another means of "deep" (rather than near-surface) disposal. Similar to the conclusion drawn in the PEIS, the LES EIS determined near-surface disposal would cause exceedance of 10 CFR Part 61.41 requirements. Currently, no "deep" disposal sites exist, and all current LLW disposal sites (existing and planned) use near-surface facilities. 89-10

8. DU Use as Spent Nuclear Fuel (SNF) Cask Shielding

DOE appears to be relying upon the potential future use of DU as SNF cask shielding for a large consumption of its DU inventory (see page 8-43 and 1-8, and Volume 2 of the EAR, which 89-11

1554

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

analyzes a DU cask manufacturing facility as the only use of DU). If this is indeed the case, DOE may wish to discuss it in more detail in the PEIS summary, and it should be noted that no currently licensed or planned SNF cask uses of DU.

9. Fate of DU SNF Cask Shielding

As currently written, the PEIS does not include a discussion of the eventual fate and potential impacts of the DU SNF cask after use (pages 2-14 and 2-15). Pages 5-55 and 5-65 mention that "no assumptions are made regarding the fate of the cask after use," and page 5-65 notes that disposal would amount to an additional 160,000 cubic meters (6.4 million cubic feet) of waste requiring disposal, with a (calculated) average specific gravity of 2.2. This does not seem inconsequential, particularly if a dedicated disposal facility is required and the impacts are estimated to be similar to disposal (e.g., page 8-83 et seq; exceeding 10 CFR Part 61.41 dose limits). Also, there are statements in the document that question if significant quantities of DU metal are suitable for disposal (e.g., last paragraph on page 2-21). Inclusion of a discussion about the disposition of the DU cask after use, and potential impacts, is recommended. 89-12

10. Technology and Equipment Development

The PEIS encompasses numerous technologies that are at different stages of development, in terms of process, understanding, equipment, (potential) impacts, and uncertainties. For example, of the conversion, application, and disposal impacts discussed within the summary, none are practiced on any scale domestically, and only conversion to U_3O_8 is practiced on a large scale internationally, producing a low density product. Thus, there is only one direct analogy. DOE should consider including a technology discussion, with status and assessment, perhaps with either a time schedule or probability of success, for some of these technologies. For example, it seems like a significant extension of existing uranium dioxide sintering technology to take pellets from 100 te(U)/yr/line to 7,000 te(U)/yr/line. From the uranium dioxide technology perspective, microspheres (e.g., from gelation) may be the more mature technology because of the (potential) use of tube furnaces and pilot plant tests with equipment processing rates an order of magnitude larger. Similarly, a uranium dioxide/concrete cask approach appears to be a significantly easier technology to understand and scale than casting a 40 te(U) metal shield. 89-13

11. Existing Facilities and Experience

There are obvious analogies with existing, commercial fuel cycle facilities, which process uranium hexafluoride into uranium dioxide (for nuclear fuel) and (to a lesser extent) uranium metal. On an international scale, Cogema has been converting UF_6 to U_3O_8, compressing it in steel containers, and storing the containers in metal reinforced seismic buildings since 1977 to avoid the hazards of storing UF_6. These facilities are already licensed by the appropriate regulatory agencies. The PEIS does not mention these facilities, either as a source of experience or as a source of processing capacity, particularly during the development of uses for the DU materials and as a means for surge capacity. The PEIS also does not appear to draw upon the operating experience of these facilities, including waste generation and uranium content of byproducts. Reliance upon existing facilities may lessen environmental impacts associated with the construction of a new facility. Thus, DOE may wish to include the 89-14

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

experience of operating commercial facilities and comment upon their potential use (or non-use) during the development of applications for the DU.

12. Economic/ Socioeconomic Analyses

The PEIS mentions a separate Cost Analysis Report (CAR) as providing input to the PEIS (page 1-7). However, program costs do not appear to be included in the analyses. DOE should consider including a brief comparison of the costs and other economic impacts in the PEIS, perhaps as part of the summary (e.g., in Table S-2). Also, from a socioeconomic standpoint, all the alternatives considered will create jobs, DOE should address whether or not the areas chosen for construction can sustain the necessary development that will accompany the influx of workers. 89-15

Specific Comments:

1. Fuel Cycle Process

In the background section of the summary on pages S-1, S-2, DOE may want to briefly explain the fuel cycle process and point out the various forms of uranium at each stage. This would help elucidate the natural occurrence of U_3O_8 and substantiate its suitability for disposal alternatives. 89-16

2. Mass of DU

The insert on page S-2 identifies some 46,422 DU cylinders distributed between the three sites. While the total quantity is listed in the main text of the report, it would be helpful to have the approximate masses (as either MTU or $MTUF_6$) for the three sites listed in the summary as well. 89-17

3. United States Enrichment Corporation DU

The insert on page S-2 also notes that an additional 8,000 cylinders have been produced by USEC. It is suggested that this number is also divided between the sites and expressed in mass quantities. It is also recommended that a brief discussion about the USEC DU be included, perhaps as part of the first paragraph on page S-4. While the EIS excludes the USEC DU from its analysis, it also implies that there is a reasonable probability of it becoming DOE's responsibility. Consequently, DOE may want to consider that possibility in its impact analysis. 89-18

4. Summary Table S.2

On pages S-17 and S-18, irreversible adverse health effects as well as adverse effects are identified for cylinder accidents. This terminology should be defined and explained by a footnote in the table. A more quantitative measure of chemical effects should be included, as uranium toxicity is a major concern that needs to be addressed. In addition, the cylinder accident scenarios should indicate estimated quantities of the releases of uranium and HF 89-19

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

shown in the table including the time period of exposure and length of time of the release. Finally, DOE should indicate exposures to involved workers instead of only exposures to the public and non-involved workers.

5. New Madrid Seismic Zone

Page S-34 mentions "the conversion accidents estimated to have the largest potential consequences were...involving the rupture of tanks of anhydrous HF or ammonia" would be caused by a large earthquake which has an assumed frequency of less than 1 in 1 million per year of operations. DOE should mention that a facility built near the Paducah Gaseous Diffusion Plant would be located near the New Madrid seismic zone. Additional seismic analyses would need to be performed for such a facility as well as an accident analysis taking into account the seismicity of this area. 89-20

6. Non-Shield Use of DU

Page 2-21 mentions uses for DU such as developing penetrators, vehicle armor, and industrial ballasts. No mention is made of quantities or relative percentages of the DU inventor that these uses would require. Also, it is not self-explanatory that DU cask manufacturing and uses bound all of the potential uses. For example, metal uses would appear to require a significant amount of alloying and/or machining, and involve handling and disposal concerns. DOE may wish to include a longer discussion and a more comprehensive explanation. 89-21

7. Leach Rates for Disposal

Page 2-22 briefly mentions leach rates and waste forms, and states that grouted wastes are representative of immobilized waste forms with low leach rates, with the implication that grouting is also representative of vitrification. DOE should clarify this text, as grouting may be representative of vitrification for some parameters (e.g., facility size) but not representative in others (e.g., energy usage, emissions). Also, while grouting should provide for somewhat lower leach rates as compared to the ungrouted material, vitrification would be expected to provide 5 to 6 orders of magnitude lower leach rates than grouting. Furthermore, a quantitative mention of the values of the leach rates is beneficial, as each uranium form will exhibit different rates. These factors may be an issue for some disposal options and consequently should be discussed. 89-22

8. Disposition of Empty Cylinders

Often when a cylinder is processed, an amount of UF_6 (the heel, containing U^{235} daughter products) remains in the cylinder. DOE should describe how the cylinders will be cleaned and how the heels are going to be dealt with. Furthermore, though potential options for the disposition of empty DU cylinders are listed on page 2-23, the impacts are not included. It would seem reasonable to provide a brief discussion on these options and include impacts from cylinder disposition in the EIS. 89-23

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COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

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9. Water and Soil Impacts from DU Disposal

The summary table of impacts (Table 2-2) and the supporting text for the water and soil section (page 2-50) note that the groundwater uranium concentrations will exceed drinking water guidelines. It is recommended that the expected concentrations are also expressed in terms of individual radiation doses. 89-24

10. Waste Management

Pages 2-52 et seq present a summary of the waste management impacts from the alternatives. Comparisons of the amounts generated are primarily made relative to the DOE waste management system, however, these facilities could also be commercially operated under NRC or State regulations. Consequently, DOE should consider adding a comparison to commercial LLW generation rates. The section should also include estimated uranium levels for the magnesium fluoride waste (from DU metal production) and discuss the aspects of DU disposal, including the potential need for either a dedicated or a deep disposal facility. 89-25

11. DOE's Preferred Alternative

Section 2.5 (pages 2-54 et seq) present DOE's preferred alternative. This section would benefit from a greater discussion of the potential uses of DU, including the SNF storage casks. 89-26

12. Generic Sites

Pages 3-58 et seq present information on the generic sites for wet and dry locations for disposal, and mention that the site data for each are derived from actual wet and dry sites. It is suggested that the actual sites which provide the basis for the generic locations be listed. 89-27

13. PEIS Time Period

Page 4-2 lists a 41 year time period for the EIS (through the year 2039), and indicates activities beyond 2039 would be subject to appropriate NEPA reviews and decisions in the future. This appears to truncate the analyses for some of the alternatives which might influence the selection of the preferred option; for example, impacts from wastes in a disposal cell are unlikely to occur by 2039, major cylinder/container replacements may be required for the storage option in the 10-20 years after 2039, significant applications for use of the DU may not have developed etc. DOE may wish to consider a time period consistent with the logical conclusion of the options or their "life-cycle," which may require a timeframe beyond 2039. 89-28

14. Background Radiation

On page 4-15, the example with background radiation appears to have left "year" out of the units. 89-29

15. Waste Management Approach

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COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

9

Page 4-25 lists the waste management approach. Inclusion of waste categorization methods and categories (e.g., per 10 CFR 61), and current commercial capabilities would be beneficial. DOE may also want to discuss if there are any waste management situations that require the development of additional waste management capabilities and/or capacity. 89-30

16. No Action and Storage Alternatives

Pages 5-3 and 5-19 discuss the estimated cylinder failure rates for the No Action and UF6 Storage alternative. These appear to use the opposite ends of the failure rate range - No Action uses the lowest failure rate, while Storage uses the highest failure rate - without explanation. Also, the existing cylinders may not have adequate wall thicknesses under either alternative due to both internal and external corrosion over the years (see Appendix E), and the DU may have to be transferred to new cylinders within the timeframe covered by the EIS. Furthermore, if the cylinder wall thicknesses deteriorate significantly, they may not meet American Society of Mechanical Engineering (ASME) code for processing. DOE should consider presenting a discussion on these items in the text. 89-31

17. Tank Rupture Frequencies

On page 5-40, Table 5.4 lists tank rupture accidents as "incredible" events, when typically they are assigned a value corresponding to the "extremely unlikely" frequency bin. A brief discussion of the basis for DOE's assessment is recommended. 89-32

18. Surface Water Dilution of Effluents

On page 5-51, the text indicates effluent levels greatly exceeding EPA guidelines for uranium, but notes that the concentration would be much lower and below the guideline after dilution in nearby surface water. This should be clarified, and potential dose consequences of these effluents presented. 89-33

19. Land Use Requirements

Page 5-55 identifies land use requirements for the facilities. Contrary to the small land requirements indicated in the PEIS, conversion and metal use plants would be anticipated to have larger land use because of facility size and require potentially larger setbacks for potential accident mitigation from uranium releases. The LES EIS maintains the amount of land required for a generic conversion facility is 1000 acres whereas the PEIS indicates only 30-40 acres are necessary. The text also does not indicate if any major setbacks, protective action distances (PADs), or planning zones are likely to be needed around the facility because of the handling of large quantities of DU, the hexafluoride, and/or the metal (including melting operations). DOE should consider a discussion in the text on these subject matters. 89-34

20. Oxide and Metal Accident Consequences

Pages 5-55 et seq discuss the use and impacts of uranium dioxide as shielding, and pages 5-66 et seq discuss the use and impacts of uranium metal as shielding. Some of the values imply non-intuitively obvious lower impacts from a metal route as compared to the oxide route; it is 89-35

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

recommended that these are discussed and explained in more detail. For example, the text on page 5-71 estimates the highest consequences from an accident with the metal route as 16 mrem (from a fire involving three cylinders, an energetic accident with reactive materials), as compared to 270 mrem (from an earthquake during uranium dioxide storage, a low energy event with non-reactive materials) - there is no explanation for the difference. Also, the supporting information in Appendix H shows similar inconsistencies; the unlikely accidents for the oxide (Table H-5, page H-18) are significantly higher than the corresponding accidents for the metal (page H-17). Page H-17 also contains apparent inconsistencies; the mishandling/dropping of solid DU metal accident releases a greater quantity of uranium than the molten uranium accidents. Upon further review, the source of these apparent anomalies goes back to Section 6.11 of the Engineering Analysis Report (EAR). These anomalies and inconsistencies include:

- Page 6.11-7-6 uses a damage fraction of 30% for the metal and 100% for the oxide; comparable or lower values would seem appropriate for the oxide.
- Page 6.11-7-7 uses a damage fraction of 1% with molten uranium metal and 100% for the oxide for a mixer/melter accident; these values for the damage fraction appear to be contradictory and may have been inadvertently reversed (i.e., they should be 100% for the metal and 1% for the oxide).
- A similar incongruity exists for the Mixer/Melter Discharging Accidents on pages 6.11-7-7 and 6.11-7-8, where the damage fraction for metal use is 1% while 100% is used for the oxide route.
- On page 6.11-7-8, the metal shield failure uses a damage fraction of 0.1% while the oxide shield failure damage fraction uses 100%; again, these appear to be reversed. Also, the failure modes may be completely different, and this does not appear to have been captured by the scenarios and calculations.
- The stated release fractions for the metal accidents on these pages appear to be unconservatively low; DOE-HDBK-3010-94 recommends 1E-02 as bounding for "disturbed molten metal surface with high turbulence" and 1.0 for "small molten metal drops hurled through air or explosion of entire metal mass." The melter failure and discharge accidents would appear to be in the latter category, and most of the other accidents would appear to be bimodal, with some portions of the release in both categories. These effects would increase the source terms for the analyses.
- The oxide and metal design basis events are analyzed with different bases; the high efficiency particulate air (HEPA) filters for the metal facility are assumed to keep functioning, while the oxide HEPA system does not function. This seems inconsistent.
- The oxide release fractions appear to be based upon fuel pellet data sintered from powders (i.e., submicron grain size), sintered too close to the theoretical density of uranium dioxide (11 g/cc). It is not clear how this data applies to the lower density

89-35 (Con't.)

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COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

uranium dioxide pellets (i.e. 6 g/cc, expect a somewhat higher release fraction) and the density of the solution formed gelation particles (much larger grain sizes - expect a lower release fraction).

- Table H-5 of the PEIS categorizes a furnace failure as an "incredible" event while the EAR (page 6-11-7-6) implies 8E-5/yr.

89-35 (Con't.)

These points should be discussed and explained better in the PEIS, and values corrected as required.

21. Metal Cask Waste

Page 5-76 of the PEIS presents waste management for the metal cask manufacturing route. Waste management appears to have overlooked secondary wastes related to manufacturing, which are unique to uranium metal. For example, induction furnaces for uranium metal are usually lined with graphite, which requires periodic removal and replacement (sometimes as frequently as every ten charges). Also, while the proposed approach appears to use primarily direct casting, some uranium metal machining operations may be required, and, historically, these generate significant wastes containing partially oxidized uranium metal. The PEIS should include these potential impacts that primarily affect only the metal route.

89-36

22. Waste Disposal

Section 5.6 (pages 5-78 et seq) and Appendix I present the impacts from disposal of the DU, for both the operational phase and the post-closure period. The radiological impacts from the accidents seem unexpectedly high. For example, public doses of up to 1.1 rem and noninvolved worker doses as high as 140 rem are determined, apparently due to earthquake initiated events, without explanation. The routine impacts also seem high for the post-closure phase and appear to follow the radiological order: mine impacts > vault impacts > trench impacts. Calculations appear to use an infiltration area effect and do not account for chemical form, solubility, and kinetic effects. Table I.31 contains values of zero for the dry site doses for all three disposal approaches, and no collective dose estimates are included. These points are not obvious and it is recommended that they are explained in more detail.

89-37

23. Other Uranium Forms

The primary uses the PEIS focuses on are uranium in concrete and DU metal for the shielding material. Other uses exist such as vitrified pellets with UO_3 and UO_2 composite material in a SNF cask. These have been published in the open literature and should be mentioned and referenced.

89-38

24. Low Estimates of Staffing Levels

The estimated numbers of staff required for several of the alternatives in the PEIS seem low. For example, the UO_2 pellet approaches use similar technologies to existing fuel fabrication

89-39

COMMENTOR NO. 89: UNITED STATES NUCLEAR REGULATORY COMMISSION (CONT'D.) WASHINGTON, D.C.

facilities of 1,000 te/yr capacity which employ several hundred people. However, the PEIS estimates only 300 workers will be needed for a plant of 20,000 te/yr capacity. This seems low even considering economies of scale. | *89-39 (Con't.)*

Principal Contributors: James E. Kennedy, Division of Waste Management, NMSS
Alex Murray, Division of Fuel Cycle Safety and Safeguards, NMSS
Priya Patel, Division of Fuel Cycle Safety and Safeguards, NMSS

1558

COMMENTOR NO. 90: BOWERS, BRIAN OAK RIDGE, TENNESSEE

TO: depleted UF6 at SAIC_BM2

Subject: DUF6 PEIS Comments

Please accept my comments below on the DUF6 PEIS. I did my best to get them to you as soon as possible. Thank you for the opportunity to comment.

Brian Bowers

****

1. General - The PEIS describes the preferred alternative as "to use the entire inventory of material." This is misleading. The goal is to use the material but since there is little demand at present, the actual action is continued storage indefinitely. Demand for use of the material, as stated in the PEIS, is quite limited at present. It is accurate to say that the material would be converted and reused as demand dictates but it is misleading to emphasize the speculative portion of the alternative when, in reality, it could be stored as UF6 for a long time. I agree that the best alternative is to continue the safe storage of the UF6 and convert/use it as demand dictates, but I think the PEIS needs to clearly present the preferred alternative in those terms rather than mislead the reader into focusing on uses that have yet to be identified. | *90-1*

2. General - The main conclusions of the cost analysis report should be included in the analysis of socioeconomics in the PEIS. It is misleading and irresponsible to analyse only the perceived benefits (employment, increased local revenues) and not consider the costs. Who is going to pay for these actions and how much is it going to cost? In this era of taxpayer dissatisfaction, consideration of costs must be included in any socioeconomic analysis as this is certainly a potential impact on the human environment. | *90-2*

3. General - The PEIS does not adequately evaluate the impacts associated with the empty steel cylinders that would be generated in the event of conversion and/or reuse of the material. What to do with over 46,000 14-ton, radioactively contaminated steel cylinders is an extremely important part of the long-term management strategy and must be appropriately analyzed and considered in any decision making. The PEIS does not demonstrate adequate analysis of this issue. | *90-3*

4. General - I understand the accident analysis methodology in terms of probability and consequence. However, I could not find in the PEIS where such "statistical" accidents were matched to real accident scenarios. From comments on other documents, it is clear this is what the public | *90-4*

COMMENTOR NO. 90: BOWERS, BRIAN (CONT'D.)
OAK RIDGE, TENNESSEE

wants to know. They want to know about the probability and consequences of a tornado and an earthquake. I could not tell if such scenarios were adequately represented in the PEIS.

5. General - There are still numerous places where the West Kentucky Wildlife Management Area is incorrectly referred to as the Western Kentucky Wildlife Management Area. — 90-5

6. p. S-3, para. 2 - I challenge the notion that the current management plan calls for conversion to triuranium octaoxide. Where is this written? How would conversion and disposal be paid for? This is not considered part of No Action. — 90-6

7. Section 3, general - Based on the text on page 3-1 and Figure 3.1, the PEIS describes the "Paducah site" as including all of the land owned by DOE including that licensed to the Commonwealth of Kentucky. The PEIS describes the "PGDP" as a 750-acre industrial area within the Paducah site. As there is a security fence around the 750-acre area (actually 748 acres) and the area outside this fence is primarily wooded, it is appropriate to discuss these separately, where necessary, to distinguish differences in the two environments. However, the PEIS makes numerous mistakes when describing various aspects of the two environments, apparently due to confusing the "Paducah site" with the "PGDP." For example, Section 3.1.6.3 states that there are no wetlands "identified on the Paducah site by the National Wetlands Inventory." This statement would be correct for PGDP but not the Paducah site. These errors are pointed out in the specific comments below. — 90-7

In addition, the PEIS often does not use the most current and accurate information readily available. For example, the National Wetlands Inventory does not provide very useful information for anyone wanting to know about wetlands that occur on the Paducah site. Two reports that should be used include:

<paraindent><param>left</param>U. S. Department of the Army, Corps of Engineers - Nashville District and Waterways Experiment Station, <italic>Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrouding Area McCracken County, Kentucky</italic>, Volumes I -V, May 1994

</paraindent> — 90-8

<paraindent><param>left</param>CDM Federal Programs Corporation, <italic>Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant</italic>, August 19, 1994, Document Control Number 7916- 003-FR-BBRY

</paraindent>

The first document reports on wetlands, floodplains, cultural resources, and threatened/endangered species on and near the PGDP site, primarily outside of the plant security fence. The latter document reports on wetlands and threatened/endangered species inside the plant security fence. There have been some informal updates to these reports since they were issued.

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COMMENTOR NO. 90: BOWERS, BRIAN (CONT'D.)
OAK RIDGE, TENNESSEE

Two sensitive resources common to the DOE reservation at PGDP but not analyzed in the PEIS are 100-year floodplains and prime farmland. Granted, there would not be much analysis based on the PEIS approach of deferring site-specific evaluations to later NEPA documents. However, the PEIS should include these resources in site descriptions and evaluate for potential impacts at the appropriate time. Information on floodplains at PGDP is reported in the Corps of Engineers report referenced above. Prime farmland information is available from site personnel or local offices of the Natural Resources Conservation Service. — 90-9

Section 3 should be thoroughly reviewed and revised to accurately describe the affected environment. Consequently, analysis of potential impacts should be revised, where necessary. — 90-10

8. Sec. 3.1 - The PEIS does not provide an accurate portrayal of the size and location of the West Kentucky Wildlife Management Area (WKWMA). WKWMA totals about 6823 acres of which the state owns 3106, 1986 acres are licensed from DOE, and 1731 acres are licensed from the Tennessee Valley Authority. WKWMA completely surrounds PGDP. Much of the area referred to in the PEIS as the Paducah site is also part of WKWMA. This is not reflected in Figure 3.1 or in some of the analyses of impacts. — 90-11

9. Sec. 3.1.5.1 - DOE received a new KPDES permit on March 13, 1998. The PEIS should be revised accordingly to reflect the changes. — 90-12

10. Sec. 3.1.6.3 - The PEIS is incorrect - there are many wetlands on the Paducah site. In fact, some were filled in to build the latest cylinder storage yard. — 90-13

11. Sec. 3.1.6.4 - The information here with regards to threatened and endangered species is misleading. First, there is a lot of significant potential summer habitat for the federally endangered Indiana bat so it is quite likely it occurs on the Paducah site. Second, there is no state list with any enforceable protection standards. I applaud the PEIS for looking at these "state-listed" species but their legal status should be made clear. — 90-14

12. Sec. 3.1.10 - Overall, the description of cultural resources is current and well done. However, there is at least one cemetery on the Paducah site, just north of PGDP. — 90-15

13. Sec. 5.8 - The PEIS purports to include other past, present, and future actions, and non-DOE actions in its cumulative impacts analysis. However, no specific actions are identified. In order for the reader to assess if cumulative impacts were adequately assessed, the PEIS needs to include specific information on what other activities were considered. — 90-16

14. Pages D-3 to D-5 tell me all I really need to know regarding potential impacts. Continued storage (No Action Alternative) would result in an estimated worst case of 59 cylinder breaches through 2039. Impacts from these breaches would be minimal. On the other hand, the action alternatives would result in an estimated worst case of 731 breaches through 2039. On the basis of potential impacts alone, it is — 90-17

COMMENTOR NO. 90: BOWERS, BRIAN (CONT'D.)
OAK RIDGE, TENNESSEE

clear that No Action is environmentally preferrable. The PEIS needs to clearly state this in all summary text areas.

15. General (Overall Conclusion) - The PEIS clearly supports continued storage of the material as UF6 until viable uses are identified (called No Action in the PEIS). Continued storage, with the assumption of at least partial use by the year 2039, is shown to have the fewest environmental impacts. It is also, by far, the least costly alternative although the PEIS is deficient in showing this. Finally, continued storage for several more years with little adverse impact would allow for further demands for the material to be developed and speculative measures, such as conversion or consolidation, would not be necessary at this time. It is disappointing that all of DOE's effort did not result in any significant, realistic near-term uses for the material but at least the PEIS shows that continued storage as UF6 at the current sites would not present unmanageable problems. *90-18*

END OF COMMENTS

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COMMENTOR NO. 91: UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CHICAGO, ILLINOIS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAY 15 1998

REPLY TO THE ATTENTION OF

B-19J

Charles E. Bradley, Jr.
Depleted Uranium Hexaflouride Management Program
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Re: Draft Programmatic Environmental Impact Statement for Alternatives Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride

Dear Mr. Bradley:

Thank you for your letter dated December 18, 1997 and the Draft Programmatic Environmental Impact Statement for Alternatives Strategies for the Long-Term Management and Use of Depleted Uranium Hexaflouride which accompanied it. It is our agency's opinion that the depleted uranium hexaflouride (DUF_6) should be converted to a form that is more stable and less hazardous, such as uranium oxide (U_3O_8), for long term storage or until an alternate use can be found and we applaud your management program for proposing this alternative. In accordance with our responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, we have reviewed the information that you submitted. Based on the information provided, we have rated this DEIS EC-2. The EC portion of the rating indicates that we have environmental concerns and the 2 portion of the rating indicates additional information, data, analyses or discussion should be included in the final EIS. To satisfy these concerns, please provide additional discussion, data, and/or analysis to addresses the following: *91-1* *91-2*

1. A single location for a conversion pilot plant should be identified to evaluate the engineering and other demands of converting the material. After experience has been gained operating a stabilization process in a single location, consideration should be given to whether the single plant, or plants at multiple locations would be best suited to converting any remaining material. *91-3*

2. Until such time as the DUF_6 is converted to a more stable form, a long-term storage strategy should be developed to address issues surrounding deteriorating storage canisters. *91-4*

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COMMENTOR NO. 91: UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (CONT'D.) CHICAGO, ILLINOIS

3. Before transporting DUF_6 in storage canisters with deteriorated or uncertain integrity, secondary containment or other engineering measures should be employed to ensure safety comparable to that provided by new canisters. *91-5*

4. U.S. Department of Energy (USDOE) and the United States Enrichment Corporation (USEC) should apply a single, compatible methodology to discharge their respective responsibilities for the materials. *91-6*

5. Conversion of this material should not be dependant on market demand. DOE should include plans to seek funds from Congress for conversion of all DUF_6. *91-7*

6. An appropriate budget should be submitted to adequately fund this process for the necessary time periods. Funding needs to be provided to insure the reduction of potential risks to the environment and to public health. *91-8*

Be advised that you may require a Section 404 permit from the U.S. Army Corps of Engineers if wetlands will be impacted during this project. You should be in contact with them to determine whether this project will require such a permit. In accordance with the Section 404(b) (1) guidelines of the Clean Water Act, wetland impacts must be avoided and/or minimized whenever possible, and satisfactory compensation for unavoidable impacts must be provided.

With respect to provision of compensatory wetlands, our Agency routinely finds that a minimum of 1.5 acres of compensatory wetlands are necessary to offset the loss of each acre of naturally occurring wetlands impacted by the project at issue. In addition, the compensatory wetlands should be designed to replicate as closely as possible the specific mix of types, functions and values provided by the project-impacted wetlands. The compensatory wetlands should be established via the process of restoration to the extent feasible, and they should be located in an area as close as practicable to the project-impacted wetlands. *91-9*

We trust that you will find these comments useful. If you should have any questions, please contact me at 312-886-7342.

Sincerely,

Michael W. MacMullen, Manager
Federal Activities Program
Office of Strategic Environmental Analysis

1561

COMMENTOR NO. 92: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION MOREHEAD, KENTUCKY

JAMES E. BICKFORD
SECRETARY

PAUL E. PATTON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
MOREHEAD REGIONAL OFFICE
200 CHERRY CREEK RD STE 3
MOREHEAD KY 40351-1346

June 4, 1998

Charles E Bradley, Jr.
Office of Facilities (NE-40),
Office of Nuclear Energy, Science and Technology
U S Department of Energy
19901 Germantown Road
Germantown MD 20874

Re: Draft Programmatic Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.

Dear Mr. Bradley:

The Natural Resources and Environmental Protection Cabinet (NREPC) serves as the state clearinghouse for review of environmental documents generated pursuant to the National Environmental Policy Act (NEPA). Within the cabinet, the Commissioner's Office in the Department for Environmental Protection coordinates the review for Kentucky State Agencies.

We have just gotten response from one of the Kentucky State Agencies, the Division of Water, which has comments (attached) on the UF_6 Management Strategy that you may be able to use in your considerations for selecting alternative strategies. I am hopeful that you can still incorporate these comments. If, and/or when, a final environmental impact statement is published, please send 16 copies of the document, and I will coordinate responses from the Kentucky State Agencies.

If you should have any questions, please contact me at (502) 564-2150, ext. 112.

Sincerely,

Alex Barber

Enclosure

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COMMENTOR NO. 92: COMMONWEALTH OF KENTUCKY, DEPARTMENT FOR ENVIRONMENTAL PROTECTION (CONT'D.) MOREHEAD, KENTUCKY

JAMES E BICKFORD
Secretary

PAUL E. PATTON
Governor

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
FRANKFORT OFFICE PARK
14 REILLY RD
FRANKFORT KY 40601

MEMORANDUM

TO: Alex Barber
State Environmental Review Officer
Department for Environmental Protection

FROM: Timothy Kuryla TK
EIS Coordinator
Division of Water

DATE: June 4, 1998

SUBJECT: PDEIS, Long Term Management of UF_6 (No Apparent Kentucky County), SERO 980114-02

The Division of Water has reviewed the Programmatic Draft Environmental Impact Statement, prepared by the U.S. Department of Energy, Office of Nuclear Energy, Science, and Technology, regarding the long term management and use of depleted Uranium Hexafloride (UF_6) (no apparent Kentucky county). The Division finds the current facility emergency response contingency plans appear to be adequate. If UF_6 were to be used or stored in Kentucky, then pursuant to 401 KAR 5:037, a groundwater protection plan would be required.

92-1

c: William Burger, Field Operations Branch
Phil O'dell, Groundwater Branch

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1562

COMMENTOR NO. 93: SANTA FE ALLOYS ALBUQUERQUE, NEW MEXICO

Santa Fe Alloys

4515 Stockbridge Avenue, NW
Albuquerque, NM 87120-5407, USA
Phone, or Call for Fax (505) 899-2178

May 30,1998

Mr. Charles E. Bradley, Jr.
Office of Facilities (NE-40)
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874
Direct Phone: (301) 903-5512
Subject: Comments for UF6 meeting on June 2, 1998

Dear Mr. Bradley:

I would like to submit the following comments for public use in your upcoming UF_6 meeting:

1. I believe that DOE offers reasonable evaluations and wise preferences among the alternative strategies, i.e., preferring 100% use of the UF_6 (i) for conversion to uranium as oxide or metal and (ii) using as much of the material as DOE can to leave it recoverable.

Roughly 99 times the potential energy of the bomb U-235 material remains with the U-238 (DU) residue--as some of your readers will know. This DU could all be used in breeder reactors to generate future electric power, and then it would have high economic value.

It would be an environmental tragedy to throw it away, yet many people urge discarding this "useless" metal.

I commend DOE's for trying its best to save the material and for how it has identified DU use for radiation shielding. This would leave the DU available and not wasted. Other uses are sought.

One of the saddest parts of this situation is that all the DU metal could be saved if we would--the DU volume from all UF_6 (and all that energy) could be stored in a cube less than 100 feet on edge. But such storage is probably not politically feasible at this time.

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COMMENTOR NO. 93: SANTA FE ALLOYS (CONT'D.)
ALBUQUERQUE, NEW MEXICO

2. The draft PEIS serves well in justifying the DOE preference above, but care must be taken that postulated processes are reasonably justified experimentally before they are heavily funded. Sometimes, an overall process is not well evaluated to see if the pieces have been combined in ways that are not awkward. *93-2*

Specifically in the case of the selected CMR production of DU metal, there should be evaluations and experimental confirmation of whether the old hydrogen reduction of UF_6 should be a precursor of the metal production, or if other approaches are better. Also, features such as minimization of radioactive transport (which the public dislike) should also be considered carefully.

3. The people doing the postulated process writeups have done well, but further input is needed. Your public meetings may provide that input, especially as combined with private meetings from outside DOE. *93-3*

Thank you for this opportunity for input.

Sincerely,

Guy R. B Elliott

Guy R. B. Elliott
President

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3 DOE RESPONSE TO COMMENTS

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3.2 DOE RESPONSE TO COMMENTS

Commentor No. 1: Hollinger, Wade

Comment 1

Make a reasonable risk-based, economical decision, hire a team of lawyers and get on with getting rid of the stuff! Just take it for granted someone is going to sue DOE because they want you to make it so that it was never here in the first place (impossible) and put your lawyers to work, by the time it gets out of court you'll have the stuff gone. MAKE THE DECISION AND DO IT! I'm tired of supporting all you do nothing bureaucrats! A NEPA review and going out to the public was not necessary for this. You know what has to be done. DO IT!

Response 1

DOE has determined that the selection of a long-term management strategy for depleted uranium hexafluoride is a major Federal action with potentially significant environmental impacts. As such, the National Environmental Policy Act of 1969 requires DOE, as the responsible Federal agency, to prepare an environmental impact statement. The National Environmental Policy Act also requires DOE to include public involvement activities during EIS preparation. The results of the EIS will be used, together with economic and engineering analyses, to select a management strategy which will be announced in a Record of Decision.

Commentor No. 2: Ragan, Guy

Comment 1

PEIS: S.4 SUMMARY AND COMPARISON OF IMPACTS FOR ALTERNATIVE MANAGEMENT STRATEGIES: What is the basis for the consequences stated? In other words, if the no-action alternative creates 110 jobs over 40 years, that is as compared to what? Compare it to continuation of the present situation? But continuation of the present situation is not an option. The PEIS states its impacts relative to an inconceivable baseline. According to DOE's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, "the no-action alternative provides an environmental baseline against which impacts of the proposed action (and alternatives) can be compared." Therefore, the consequences should be stated as deviations from the no action alternative. For example, as compared to the No Action alternative, for operations, Long-Term Storage creates 10 jobs per year over 20 years. Then there are 110 federal jobs from 20 to 40 years. For construction, no jobs are created relative to No Action. Comparisons like this should be made explicit by stating all consequences as deviations from the No Action alternative. This comment applies to all types of environmental consequences, not just socioeconomic impacts.

Response 1

In EISs for proposed new facilities or programs, the no action alternative does indeed represent an environmental baseline, often described as no change to the existing environment. However, DOE is currently managing existing depleted uranium hexafluoride cylinders in existing facilities; so that, even if DOE were to take no further programmatic action, cylinder storage would continue at the three sites. Continued cylinder management includes steps necessary to maintain the cylinders in a safe and environmentally protective condition, which means that in the future the no action alternative will also have impacts on the natural and human environment. Recognizing this fact, the PEIS evaluates the impacts of all alternatives, including the no action alternative. This allows comparison of the impacts of alternatives in a manner similar to other NEPA assessments and allows alternatives to be compared on equal footing. The impacts of all the alternatives, including the no action alternative, are presented in Chapter 5 and compared side-by-side in Sections 2.4 and 2.5 of the PEIS. Any differences among the alternatives can be discerned from Tables 2.2 and 2.4 and the accompanying text in Sections 2.4 and 2.5.

Commentor No. 3: Ellison, Phillip
Idaho National Engineering and Environmental Laboratory

Comment 1

I briefly reviewed the UF_6 Draft PEIS. It appears to be a well developed and documented effort. One area that you may wish to improve is the hazardous analyses of the HF and NH_3 tank farms. Other events, including tornado induced missiles may wish to be addressed. These events may have been covered but I was unable to locate data of the results of the analyses.

Response 1

Impacts associated with potential releases from HF and NH_3 tanks during both normal operations and postulated accidents are addressed in the PEIS. The impacts are summarized in Table 2.2, and discussed in detail in Appendix F, Section F.3, and in the backup report for the PEIS (Policastro et al. 1997; the full citation is provided in Chapter 8 of the PEIS).

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports (SARs) recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as tornadoes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include tornado scenarios,

which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point.

For the other cylinder management options (i.e., cylinder preparation for shipment, conversion, long-term storage, manufacture and use, and disposal), analysis of adverse impacts associated with tornado-induced missiles were conducted, but for purposes of conciseness, the results were included in the PEIS only if the accident affected a greater number of people than any other accident in the frequency category (see Sections E.3.2, F.3.2, G.3.2., H.3.2, and I.3.2). Impact estimates for tornado-induced missile accidents are presented in the PEIS for some conversion options (see Tables F.8-F.11) and for some manufacture and use options (see Tables H.6-H.9). Tornado-induced missile accidents were not included in the appendices for cylinder preparation, long-term storage, or disposal because they affected fewer people than other accidents in the same frequency category. However, the results of impact analyses for all accidents considered (including tornado-induced missiles) are given in the backup report by Policastro et al. (1997) referenced in the PEIS. This report and other PEIS supporting documents are available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Commentor No. 4: **Dyer, Robert**
Dyer Enterprises

Comment 1

I was happy to see that you are getting better at meeting schedules, only six months late in getting out the two volume Draft PEIS for the alternative strategies for the future of the few cylinders of depleted that are stored around.

I have spent some time reading it and thinking about the way it is presented, both from my own point of view as one who knows what the stuff is and also from the point of view of one whose knowledge of depleted UF_6 is from these writings. As you can see by my comments, I think you missed your opportunity to inform the unknowing and get them on your side once you make the long-term management strategy.

I am interested in your reaction to my comments, and maybe we can work together to improve the document.

As a result of several days of pouring through the two volumes of the referenced document, I have the following comments and suggestions to make. I believe that I am qualified to review the work because I have had 53 years of experience in the operation and design of the gaseous diffusion process in Oak Ridge while working 35 years for the operating contractor followed by 15 years for

DOE. I have seen the depleted cylinders at all three plants, I actually filled some of them in Oak Ridge, I know the chemistry and physical properties of UF_6, I was on the committee to investigate the cause and effect of the wall failures of the two Portsmouth cylinders and I am a voting member of the ANSI N14.1 Uranium Hexafluoride-Packaging for Transport standards committee that establishes cylinder design and fabrication criteria. Twice, I have presented my training course "Fundamentals of Gaseous Diffusion Plant Operations" to members of the Argonne National Laboratory staff who have prepared this report. I will start with some general comments and proceed to some specific ones.

Response 1

The commentor's qualifications and statement of accomplishments are noted.

Comment 2

UF_6 Storage Cylinder Description: Let me quote some of the words in the box on Page S-1 in Volume 1. "Sufficient information must be included in the EIS for reviewers to evaluate the relative merits of each alternative."

It seems to me that you have to describe the problem in order for reviewers to see the merits of any of the possible solutions, including continued long term storage. In this case, the problem is what to do with the large quantity of depleted uranium hexafluoride that has accumulated at the gaseous diffusion plants in Oak Ridge, TN, Paducah, KY and Portsmouth, OH. I think you have to accept the fact that UF_6 is not a commodity that is familiar to the general public, especially those living in the vicinity of the plants. Therefore the description of the depleted UF_6 in storage cylinders on page S-2 is grossly understated. "Depleted UF_6 is stored as a solid at all three sites in steel cylinders. Each cylinder holds approximately 10-14 tons (9 to 12 metric tons) of material."

The next mention of stored cylinders of UF_6 that I found was on page B1 in Volume 2. "Depleted UF_6 has been stored in steel cylinders in outdoor yards at the three DOE storage sites since the 1950s. Most cylinders have either a 10- or 14-tons (9 to 12 metric tons) capacity and a nominal wall thickness of 5/16 in. (0.79 com or 312.5 mil)." It is a little more correct, in stating the cylinder capacity as 10 or 14 tons but is still oversimplified:

I, as a reviewer, know the details of the design criteria and methods of fabrication for the storage cylinders, and know that the UF_6 is being safely stored at the plants. I do not think the smidgen of information you have included will sufficiently inform and convince the farmer working the fields next to the plant, or the housewife in Wakefield, Ohio, or the new tenant in one of the K-25 buildings that they have nothing to worry about. These people should not (be) forced to imagine what is in those somewhat rusted cylinders they see stored in the yards. I think you should at least use some of the pictures and descriptions of the cylinders form the ORO 651 series of documents. I can give you copies of ORO 651 Rev 5 and ORO 651 Rev 6, but you will have to buy the successor document USEC 651 Rev 7 from the USEC for which they charge $5.00. Also, and more

importantly, you should point out that there is an American National Standard, ANSI N 14.1, Uranium Hexafluoride-Packaging for Transport, which governs the quality of the material in and fabrication of these cylinders. You should be sure to point out that the cylinder has only one valve for filling and emptying. This valve is located at the 12 o'clock position on one of the ends.

Assuming you expand your description of the cylinders, then you need to tell the people what is in them. You need to tell them that the U-235 isotope concentration has been reduced from the naturally occurring 0.711% to 0.2-0.3%, resulting in a proportional increase (in) the concentration of U-238.

You need to tell them that UF_6 is a chemical compound that has one atom of uranium combined with six atoms of fluorine. It can be either a solid, a liquid, or a gas depending upon its temperature. In the storage yards it is a solid in the bottom of the cylinders and a gas at subatmospheric pressure in the top. If a cylinder is heated, the solid will melt to a boiling liquid at 147 degrees F. You need to tell them that it is a greater chemical hazard than a radioactive one.

You need to tell them how UF_6 reacts with the iron on the inner surfaces of the steel cylinder to form a corrosion inhibiting, protective surface layer of iron fluoride. This protective coating insures the UF_6 inside the cylinder will not react with and corrode the cylinder wall, i.e., if you protect the outside of the cylinder, and prevent it from rusting away, the UF_6 can stay in storage in the cylinders forever.

Response 2

In response to this comment, more detailed descriptions of the characteristics of both the storage cylinders and depleted UF_6 have been added to Section S.1.1 of the PEIS Summary and Section 1.1 of Chapter 1. Detailed information has been added which addresses the physical characteristics of the cylinders which are used for storage, as well as the physical and chemical characteristics of the depleted UF_6. Photographs have also been included which detail the cylinder and its associated parts which are referenced in the document, such as the cylinder skirt and stiffening rings.

Both the ORO-651 series of documents (DOE's own standard for handling UF_6) and the ANSI N14.1 Standard were reviewed during preparation of the PEIS. The ANSI standard is incorporated under Title 49, Code of Federal Regulations, Section 173.420, the federal regulations governing transport of depleted UF_6. Reference to the 49CFR173 has been added to Section 1.1 of the PEIS.

Comment 3

Cylinder Fill Limits: There are long standing specific requirements that have been used to determine the quantity of UF_6 that can be safely stored in an approved design cylinder. The fundamental concepts of the approach to assuring the safety of the many cylinders of depleted UF_6 stored at Paducah, Portsmouth, and Oak Ridge are certified minimum volume and 5% ullage. In particular, my comment concerns the UF_6 fill-limit and heating temperature limit for 48G cylinders, although the same rationale applies to the other sizes of UF_6 cylinders.

The crucial concept is the certified minimum volume of the cylinder. UF_6 cylinders are fabricated in strict accordance with the drawings and criteria in the American National Standards Institute standard ANSI N14.1, Uranium Hexafluoride-Packaging for Transport. One of the code requirements is that upon final fabrication, in order to determine its exact internal volume, the cylinder will be completely filled with 60°F water and weighed on a scale accurate to 0.1%. The actual water weight obtained is recorded for the individual cylinder certification data and stamped on the cylinder nameplate to conclusively demonstrate that the requirement has been met. For a cylinder to be acceptable, the quotient of the certified full cylinder water weight divided by 62.37 (the weight in pounds of 1 ft^3 of water at 60°F) shall not be less than the published minimum volume. For a 48G cylinder, the minimum volume is 139 ft^3, equivalent to a water weight of 8,669 lbs. Using this method of measurement, the actual internal volume of a cylinder can be determined and if it is not greater than the minimum volume, the cylinder is destroyed.

The density, or weight of a cubic foot of UF_6 has to be known in order to use the certified minimum volume to determine a safe-fill quantity of UF_6 for the cylinder. During the first 20 years of the atomic age, much research work was done to determine the physical properties of UF_6. R. DeWitt of the Goodyear Atomic Corporation made an extensive literature search and compiled the results in a document, GAT 280, "Uranium Hexafluoride: A Survey of the Physico-Chemical Properties January 29, 1960." Data from this source has been used to produce Figures 1 and 2. Solid UF_6 undergoes a significant expansion as it is heated and melts from a solid to a liquid. This is illustrated in Figure 1, Density of Solid UF_6, and Figure 2, Density of Liquid UF_6 235-300°F.

Knowing that all cylinders are larger than the certified minimum volume allows the establishment of a safe UF_6 fill limit for them. This weight is obtained by using the density of liquid UF_6 at the 250°F design temperature of the cylinder and determining how much of this 250°F liquid UF_6 will fill 95% of the cylinder's certified minimum volume. Because all cylinder volumes are certified to be greater than the minimum, this guarantees that there will be at least 5% of the certified minimum cylinder volume as ullage (space above the liquid in the cylinder) when the cylinder is heated to its design temperature of 250°F, and thus there will be no possibility of hydraulic forces developing in the liquid to cause cylinder rupture.

From ANSI N14.1, the minimum volume for a 48G cylinder is 139 ft^3 and from Figure 2, the density of liquid UF_6 at 250°F is 203.7 lbs/ft^3. For a 48G cylinder, the calculation of the fill limit is:

$$95\% \ (139 \ ft^3) \ (203.3 lbs/ft^3 \text{ of } UF_6) = 26{,}840 \text{ lbs of } UF_6$$

Keep in mind that because all cylinders are required to prove that they have greater than a minimum volume, there will always be at least, if not more than, a 5% ullage to prevent hydraulic rupture at the design temperature. At lower than design temperatures, because the density of liquid UF_6 in lbs/ft^3 increases as the temperature is lowered to the freeze point of 147°F, the percentage of the cylinder volume occupied by gaseous UF_6 will increase and be larger than 5%. For example, prior to going to the storage yards, after all the air was evacuated from inside them, the depleted UF_6 cylinders were filled to the fill limit with liquid UF_6 at a temperature of 160°F with a density of 224 lbs/ft^3. The ullage in this case is at least 14%. There can be no hydraulic rupture as long as gas in the ullage provides a cushion.

This fill-limit calculation assures safety if the cylinder is heated to the design temperature and before any material is removed from it. In diffusion plant practice, the cylinder is never heated above 100°F. As UF_6 gas is withdrawn, there is a smaller mass of liquid UF_6 in the cylinder so the ullage increases. Any volatile impurities that may have been in the cylinder will be expelled when feeding is first started so the pressure of the system will correspond to the vapor pressure of UF_6 for the temperature.

When the cylinder is filled with liquid UF_6 to its proper fill limit, and has cooled to room temperature, based on the data in Figure 1, showing the density of 68°F to be 317.8 lbs/ft^3, the solid UF_6 will occupy 26,840 $lbs/317.8 \ lbs/ft^3 = 84.45 \ ft^3/139 \ ft^3 = 61\%$ of the certified minimum volume. The remaining 39% of the volume will be filled with UF_6 gas at subatmospheric pressure or vacuum.

Response 3

Comment noted. However, it should also be pointed out that not all of the depleted cylinders in storage have an individual "certified volume" which allows the actual cylinder volume to be calculated and filled accordingly. Some of the older cylinders in storage must be assessed based on the published ANSI N14.1 minimum volume required and therefore will "appear" to be overfilled.

Comment 4

Minimum Cylinder Wall Thickness. The 0.25" minimum wall thickness specified in ANSI N14.1 and the ORO 651 series for the 48G, 48H, 48 HX, 48 O, and 48 OM cylinders is for a pressure vessel rated at 100 psig. However, this pressure is only achieved if the cylinder of solid is heated 147°F to liquefy the UF_6 and the heating of the liquid continued until the temperature of the liquid is increased to 200°F, as is done in gaseous diffusion plant operations requiring rapid emptying of

the cylinder's contents. However, if by strict administrative control, the cylinder is only heated to a skin temperature of 133°F, 14 degrees below the liquefaction temperature, the UF_6 gas pressure in the cylinder will be atmospheric pressure (14.7 psia), and the UF_6 can be changed directly from solid into gas without going through the liquid phase in order to remove it from the cylinder at a slow rate. (This is the way the French feed their diffusion plant, and is what you have heard referred to as "cold feeding.")

Response 4

The 0.25" minimum wall thickness indicated in the PEIS is specifically a measure by which the existing cylinder inventory at the three G.D.P. sites was assessed for off-site transportation. The criteria for offsite shipping is a minimum of 250 mils (1/4 inch) for thin-walled cylinders which had an original wall thickness of 312.5 mils (5/16-inch). The minimum acceptable cylinder wall thicknesses for the various depleted UF_6 cylinder models is provided in Table 4-3 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), with a description of the requirements for offsite transportation of depleted UF_6 cylinders given in Section 4.0 (Identification and Comparison of Options) in the engineering analysis report.

Comment 5

Radiation Emanating from a Depleted Cylinder of UF_6. There is another aspect of the filled cylinders that I do not think has been adequately covered. There should be a statement concerning how many, or few, curies or sieverts of radiation emanates from one cylinder. Depleted UF_6 is by definition U-238. The handbooks show U-238 to have a half life of 4.47 billion years (about as long as the earth has been around). The thorium and protactinium daughter products have melting points in the range of 1650-1850°F. This means that any daughter products that may be in a cylinder of normal assay UF_6 being fed into the cascade will not be vaporized and expelled from the cylinder with the UF_6 gas at 200°F. In essence, since no uranium daughter products are fed to the cascade, the only ones in depleted UF_6 are the ones that have grown in the past 50 years. With U-238's half life, there can't be more than a handful!

I know from experience that it is very difficult to measure any gamma radiation when scanning the outer surface of a full cylinder in storage with a radiation meter. However, after a cylinder has been heated, liquefied, emptied, and cooled, the scan will show a small amount of gamma radiation on the bottom of the cylinder. Keep in mind that the purpose for which diffusion plants were built was to prepare uranium for fission, either in a weapon or a nuclear reactor. The diffusion process removes 70% of the fissionable isotope found in naturally occurring uranium. The stored depleted uranium has never been used as a fuel in a nuclear reactor where fission products occur in great abundance. There are very few gamma emitting fission products in the depleted UF_6. The gamma radiation in the depleted uranium is coming from uranium decay daughter products. These non-volatile daughter product form extremely slowly throughout the cake of solid UF_6 as uranium decays. They are homogeneously mixed with the solid UF_6 resulting in their gamma rays being shielded by the uranium atoms. Because the daughters are chemically different from the UF_6,

they will not vaporize and be removed from the cylinder as a gas. They concentrate in an ever diminishing pool of liquid until they are all that is left on the bottom. In this location, their radiation is directed downward away from people working with the cylinders. If you sit on top of a cylinder, your butt is at least four feet from the emitters.

I make no pretense of being a Health Physicist, so I find it hard to understand how you can estimate the exposures that people will get, if you don't state the intensity of the radiation at the source. Just one of many examples, Table D.1 page D-6 states as an impact during Storage (1999-2039) the total collective dose to a population within 50 miles (3 sites) will be 0.38 person-rems. How can you be accurate to two decimal points when you don't know how much radiation, if any, is coming from a cylinder of depleted UF_6? Here is an area where you could do a lot of good in taking the hocus pocus out of Health Physics and educating the public about radiation and its effects! Don't let them learn it from the Simpsons on the anti-nuke Fox Network.

Response 5

The radiation exposure of workers handling cylinders was estimated using computer models that calculate the external gamma dose rate in the vicinity of a cylinder. These models account for the ingrowth of gamma-emitting uranium decay products and shielding by both the cylinders walls and the depleted UF_6 itself. The results of the computer modeling were in good agreement with actual radiation measurement results provided by the cylinder storage sites that indicate that the external radiation level on the outside surface of a filled cylinder is typically about 2 to 3 mR/hr, decreasing to about 1 mR/hr at a distance of 1 ft. The methods used to calculate worker dose are summarized in Appendix C, with results provided in Appendix D of the PEIS. For purposes of conciseness, details related to these calculations are provided in the backup report by Cheng et al. (1997) referenced in Appendix C of the PEIS. A discussion of UF_6 cylinder hazards and dose rates has also been added to Sections S.1.1 and 1.1 of the PEIS to address this comment.

The population dose of 0.38 person-rem referred to by the commentor is the estimated radiation dose to the off-site public resulting from uranium potentially released from breached cylinders and transported to the off-site environment by air or water (see Section D.2.1.1 of the PEIS and Cheng et al. (1997) for additional details). The gamma radiation emitted by the cylinders does not contribute to the off-site public dose. Although a large degree of uncertainty is associated with such calculations, dose estimates were presented to two significant figures throughout the PEIS for purposes of comparison among alternatives.

Comment 6

Table S-3 Page S-46: What are the quantities of uranium compounds and HF considered to be released from a "Corroded cylinder spill, dry conditions," and "Corroded cylinder spill, wet conditions"? Without these numbers, it is difficult to understand the postulated consequences. The rest of the table has the same problem of not stating how much UF_6 or HF or UO_2 is released in the accidents.

Response 6

Table S.3 is a summary of potential environmental consequences of the preferred alternative. Data and methodologies used to arrive at the numbers presented in this table are given in the Appendices. The amount of UF_6 assumed released from a corroded cylinder spill under dry conditions was 24 lb. The amount of HF assumed released from a corroded cylinder spill under wet conditions (the solid UF_6 would be deposited on the ground and the HF subsequently generated) was 96 lb. This information, along with other details about the accident scenario, is provided in Table D.6 of Appendix D. Similar accident summary tables are provided in Appendix E (Cylinder Preparation), Appendix F (Conversion), Appendix G (Long-Term Storage), Appendix H (Manufacture and Use), and Appendix I (Disposal).

Comment 7

PAGE 1-1 SECTION 1.1 BACKGROUND INFORMATION: The statement is made: "At atmospheric pressure, UF_6 is a solid material below a temperature of 134°F and a gas at temperatures above 134°F (additional information about the characteristics of the chemical UF_6 is provided in Appendix A)." When I go to the Appendix A, I was amazed at the paucity of information presented not only for UF_6, but also for the other uranium compounds and HF. I thought at least, I would find the phase diagram of UF_6 that clearly shows the inaccuracy of the above statement but, alas, it wasn't there! UF_6 can be a gas below 134°F as well as above 134°F, and a solid all the way up to 147°F.

Response 7

The text on page 1-1 is correct, in that UF_6 is a solid material at atmospheric pressures below a temperature of 134°F and gas at temperatures above 134°F. The commentor is correct in stating that UF_6 can be a solid at a temperature of 147.3°F but this is at a pressure of 22.04 psia, higher than atmospheric pressure (14.696 psia).

Explanatory text and associated phase diagram for UF_6 have been added after the first paragraph of section A.1.1 on page A-1 of Appendix A, as suggested by the above comment.

Comment 8

PAGE 3-50 TABLE 3.13 FOOTNOTE c: The footnote states: "Radiation dose could result from drinking 365 L of K-25-site water (0.3 mrem/yr) and ingesting the maximally contaminated fish (1.6 mrem/yr)." Do you have to drink all 96.5 gallons (365 L) of water and eat the fish at one sitting? If you do, this is nonsense and serves no purpose. If you don't, what is the time period?

Response 8

The stated ingestion rates of water and fish are annual consumption rates. The footnote has been revised to make this point clear.

Comment 9

PAGE 4-14 DEFINITIONS: "Involved Worker — Might be exposed to direct gamma radiation emitted from radioactive materials such as depleted UF_6 or other uranium compounds." Here again, the question has to be asked, "How much radiation does depleted UF_6 or other uranium compounds emit/unit quantity of the substance?" Is the UF_6 still in the cylinder? Do you take credit for the shielding of the uranium in the UF_6 in the cylinder? The way this is written does absolutely nothing to allay the fears of the uninformed.

Response 9

The section of the PEIS referred to is intended to define the categories of workers considered in the radiological assessment. The sources of radiation exposure vary according to the category of worker being addressed and the option or alternative being considered in the PEIS. For example, the primary radiation source for involved workers during cylinder management activities is the uranium and decay products contained in the cylinders. However, during conversion, radiation exposures for involved workers considered both radiation from uranium contained in cylinders and from uranium in processing equipment and post-conversion containers. For purposes of conciseness, a description of the methods used to calculate the potential impacts to workers is summarized in Appendix C, with detailed information provided in the backup report by Cheng et al (1997), as referenced in Appendix C of the PEIS.

In response to the question concerning the dose rates associated with UF_6 cylinders, the radiation exposure of workers handling cylinders was estimated using computer models that calculate the external gamma dose rate in the vicinity of a cylinder. These models account for the ingrowth of gamma-emitting uranium decay products and shielding by both the cylinders walls and the depleted UF_6 itself. The results of the computer modeling were in good agreement with actual radiation measurement results provided by the cylinder storage sites that indicate that the external radiation level on the outside surface of a filled cylinder is typically about 2 to 3 mR/hr, decreasing to about 1 mR/hr at a distance of 1 ft. A discussion of UF_6 cylinder hazards and dose rates has been added to Sections S.1.1 and 1.1. of the PEIS to address this comment.

Comment 10

PAGE 9-18 DEFINITION OF TRANSURANIC WASTE: The word "transuranic" means "beyond uranium" i.e. elements that have a greater than the 92 atomic weight of uranium, like plutonium, neptunium, americium, etc. They probably do have half-lives greater than 20 years. Plutonium is deliberately made in nuclear reactors and extracted from spent reactor fuel. In the late '70s, a very small quantity of uranium recovered from spent reactor fuel was refined, converted to UF_6, and fed into the diffusion plant complex. They do not exist in sufficient quantity in depleted UF_6 to be a problem. Here again is a place where you could do good in educating.

Response 10

The definition shown on page 9-18 for transuranic waste has been revised to indicate transuranic waste to be "Waste contaminated by alpha-emitting transuranic radionuclides (i.e., radionuclides with atomic numbers greater than 92) with half-lives of more than 20 years and concentrations ...." As indicated by the commentor, the quantity of transuranic elements in the depleted UF_6 is very small. One reason is as given in the comment that there was very little UF_6 fed into the enrichment cascades that came from recycling operations. Another reason is that depleted UF_6 produced as the result of uranium recovered from spent nuclear fuel would not be expected to contain appreciable amounts of transuranic radionuclides. Among the various fluorides of plutonium, only plutonium hexafluoride (PuF_6) is volatile (and thus would be separated during the gaseous diffusion process of enriching uranium). Unlike the stable uranium hexafluoride, plutonium hexafluoride is thermodynamically unstable, dissociating into fluorine gas (F_2) and the relatively nonvolatile PuF_4 (plutonium tetrafluoride). Neptunium hexafluoride, like plutonium hexafluoride, is decomposed in the presence of light. Therefore, they would not end up in the UF_6 stream that was fed into the enrichment cascades.

Comment 11

PAGE A-2 TABLE A-1: It seem incredulous that the particle and bulk density of UF_6 are each 4.6 g/cm^3, and neither one of them is the generally accepted 5.1 g/cm^3 at 68°F.

Response 11

The document "Calculational Methods for Analysis of Postulated UF_6 Releases" by W.R. Williams (NUREG/CR-4360, Sept. 1985) provides the following correlation for the density of solid UF_6 in the cylinder:

$$[\text{Density, solid } UF_6 \text{ (lb/ft}^3)] = 330.0 - (0.18 \times [\text{Temperature of solid } UF_6 \text{ (degrees °F)}])$$

so that at 68 °F, the solid UF_6 density is approximately 318 lb/ft^3 or 5.1 g/cm^3. The value in the text has been revised accordingly.

Comment 12

PAGE A-2 TABLE A-1: A.1.2 I think you should mention that uranyl fluoride picks up water of hydration from humid air and in doing so changes color from brilliant orange to yellow. If a cylinder should break open in the storage yard, this color change would probably be observed.

Response 12

The text of Section A.1.2 has been revised to include a statement to indicate that uranyl fluoride is hygroscopic and changes in color from brilliant orange to yellow after reacting with water.

Comment 13

PAGE A-4 A.2.1: UF_6 is essentially inert to copper, witness all the copper tubing instrument lines in the plants. Also don't forget Teflon that was developed specially for the Manhattan Project.

Response 13

The text on page A-4 of the PEIS has been revised to indicate that UF_6 is essentially inert to clean aluminum, steel, Monel, nickel, aluminum, bronze, copper, and Teflon and that Teflon is commonly used in the packing and cap gasket for cylinders storing depleted UF_6.

In general, design considerations such as using copper for instrument lines in contact with gaseous UF_6 have been factored into the facility layouts provided in the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The design sign basis and processing parameters for the various options are provided in the EAR, as well as any process considerations such as the material of construction of the various reactors and process equipment.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 14

PAGE B-7, 4TH FULL PARAGRAPH, LAST SENTENCE: "It was assumed that uranium would be released as solid uranyl fluoride (UO_2F_2),which would be deposited on the ground." You should do more than say it lays on the ground. Uranyl fluoride (UO_2F_2) has a characteristic of being very soluble in water, so as soon as it rains, its will go into solution which, because of the HF, will be acidic and be neutralized by the cement or limestone construction materials of the storage yard. The resulting calcium salts will probably be insoluble in water and lay where they have been formed.

Response 14

It is true that uranyl fluoride would react further upon contact with water. The second paragraph of section C.2.1 of the PEIS indicates that the estimation of potential impacts to water resources from cylinder breaches assumed reaction of the uranyl fluoride laying on the ground with water to form hydrogen fluoride and various uranium compounds which could dissolve and infiltrate surface and shallow groundwater resources. Text has been added to Section B.3 to clarify this point.

Comment 15

PAGE C-3, C-2.1 CONTINUED CYLINDER STORAGE, 1ST PARAGRAPH 3RD SENTENCE: "Because of their age, potential direct contact with the ground, and skirted ends, many of the cylinders show signs of corrosion." Unless you include the ORO 651 series of documents, how is the reviewer to know what you are talking about when you suddenly introduce "skirted ends"?

Response 15

A definition of "skirted ends" has been added to the text referenced in the comment.

Comment 16

PAGE E-20, FIGURE E.1: The design of the Horizontal "Clamshell" Overcontainer looks interesting, and since you will have to use it at all three plant sites, while you are at it, why don't you design to be a 100 PSIG pressure vessel and use the steam-heated autoclaves that you have at the plants to empty the defective cylinders? Otherwise you have to come up with an autoclave designed for hot air heating which will require different than your presently approved safety systems to avoid gross overheating with hot air.

Response 16

Air-heated autoclaves were utilized in the design to assure safe vaporization of UF_6 from incoming cylinders that are substandard due to corrosion defects, overpressuring, or overfilling. It was assumed that the use of steam-heated units could result in a steam/UF_6 reaction due to in-leakage of steam in a substandard cylinder. This potential steam in-leakage would result in the formation of uranyl fluoride and hydrogen fluoride, which would be a potential health and safety hazard to the workers supervising cylinder withdrawal. In addition, the hydrogen fluoride produced during steam heating could lead to equipment failure and the potential large-scale release of UF_6 in the vapor state to the atmosphere, which would present an environmental hazard.

Comment 17

PAGE E-21, E.2.2 CYLINDER TRANSFER. You will have some damaged cylinders at all three sites, and if you can't get a DOT permit to ship them off the plant site, how would one of these expensive cylinder transfer facilities at each site be of value to the enterprise?

Response 17

The cylinder transfer facility, if deemed appropriate, would mainly be used to transfer the contents of intact cylinders that do not meet the requirements of the Department of Transportation (DOT) for off-site transport into cylinders that do meet those requirements, if it became necessary to transport the cylinders to another site, for example, for conversion to another chemical form. The damaged cylinders would be handled on a case by case basis.

Comment 18

PAGE F-3, SITE LAYOUT FOR A CONVERSION FACILITY: Why do you store the full cylinders outside, and build the biggest building on the site for the empties to be under cover?

Response 18

It is assumed that the "biggest building on the site" that the comment refers to is the Outgoing Empty Cylinder Storage Building. This building is primarily a warehouse which provides space for three months storage of emptied cylinders during radiological "cooling." Preliminary

estimates have indicated possible dose rates in the range of 1 rem/hr at the lower surface of UF_6 cylinders which have been emptied of their contents, due to the retention of a heel of radioactive daughter products of uranium in the cylinder after emptying. Analysis performed for the engineering analysis report (LLNL 1997a) indicated that a period of approximately three months of on-site storage is required to allow these daughter products to decay to acceptable levels for shipment off-site. The emptied cylinders would be stored inside of a metal-frame building, which would be a restricted area with limited personnel access, to reduce worker exposures. The functions of the Empty Cylinder Storage Building, as shown in Figure F.1, page F-3 of the PEIS, are explained in Section F.2 of the PEIS. There is also a section describing this building in each of the conversion reports in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) (see for example Section 2.1.3.4 in 6.4, U_3O_8: Defluorination/Anhydrous HF Facility).

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 19

PAGE F-11, 1st PARAGRAPH: Why wash the empty cylinders with water when a nitric acid solution would do a better cleaning job? The used solution could also be evaporated to dryness for disposal.

Response 19

The PEIS assumes that the empty cylinders would be treated only with water, and that contaminants not removable by simple wash and rinse procedures will remain in the cylinders prior to their disposition. Water would be used to remove the heels from the empty cylinders, as a heel as great as 50 pounds of UF_6 can be treated with 10 gallons of water without exceeding the solubility limit of UO_2F_2 (i.e., about 32%). The UO_2F_2 produced during cylinder washing could then be processed at a UF_6 conversion facility to generate U_3O_8 or UO_2, minimizing costs. Addition of nitric acid would produce uranyl nitrate hexahydrate, $UO_2(NO_3)_2*6H_2O$, which would require processing techniques different from those considered in the PEIS to produce either U_3O_8 or UO_2. The uranyl nitrate could be evaporated to dryness for disposal purposes, but this would generate a relatively large amount of uranium-bearing waste (on the order of 500 to 600 tons) that would require disposal as a low-level waste.

Comment 20

PAGE F-1 3, F.2.3 CONVERSION TO METAL, 3RD PARAGRAPH, 4TH SENTENCE: "The more dense molten uranium/iron would settle to the bottom of the reactor where it would be continuously withdrawn." What kind of material are you going to use for the reactor and liquid uranium/iron draw off piping? I have always been told that liquid uranium at 2100°F, and uranium

alloys at lower temperatures are the universal solvents. Nothing, even yttrium lined equipment will contain them for very long.

If you go with the Fe/U alloy just to lower the molten metal temperature, how good a radiation shield will your alloy be as compared to pure uranium?

Response 20

The reactor and associated piping would be both insulated and graphite-lined. The service life of the graphite liner is limited by erosion/corrosion, and is assumed in the PEIS to be on the order of 8 months.

Iron is added to produce an uranium alloy with 3% iron. This small percentage of iron should not significantly attenuate the radiation shielding potential of the uranium-iron alloy compared with pure uranium metal.

Comment 21

PAGE F-14, IMPACTS OF OPTIONS: The amount of HF produced from any of the conversion options should be expressed because it is the big safety hazard. The design rate of 2300 48G cylinders of UF_6 a year equates to 6.3*26,840 lbs or 169,100 lbs UF_6 a day. Using a molecular weight of 352 for UF_6, these 6.3 cylinders contain 480 lb/mols of UF_6. Each lb/mol of UF_6 that reacts with water will create six lb/mols of HF. Thus 480 lb/mols * 6 = 2880 lb/mols HF/day. Using a molecular weight of 20 for HF, this equates to 57,000 lbs or 6600 gallons of anhydrous HF/day produced. Remembering that HF boils at 60°F, this is a lot of HF to handle day in and day out in plastic pipes and tanks. You are buying a much bigger safety problem than I think you are portraying in these tomes. You should know that a drop of this liquid will burn a hole through your unprotected hand and the fumes can kill as happened at Kerr McGhee in Gore, OK!

Response 21

The amount of hydrofluoric acid that would be produced during UF_6 conversion would be on the order of 7,400 gallons per day, assuming complete conversion of DOE's depleted UF_6 inventory within a 20-year period. This daily production rate is equivalent to an annual production rate of about 9,200 MT/year, which is 5% or less of the estimated U.S. annual capacity for HF production. The safety issues associated with the production of hydrofluoric acid have been considered in the PEIS. As an example, the anhydrous HF produced during UF_6 conversion would be stored in tanks and a building cooled to about 50 °F to minimize the HF that vaporizes if a spill should occur. The storage tanks themselves would have high level alarms and interlocks that stop the transfer pump, and would be diked to contain spillage. The building itself would have HF air monitoring instruments and a water spray system that can be activated to absorb HF. Further information concerning the engineering aspects of the production and storage of HF is provided in the engineering analysis report (1997a; the full citation is provided in Chapter 8 of the PEIS).

Comment 22

PAGE F-23, TABLE F.7: In the conversion to U_3O_8 section, the last accident is a U_3O_8 drum spilling its contents onto the floor after an accident with a forklift. These drums contain 1600 lbs of U_3O_8 powders, and you are asking the reviewer to believe that the spill quantity will only be 63 milligrams! This tends to lose your credibility for the whole study! Later on in the Table, you show a 2400 lb drum of UO_2 in a similar accident only spilling 25 milligrams but you have an extremely unlikely 3, UF_6, cylinders bursting from some kind of fire and dumping 24,000 lbs in 30 minutes. I believe you lose integrity when you ignore the historical fact that this cylinder rupture scenario has not occurred, or even come close, in the past 50 years of cylinder storage. On the other hand, you seem to completely accept speculation about future accidents in plants that have not been built. It sure looks like you are trying to make people think this UF_6 stuff is the most hazardous thing there ever was?

Response 22

The accident analysis in the PEIS was performed using standard methodologies based on research and historical experience to determine the accident source terms. The difference in the amount assumed to be released for the accidents is primarily due to the physical form of the material involved (solid versus gas) and type of accident (simple drum spill versus fire-induced rupture of a UF_6 cylinder). The U_3O_8 drum spill accident for the conversion to U_3O_8 option assumed that 50% of the solid U_3O_8 would be released from the breached drum containing 1,380 lb U_3O_8, and that 0.02% of the released amount would be rendered airborne by the accident and contain powder in the respirable range. It should also be noted that the building filtration system would reduce the release by 99.9%, thus resulting in a release to the atmosphere of 0.00014 lb (1,380 lb × 0.5 × 0.0002 × .001).

The fire-induced UF_6 cylinder rupture accident scenario postulates that a vehicle with a large fuel inventory would crash into a UF_6 cylinder storage pad, and that the UF_6 cylinders would hydraulically rupture during heating, releasing UF_6 both as liquid and vapor. It should be noted that the total release of vapor UF_6 is respirable, unlike that of solid U_3O_8 for which a small portion is respirable.

Further information about the details of the source terms for the accident analysis performed in the PEIS can be found in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). This report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 23

PAGE F-29, CYLINDER TREATMENT FACILITY EXTREMELY UNLIKELY ACCIDENTS: Why is the amount released in an earthquake where 50% of the stored drums are

breached only 1.9 lbs, whereas in a Tornado that pierces only one drum of U_3O_8 the quantity released is 69 lbs? You need to cross check all these tables you publish. I am sure that I have not found all the inconsistencies.

IBID, PAGE F-29, CYLINDER TREATMENT FACILITY EXTREMELY UNLIKELY ACCIDENTS: The 3.4 lbs of HF released when the evaporator tank fails and the pool of HF evaporates into the building is just plain wrong. I can tell that none of you ever worked at Fernald! If the temperature is above 60°F, 3.4 lbs of anhydrous HF will become 61 standard cubic feet of extremely toxic and obnoxious gas.

Response 23

All the appendix tables summarizing accidents considered for the various options have been checked; there are no known errors. Background information and details on the rationale for the release amounts are given in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), which is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

With respect to the specific questions raised in the comment, the difference in the release amounts for earthquakes and tornadoes is mainly due to the high winds which accompany a tornado. During a tornado, a wind-blown missile could impact a single U_3O_8 drum and release the 1,380 lb inventory of the drum, with 5% of the released amount rendered airborne outside the building and containing powder in the respirable range, resulting in a release of 69 lbs. For an earthquake, it was assumed that 50% of the 28 drums stored in the Solids Product Building would be damaged, 50% of the material in the drums released, and 0.02% of the released amount would be rendered airborne outside the building and contain powder in the respirable range, for a total of 1.9 lbs. An analogous situation would be dropping a bag of Portland cement onto a hard surface. The bag would rupture and a very small amount of fine dust particles would be emitted in the air. In the case of a tornado, the entire contents of the cement bag that had burst open would be entrained by the high winds.

With regards to the evaporator tank failure which was postulated to release 3.4 lb of hydrogen fluoride (HF), the evaporator would contain 154 gallons of 13.3% HF (equivalent to 176 lb. HF) at its boiling point. The accident scenario postulates that the evaporator tank would fail and the entire contents be spilled. Flash evaporation (due to HF being at its boiling point) of the tank contents would result in 1% being vaporized (1.8 lb HF flashed vaporized). Normal evaporation of the HF spill on the concrete floor over a 60-minute period would result in another 1.6 lb HF being released, for a total of 3.4 lb HF over a 60-minute duration.

Comment 24

PAGE G-16, SECTION G.2-2: I don't find recognition of the cylinder sweating problem in any of the inside storage options. During the winter, the 10 or 14 ton cake of UF_6 in each cylinder cools approaching the temperature of the coldest day. When spring comes and the warm humid days return, the outer surface of the cylinders becomes a condenser for the water in the air, not unlike the sweating on your evening rum and coke glass. Unless you air condition the buildings, vaults, and mines, the cylinder wall corrosion will continue especially in the spring.

Response 24

The PEIS assumed that designs for the three storage options would include heating, ventilation, and cooling (HVAC) in order to avoid the effects of temperature and humidity extremes mentioned in the comment. This should limit the potential for cylinder sweating.

Comment 25

PAGE H-16, TABLE H-5: Why is that the drop of a single 2400 lb drum of UO_2 only releases 7.3×10^{-7} pounds (3.3 mg) of UO_2 in this accident whereas the same accident in Table G.6 page G-26 releases 1.1×10^{-4} lbs (50 mg) of UO_2? Once again, what you got don't make no sense!

Response 25

The reason for the difference is the degree of filtration, which would reduce the amount of UO_2 that is released to the environment through the stack. Table G.6 indicates accidents that could occur during storage of UO_2 in a metal building with minimal filtration, while the building design for Manufacture and Use in Table H.5 would include a number of filtration units to reduce emissions.

It should be noted that the amount of released solid material such as UO_2 or U_3O_8 during an accident would be a function of the fraction of the material made airborne at the point of the accident, the fraction of the release in the respirable size range, and the fraction of the material that would be released from the building to the environment after being mitigated by air-treatment attenuation devices such as air filters. The fraction of the material made airborne at the point of the accident would be a function of the type of the material. During conversion of UF_6 to form UO_2, very dense and hard pellets are formed, similar to those used in nuclear reactor fuel. The UO_2 pellets would not be expected to release many airborne particles after simply being dropped, which explains why such a relatively small percentage of the drum contents would be released to the atmosphere.

Comment 26

PAGE J-28, SECTION J.3.4.3, CYLINDER TREATMENT FACILITY: I question the assumption that emptied UF_6 cylinders will retain a 22 lb heel. Why not use dry air to purge the UF_6 gas from the emptied cylinder in the autoclave and let these purge gases go directly to your

conversion apparatus. If you do this you should get your heels to be around 10 ppm UF_6. However, even if you do this, you will still have to wash the cylinders to get the daughter product out.

Response 26

The amount of UF_6 remaining as "heels" (22 lbs) was taken from the document "Cost Study for the D&D of the GDPs, Depleted Uranium Management and Conversion," K/D-5940-DF (Sept. 1991). This document presents a preliminary design developed by the Central Engineering Department at the Oak Ridge Site for conversion of the depleted UF_6 to form U_3O_8. This document also indicated that on the order of one pound of insoluble solids per cylinder would be removed during cylinder washing. Reference to this report has been added to Appendix F and Appendix J of the PEIS.

Commentor No. 5: **Denton, Dr. Mark S.**
Mountain Technologies Network Group

Comment 1

I am currently reviewing the Draft PEIS Summary, Vol. I and Vol. II. Thank you for the opportunity to provide comment. I have been tracking this problem (which I feel is of the highest priority along with the Gunnite Tanks and Melton Valley Storage Tanks at ORNL) since 1992 at Oak Ridge (K-25), PGDP and PORTs.

Response 1

Comment noted.

Commentor No. 6: **Weigel, Rudy**

Comment 1

Question: I didn't think "economics" was a consideration of the NEPA process. If it's not, why is it presented in the PEIS? It's being presented could adversely influence ultimate decisions for the project-people will look at the dollars instead of the best project option.

Response 1

NEPA and its implementing regulations require that federal agencies address the impacts of proposed actions on the human environment. Consequently, the PEIS addresses socioeconomic impacts on human communities, including changes in employment, local housing demand, public finances, and population in-migration. The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, including socioeconomic impacts, along with other information, such as cost and engineering data,

to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Commentor No. 7: Peelle, Bob

Comment 1

In discussing possible future uses of depleted uranium, you predominantly mention radiation shielding. True for x-rays and gamma rays, and sometimes true for electrons. Never true for neutrons! (fast or slow). (I was associated with some simple minded experiments 40 years ago that made the point dramatically.) The neutrons produce fissions, and the (subcritical) multiplication ruins the shield. Uranium pellets would ruin concrete blocks, if many neutrons are around. So for any application including around an accelerator, an analysis would have to be made. So, qualify the statements to apply only to x-rays or x-ray shields.

Response 1

Dense materials, such as uranium, are primarily used for shielding x-ray, gamma, and beta radiation. Qualifying statements have been added to the PEIS (Sections 1.5.3 and 2.2.4) to indicate that uranium would be used to shield these types of radiation.

Commentor No. 8: Plansky, Dr. Lee

Comment 1

A. re: Disposal Options U- minerals are deposited in reducing environments. It would seem that you would chose a *grout* that would tend to be chemically neutral or also reducing, perhaps a glass or synroc. The oxidizing environment implied in the present scenario (cement grouts, implies rapidly rusting metal drum, and oxidation of U to U ++++++ (+6, or +5) and we mobilize what we don't want to.

Response 1

The PEIS considers disposal of uranium in the form of uranium oxides such as U_3O_8. Uranium appears in nature as U_3O_8 and this is the generally recommended form for disposal due to its inertness and low solubility.

Grouting of waste materials is widely practiced in the disposal of radioactive waste. Most processes use a cementing or binding agent (for example Portland cement or asphalt). The resulting block of waste, with relatively low permeability, reduces the surface area across which the transfer of pollutants such as uranium can occur. Some versions of waste stabilization involve adjusting the pH and oxidation-reduction conditions in the waste to prevent waste solubilization in groundwater. This is not necessary with uranium oxides such as U_3O_8 due to their low solubility in groundwater.

Comment 2

B. The PEIS downplays the importance of U-toxicity as a metal. Refer to any simple MSDS on U METAL and you and the public will all be shocked.

Response 2

The analyses of potential health impacts conducted for the PEIS addressed both the chemical and the radioactive toxicity of uranium as several different compounds: UF_6, UO_2F_2, UO_2, U_3O_8, UF_4, and uranium metal. For normal operations, the chemical toxicity was addressed by comparing potential exposure amounts with the U.S. Environmental Protection Agency's reference dose for uranium. For accidents, the chemical toxicity was addressed by comparing potential intakes with: 1) the intake of 30 mg given as the threshold for potential irreversible kidney damage under U.S. Nuclear Regulatory Commission (NRC) guidelines for certification of gaseous diffusion plants (NRC 1994a; full citation is provided in Chapter 8 of the PEIS); and 2) the intake of 10 mg, which NRC publications give as the threshold for potential adverse chemical effects (generally temporary, reversible effects occur in the range from 10 to 30 mg of intake). The chemical toxicity analyses for uranium are summarized in Sections 4.3.1.2.2 and 4.3.2.1 of the PEIS, and discussed in greater detail in Sections C.5.1.2 and C.5.2.1.1. Chemical toxicity was assessed for each alternative, and the results of the accident analyses show that the largest potential impacts from accidental uranium releases would be chemical impacts. Please see text in Sections S.4.2.2 and 2.4.2.2, which states "chemical effects (kidney damage) occur at lower exposure levels than radiological effects," and elaborates on the numbers of workers and members of the general public estimated to experience these adverse chemical effects under the various accident scenarios analyzed.

Comment 3

C. The way I understand it, the new proposed 20 micrograms/liter EPA MCL on U-238 is inviolable. Depleted uranium material would be disposed of as low-level radioactive waste. The disposal options assessed in the PEIS were defined on the basis of the chemical form of the uranium and the type of disposal facility. The following disposal options were considered: Disposal as U_3O_8. Depleted uranium could be disposed of as U_3O_8, either ungrouted (bulk) or grouted U_3O_8, following conversion. The disposal facilities considered included shallow earthen structures, below ground vaults, and an underground mine. Disposal as UO_2. Similar to U_3O_8, depleted uranium could be disposed of as UO_2 following conversion, either in ungrouted or grouted form. The disposal facilities considered were the same as those considered U_3O_8: shallow earthen structures, below ground vaults, and an underground mine.

Response 3

The proposed maximum contaminant level (MCL) for uranium was used as a guideline in the PEIS to estimate the potential for adverse environmental impacts to groundwater and surface water of the various alternatives. The potential impacts of the options listed in the comment (e.g.,

disposal as grouted or ungrouted U_3O_8 or UO_2 in shallow earthen structures, below ground vaults, or a mine) were considered under the disposal alternative.

Commentor No. 9: **Lemar, Cathy / Goldtooth, Tom / Fahey, Dan**
Military Toxics Project / Indigenous Environmental Network / Swords to Plowshares

Comment 1

We believe that all of the strategies that proposed have serious environmental justice concerns and potential impacts to communities that you have not adequately reached with the Draft PEIS. We also believe that the meetings that DOE has held in the past, as well as the ones that are beginning on February 19,1998 in Paducah, are not properly reaching people who are or may be impacted by decisions that your agency will be making regarding the long-term plan for use of this dangerous material.

Response 1

The approach used in the PEIS to assess environmental justice concerns is consistent with guidelines in "Environmental Justice: Guidance Under the National Environmental Policy Act" (Council on Environmental Quality 1997; the full citation is provided in Chapter 8 of the PEIS). The approach taken involved a two-step process to identify impacts associated with environmental justice (see Section 4.3.12 of the PEIS). The first step concerns the presence of disproportionately high percentages of low-income or minority populations in those areas anticipated to experience high and adverse impacts. The second step concerns the presence of high and adverse impacts in general, and thus affecting the total population. Section C.8 of the PEIS provides a detailed discussion of the methods used to identify and assess potential environmental justice impacts.

Because one must know the economic and racial composition of an area potentially affected in order to assess environmental justice impacts, the assessment must be site-specific. In the PEIS, the only alternative components for which locations are known are continued cylinder storage (Appendix D) and cylinder preparation (Appendix E). For these components, environmental justice issues were examined thoroughly (see Sections D.2.11 and E.3.11 which discuss environmental justice impacts). As discussed in these Sections, no high and adverse human health effects or environmental impacts would be expected from continued storage of cylinders or cylinder preparation activities at the Paducah, Portsmouth, and K-25 sites. Because of this general lack of high and adverse impacts, and because minority and low-income populations would not be more prone than the general population to experience impacts from the two site-specific activities, no environmental justice impacts are anticipated. With regard to the remaining four alternative components (that is, conversion, long-term storage, manufacture and use, and disposal), because their locations currently are unknown no environmental justice evaluation could be conducted in the PEIS. If in its Record of Decision for this PEIS DOE selects an approach to the management

of its depleted uranium inventory that involves any of these alternative components, possible sites will be identified and those sites evaluated in subsequent NEPA documents, as described in Section 1.4 of the PEIS. One component of those evaluations would be an assessment of environmental justice impacts.

With regard to reaching people who are or may be affected by decisions on the management of the DOE depleted uranium inventory, the Department has made a substantial effort as part of the public outreach component of the PEIS to inform all interested parties of the document's preparation and various means of participating in the process of its preparation. DOE distributed PEIS documents and public hearing notices to about 2,400 individuals and organizations identified by the three current storage sites and through the DOE stakeholder mailing list as parties potentially interested in the PEIS. Those contacted included advisory boards, environmental groups, interest groups, local organizations, tribal organizations, and government representatives at the local, state, and federal levels. Publicity for the Draft PEIS and the four public hearings included Federal Register notices, newspaper display advertisements, site press releases and/or newsletters, public service radio announcements, postcard notices to local stakeholders, the Depleted UF_6 World Wide Web site (http://www.ead.anl.gov/uranium.html) and DOE's NEPA Web site (http://tis.eh.doe.gov/nepa). The entire PEIS is available for review on the Depleted UF_6 World Wide Web site. DOE believes all groups were provided adequate opportunity to comment on the Draft PEIS.

Comment 2

Keeping with the spirit and intent of President Clinton's Executive Order on Environmental Justice and Secretary Pena's Openness Initiative, we feel that it would be reasonable to request that the DOE initiate round table meetings, much like the Federal Facilities Restoration Dialogue meetings. We believe that it is necessary and just to bring in grassroots leaders from community, labor, and environmental justice groups to further discuss the implications of strategies that have been proposed.

Response 2

Openness and public outreach were important components of the process to prepare, distribute, and solicit comments on the Draft PEIS. DOE distributed PEIS documents and public hearing notices to about 2,400 stakeholders in December 1997. This distribution included many environmental groups, including environmental justice advocates. Public hearings were conducted in March and April 1998 in Paducah, Kentucky; Oak Ridge, Tennessee; Piketon, Ohio; and Washington, D.C. These hearings provided opportunities for community leaders, labor organizations, environmental groups, and other individuals and organizations to provide oral and written comments on the Draft PEIS and to discuss the Draft PEIS with representatives of DOE's depleted uranium hexafluoride management program. Publicity for the Draft PEIS and the public hearings included Federal Register notices, newspaper display advertisements, site press releases and/or newsletters, public service radio announcements, postcard notices to local stakeholders, the

Depleted UF_6 World Wide Web Site, and DOE's NEPA Web Site. DOE believes all groups were provided adequate opportunity to comment on the Draft PEIS during the 120-day comment period.

Comment 3

We further request that the comment period be extended to six months to give these folks the opportunity to meet with you, in addition to the hearings that are taken place now, as well as the opportunity to obtain expert technical advice regarding the impact of the various different strategies.

Response 3

DOE announced a 120-day public comment period upon publication of the Draft PEIS in December 1997. This comment period was much longer than the 45 days required by Council on Environmental Quality and DOE regulations implementing the National Environmental Policy Act. DOE believes this comment period was of sufficient duration to allow review of the Draft PEIS and submittal of comments by government agencies, potentially affected communities, and other individuals and organizations.

Commentor No. 10: Comment letter was submitted but since withdrawn

Commentor No. 11: Adkisson, Ron
Rio Algom Mining Corporation

Comment 1

One long-term alternative which has not been considered to date for long-term storage of the converted uranium (i.e., UO_2, U_3O_8, etc.) is the placement in a uranium mill tailings impoundment for long-term retrievable storage. Mill tailings impoundments are designed for 1,000 year stability and long-term care and maintenance is legally the responsibility of the Department of Energy. Quivira Mining Company's mill tailings site in New Mexico, for example, is presently licensed to dispose of 5,000,000 tons of byproduct materials even though the structural stability of the site was designed for an additional 43,000,000 tons. The primary advantages of using a mill tailings site are: (1) the inventory would be consolidated and isolated from the environment; (2) placement in a tailings impoundment would be relatively simple and with minimum personnel exposure; (3) it would remain in the custody of the US Government for long-term monitoring and care; and (4) it could be retrieved at any time in the future should the need arise.

Response 1

Uranium mill tailings are the residual wastes of milled ore that remain after uranium has been recovered. Uranium mill tailings are part of a broad category of radioactive wastes called by-product materials. The tailings contain about 0.004 to 0.01% U_3O_8.

Uranium mill tailings are to be disposed of in a tailings impoundment. This must have a cover designed to control radiological hazards for a minimum of 200 years. The Ambrosia Lake uranium mill tailings site operated by the Quivira Mining Company is authorized by the U.S. Nuclear Regulatory Commission to accept 11e.(2) material for disposal. The term "11e.(2)" material means by-product material produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. The basis for the definition of this group of by-product materials is Section 11e(2) of the Atomic Energy Act of 1954. Depleted uranium would not be classified as 11e.(2) material, and as such, could not be disposed of at the Ambrosia Lake uranium mill tailings site (or any other mill tailings site) without relicensing to allow emplacement of depleted uranium. It would be highly speculative within the PEIS to consider amendment of legislation such as the Atomic Energy Act of 1954 to allow disposition of depleted uranium within a mill tailings impoundment.

Commentor No. 12: Balding, Andrew

Comment 1

Appendix D, pg. 5, 1st Para: The assumption that any further breaches would be a result of handling damage vs. corrosion is very valid, however the follow on assumption that this breach or damage would go undetected for 4 years is not a valid assumption. The same detailed Inspection of a cylinder is required each and every time it is handled as it is Quadrennially or Annually, the Inspections in fact almost identical, the same procedures and checklists are used regardless of the type of inspection or frequency. Any damage that might occur under the current regimented and proceduralized handling activities whether during painting, cylinder relocation to improved storage, or just normal storage yard operations, would be immediately noted and dealt with at the occurrence. Therefore there would be no release and no "Environmental Impact" whatsoever, furthermore the one handling damage induced breach (the Paducah cracked cylinder) was caused by handling damage in 1987; since that time this Site has handled thousands of cylinders without breaching a cylinder due to handling damage, the current Project alone has handled over 30,000 cylinder relocations since 1992 without causing damage to a cylinder sufficient to cause a breach. The facts do not support the conclusions of the predicted number of cylinder breaches portrayed in the "No Action Alternative": the estimate of 444 at Paducah over the next 40 years with only one under old handling practices (even disregarding that those practices have been improved) is sensationalistic.

Response 1

The commentor seems to be referring to the text of the Introduction to Appendix D, paragraphs 9 through 11 (found on pages D-3 and D-4 of the Draft PEIS). With regard to the number of breaches estimated to occur during the period of operations, two separate analyses were conducted. The first analysis took credit for the improved management program, and specifically assumed that the painting program would eliminate breaches caused by corrosion. Under these assumptions, the assumed breaches would be the result of mechanical damage occurring during

handling. The number of breaches assumed to occur from handling damage through 2039 were 36 for the Paducah site, 16 for the Portsmouth site, and 7 for the K-25 site (as stated in the text). These assumptions are quite reasonable based on the large numbers of annual cylinder relocations and/or paintings assumed for the three sites; these assumptions were used as the base case for the assessment of continued storage impacts, as presented in detail in Sections D.2.1 through D.2.11 of Appendix D.

Another reasonably foreseeable scenario for cylinder breaches would be the possibility that the painting program would not be effective in controlling further corrosion, or that the required painting schedule could not be maintained. In order to address this possible (but less likely) scenario, a second assessment based on the assumption that external corrosion was not halted by improved storage conditions and painting was also conducted. Based on these assumptions, the total numbers of breaches estimated through 2039 were 444 for the Paducah site, 74 for the Portsmouth site, and 213 for the K-25 site. The impacts based on these assumptions are presented in Section D.3 of Appendix D as a supplemental analysis.

With respect to the period of time before a breach would be detected (assumed to be 4 years), the PEIS analyses used a reasonable value based on available data. Since all of the cylinders must be inspected at least once every 4 years, this would be the maximum amount of time a breach could go undetected. This assumption was also used because data exist on how much of the cylinder content would be lost during that period of time; a breached cylinder at the Portsmouth site which had been in storage for 4 years prior to discovery of the breach was estimated to have lost 4 lb of uranium (see Section B.3 of Appendix B).

Commentor No. 13: Davis, Mary B., Ph.D.
Ygdrasil Institute

Comment 1

We are writing to you to request that you extend by six months the period for comment on the Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride. The material in the draft is very technical and complex, and many people concerned with the management of the hexafluoride have only recently received copies of it.

Response 1

DOE announced a 120-day public comment period upon publication of the Draft PEIS in December 1997. This comment period was much longer than the 45 days required by Council on Environmental Quality and DOE regulations implementing the National Environmental Policy Act. PEIS documents and public hearing notices were widely distributed and were publicized in Federal Register notices, newspaper display advertisements, site press releases and/or newsletters, public

service radio announcements, postcard notices to local stakeholders, the Depleted UF_6 World Wide Web Site, and DOE's NEPA Web Site. DOE believes the 120-day comment period was of sufficient duration to allow review of the Draft PEIS and submittal of comments by government agencies, potentially affected communities, and other individuals and organizations.

Comment 2

We should also like to recommend that people in the affected communities be invited to round table meetings like those for the Federal Facilities Restoration Dialogue. The affected communities should include those likely to be at risk if transportation of uranium hexafluoride on a large scale takes place.

Response 2

Openness and public outreach were important components of the process to prepare, distribute, and solicit comments on the Draft PEIS. DOE distributed PEIS documents and public hearing notices to about 2,400 stakeholders in December 1997. This distribution included the communities surrounding the current storage sites that could be affected if cylinders were to be transported from their current locations. Public hearings were conducted in March and April 1998 in Paducah, Kentucky; Oak Ridge, Tennessee; Piketon, Ohio; and Washington, D.C. These hearings provided opportunities for community leaders, labor organizations, environmental groups, and other individuals and organizations to provide oral and written comments on the Draft PEIS and to discuss the Draft PEIS with representatives of DOE's depleted uranium hexafluoride management program. Publicity for the Draft PEIS and the public hearings included Federal Register notices, newspaper display advertisements, site press releases and/or newsletters, public service radio announcements, postcard notices to local stakeholders, the Depleted UF_6 World Wide Web Site, and DOE's NEPA Web Site. DOE believes all groups were provided adequate opportunity to comment on the Draft PEIS during the 120-day comment period.

Commentor No. 14: Whitehead, Corinne
Coalition for Health Concern

Comment 1

We urge DOE to determine all leaking cylinders at PGDP. Transfer the contents of leaking cylinders into heavy gauge new containers. Store in an earthquake proof concrete structure off the floor so they can be monitored for leaks. No major efforts to transfer contents and wash out containers in a process to change to uranium oxide should be at the Paducah facility.

Response 1

An intensive effort is ongoing to improve yard storage conditions at all three cylinder storage sites. New storage yards with stabilized concrete bases and monitored drainage have been constructed at the Paducah and Portsmouth sites. Cylinders are being relocated to allow space for

adequate visual inspections; relocated cylinders are being placed on concrete saddles to keep them out of ground contact. Each site has an intensive cylinder inspection program to allow identification of any damaged or breached cylinders as well as a radiological program to detect leakage from valves. At the Paducah site, for example, approximately 23% of the cylinders are inspected annually. Annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of heavy pitting or corrosion. All other cylinders must be inspected once every four years. Through these efforts, 7 breached cylinders were identified at the three sites before 1998 (one at the Paducah site). An additional breached cylinder was identified at the K-25 site in 1998; see Appendix B, Section B.2 of the PEIS for further details on this cylinder breach. Due to the improved storage conditions and frequent inspections, any breached cylinders identified in the future are expected to be recently breached with little material loss. Breached cylinders are either patched or have the contents transferred to new cylinders to prevent further material loss. See the introduction to Appendix D of the PEIS for more details on the current cylinder management program.

The proposed action of this PEIS is to select a long-term management strategy for the depleted UF_6 inventory. Options of storage in buildings, cylinder content transfer (including cylinder washing), and conversion to oxide or metal have been considered. The Department of Energy acknowledges the commentor's preference for storage as UF_6 in buildings, and the preference that cylinder content transfers and/or conversion should not take place at the Paducah facility. The selection of a long-term management strategy will be based on environmental analyses, technical and economic studies, national policy considerations, and public input. However, siting decisions are being deferred until after the selection of a long-term management strategy.

Comment 2

DOE has known details of severe seismic potential since the late 1970's and has taken little or no action to protect the workmen or the community. Negligence is not an "Act of God" if acute damage is done to the facility or the community during seismic events. We urge a comprehensive environmental impact study be made with full report to the public. We urge attention to damage and hazard reduction re: the earthquake potential utilizing national and international earthquake engineering and seismic scientists, who are respected in that field.

Response 2

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Of the three storage sites, an earthquake which could cause more than slight damage is considered credible (though highly unlikely) only for the Paducah site.

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports (SARs) for each of the three storage sites (LMES 1997f-h; the full citations are provided in

Chapter 8 of the PEIS). The SARs were issued in February 1997 by the DOE's management and operating contractor, and were subsequently reviewed and approved by DOE in March 1997.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 3

We deplore the use of depleted uranium in military equipment.

Response 3

The commentor's objection to the use of depleted uranium in military equipment is noted. DOE's PEIS for selecting a management strategy for its depleted UF_6 inventory does not establish policy or requirements for depleted uranium uses by the U.S. Department of Defense in munitions or other military equipment. As described in Section 2.2 and Appendix H of the PEIS, the two use options evaluated in the PEIS, use as depleted uranium oxide and use as depleted uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks.

Commentor No. 15: Hamblin, L. Lee
Jacobs Engineering Group, Inc.

Comment 1

Page S-1; Para. 2; Sent.4 and Page S-4; Sect. S.1.2; Sent.2: Text states: "Additional NEPA analyses, as appropriate, will be prepared once a long-term management strategy has been selected ....This PEIS examines the environmental consequences of alternative strategies of long term storage, use, and disposal of the depleted UF_6 inventory." This document does not appear to analyze completely the use and disposal of the depleted UF_6 inventory when it defers the analysis of future siting, design, and construction to possible separate NEPA analyses (as appropriate) in the future

when, in effect, they appear to be "connected actions" and/or "cumulative actions" and should be evaluated thoroughly in this PEIS.

Response 1

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2 of the PEIS). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities is included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site-specific evaluations will be performed, including the effects of site-specific projects and range of alternative actions, including a "no action" alternative.

NEPA and its implementing regulations do not require site-specific evaluations when specific projects are not being proposed. Under the CEQ regulations, it states that major federal actions tend to fall into one of the following categories: (1) adoption of official policy, such as rules, regulations and interpretations; treaties; formal documents establishing an agency's policies which alter agency programs; (2) adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative uses of federal resources, and upon which future agency actions will be based; (3) adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources; and (4) adoption of specific projects, such as construction or management activities located in a defined geographic area. This PEIS evaluates the adoption of a formal guidance upon which future DOE actions will be based (item 2 above).

The Council on Environmental Quality (40 CFR, part 1508.25(a)(1)(I-iii)) defines "connected actions" as those which:

- *"automatically trigger other actions which may require environmental impact statements."*
- *"cannot or will not proceed unless other actions are taken previously or simultaneously."*
- *"are interdependent parts of a larger action and depend on the larger action for their justification."*

This PEIS focuses on the selection of a strategy for the long-term management of depleted UF_6. The action of selecting a management strategy for depleted UF_6 does not automatically trigger (that is, guarantee the selection of) any particular strategy, such as a specific use or disposal.

Similarly, although the selection of some particular approach for the long-term management of depleted UF_6 (including use or disposal) will be based partially on the results of this PEIS, that selected management strategy and its specific implementation do not rely on some other, previous action. Finally, the selection of a particular strategy for long-term management and the implementation of that strategy are not parts of a larger action. Thus, the action in this PEIS and the action of implementing a specific long-term management strategy for depleted UF_6 are not connected actions.

The Council on Environmental Quality (40 CFR, part 1508.25(a)(2)) defines "cumulative actions" as "actions which, when viewed with other proposed actions, have cumulatively significant impacts and should therefore be discussed in the same environmental impact statement." As noted above, this PEIS focuses on the selection of a strategy for the long-term management of depleted UF_6. As such, it estimates the potential environmental impacts associated with each alternative strategy. Following selection of a management strategy, a decision will be made to implement that strategy at a particular location. That implementation, rather than a cumulative action when associated with the selection of a management strategy, is a more specific action which will follow the decision on a depleted UF_6 management strategy supported by the present PEIS.

Based on the considerations given above, cumulative impacts were evaluated only for components of the alternatives for which the locations of the proposed actions were already known. These components were continued cylinder storage and cylinder preparation for shipment, which were individually evaluated for each of the three current storage sites. The cumulative impacts of these components are described in Section 5.8 of the PEIS.

Comment 2

Page S-42; Sect. S.4.13; Sent.1: Text states: "All depleted UF_6 management alternatives would result in environmental impacts that, even when combined with other activities that could occur at the three current storage sites, would be expected to be relatively minor." This statement does not adequately address cumulative impacts from all alternatives considered in this Draft PEIS. This statement conflicts with the statement on page 4-27 that states: "The cumulative impact analysis was conducted by examining those impacts resulting from depleted UF_6 management activities that would occur at the three current storage sites (Paducah, Portsmouth, and K-25). The impacts from these activities- including continued cylinder storage and cylinder preparation- were then added to the impacts of other past, present, and reasonable foreseeable future actions at these sites to assess potential cumulative UF_6 impacts." What past, present, and reasonable foreseeable future actions at these sites (specifically) were assessed, and where is the methodology discussing such assessment?

Response 2

The methods used to estimate cumulative impacts, the issue areas examined, and the results of the cumulative impact analyses are presented in Sections 5.8 and 6.3.8 of the PEIS. For all three current storage sites for depleted UF_6, the impacts of past and existing operations were determined

using data from Annual Site Environmental Reports, assorted sources on environmental restoration activities, and pertinent recent NEPA documents — with both the activities causing impacts and the sources of information cited in Tables 5.12 (Paducah site), 5.13 (Portsmouth site), and 5.14 (K-25 site). The impacts of continued cylinder storage and cylinder preparation options were obtained from PEIS analyses (see Appendices D and E). Reasonably foreseeable future actions varied among sites and are listed under footnote "a" for each of Tables 5.12, 5.13, and 5.14.

The text referenced from Section 4.3.13 in the comment has been changed to clarify that the site locations are only currently known for continued cylinder storage and cylinder preparation components of the alternative management strategies. Section S.4.13 in the PEIS has also been changed to make it clearer.

Further cumulative impacts analyses would be performed as required by NEPA and DOE regulations for any technology or siting proposals. The results of the analyses would be presented in the site-specific documents.

Comment 3

Page 3-12; Sect. 3.3.6.3; Sent.1: Text states: "No wetlands were identified on the Paducah site by the National Wetlands Inventory (ANL 1991a)." This may be a true statement; however, jurisdictional wetlands were delineated by a wetlands survey performed in 1995 and confirmed by the U.S. Army Corps of Engineers in 1996 in some of the drainage ditches on the Paducah site. So the text stated above may be true, but it is inaccurate as far as the current wetland scenario on the Paducah site. Is it possible old information has been quoted?

Response 3

The text of Section 3.1.6.3 has been changed to reflect the jurisdictional status of the drainage ditches. The appropriate references have been added to the PEIS reference list.

Comment 4

General: Cumulative impacts are not analyzed thoroughly throughout this document. The storage and management scenarios are well known and scoped; however, the unknowns (siting, design, and construction) are described in enough detail (with enough siting criteria described) to narrow the likely locations at which of these facilities possibly will be sited and constructed to be evaluated for cumulative impacts in this document. These "Phase II actions" appear to be "connected actions" and should be analyzed in this PEIS. Phase II is described as "implementation of the strategy selected." (Page S-5, 1st paragraph, 1st sentence). It would be difficult to implement efficiently a strategy of this magnitude that has "connected actions" that are not fully described, planned, and evaluated in this document.

Response 4

Cumulative impacts are analyzed as thoroughly as possible in this PEIS, which is programmatic in focus and designed solely to support the selection of a strategy for the long-term management of depleted UF_6. The only activities associated with the management alternatives considered in this document which have certain known locations are continued storage and cylinder preparation for transportation, which would occur at the three current storage sites; these activities are considered in the calculation of cumulative impacts. The locations of long-term storage, conversion, and disposal activities, in contrast, ultimately could occur at many locations, both government-owned and privately-owned, several of which could not even be speculated on at the time of PEIS preparation given the absence of key information. The PEIS evaluates the cumulative impacts of those activities for which adequate site-specific information is available to support their analysis. Out of necessity, for the purpose of evaluating cumulative impacts the PEIS defers the analysis of activities where locations are unknown — although it estimates their impacts at representative locations to enable a complete assessment of all proposed depleted UF_6 management alternatives (see Sections 2.1 and 2.2 of the PEIS).

The methods, assumptions, and results of examining cumulative impacts appear in Section 5.8 of the PEIS. The use of a two-phased approach to NEPA evaluation is consistent with the Depleted UF_6 Management Program, which also involves two phases (see Section 1.4 of the PEIS). It also is consistent with a "tiered" approach to NEPA analysis, where more general or programmatic issues are evaluated in support of general decisions, and more specific issues are evaluated subsequently once the general choices have been implemented. In the present context, a depleted UF_6 management strategy will be chosen to provide both a sense of direction for the DOE program and a basis for coordination of future decisions related to the future of depleted uranium at the three sites.

Although Phases I and II are related to one another, they are not "connected." The Council on Environmental Quality (40 CFR, part 1508.25(a)(1)(I-iii)) defines "connected actions" as those which:

- *"automatically trigger other actions which may require environmental impact statements."*
- *"cannot or will not proceed unless other actions are taken previously or simultaneously."*
- *"are interdependent parts of a larger action and depend on the larger action for their justification."*

This PEIS focuses on the selection of a strategy for the long-term management of depleted UF_6. The action of selecting a management strategy for depleted UF_6 does not automatically trigger (that is, guarantee the selection of) any particular strategy, such as a specific use or disposal. Similarly, although the selection of some particular approach for the long-term management of depleted UF_6 (including use or disposal) will be based partially on the results of this PEIS, that selected management strategy and its specific implementation do not rely on some other,

previous action. Finally, the selection of a particular strategy for long-term management and the implementation of that strategy are not parts of a larger action. Thus, the action in this PEIS and the action of implementing a specific long-term management strategy for depleted UF_6 are not connected actions.

Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site- and technology-specific evaluations will be performed, including the effects of site-specific projects and a range of alternative actions, including a "no action" alternative. These subsequent evaluations will include a more complete assessment of cumulative impacts, which will be possible at that time by virtue of the assessment of specific sites.

Comment 5

Pages 5-2, 5-18, 5-55, 5-66, 5-78, and 5-94: No cumulative impacts discussions were included for each of these alternative discussions even though Figure 4.1 on page 4-7 shows "Areas of Potential Impact Evaluated in the PEIS for Each Alternative." The "Cumulative Impacts" box appears in the center at the bottom of this figure.

Response 5

The PEIS text cited in the comment accurately states that cumulative impacts were not assessed for those activities whose locations were not known. Cumulative impacts were assessed only for activities (continued storage and cylinder preparation for transportation) certain to occur at the three current storage sites for depleted UF_6 (see Section 5.8 of the PEIS). Figure 4.1, on page 4-7, has been modified to convey more accurately the areas of potential impact examined in the PEIS by noting that certain issues were not evaluated for activities with unknown locations.

Comment 6

Page 5-104, Sect. 5.8, Sent. 4: Text states: "No non-DOE actions have been identified that would have potential cumulative impacts at the three sites." How was this conclusion reached? What "non-DOE" entities were contacted and what past, present, and reasonably foreseeable actions were analyzed that considered these "non-DOE" entities' actions? Were local governments, municipalities, regional planning agencies, federal agencies, state agencies, local industries, and other non-DOE entities directly communicated with in this PEIS? Are they referenced in this document?

Response 6

The issue of ongoing and reasonably foreseeable actions of other, non-DOE agencies has been reexamined. This reexamination yielded four non-DOE activities to consider under cumulative impacts. Three of these are associated with the Paducah site: continued operation of the Tennessee Valley Authority's Shawnee Power Plant, slightly north of the site; continued operation of the Joppa Power Plant, northwest of the site; and continued operation of the Allied Signal, Inc. UF_6 conversion facility, northeast of the site. The fourth non-DOE activity involves the K-25 site, parts

of which DOE is leasing out for use by multiple private industries. Impacts of all of these activities have been added, as appropriate, to the cumulative impacts at the sites, as discussed in Section 5.8 of the PEIS and noted in Tables 5.12 and 5.14.

With regard to methods used to identify cumulative impacts, a two-step approach was employed to discover both DOE and non-DOE actions that could contribute to the impacts at the three depleted UF_6 storage sites. The first step was to contact management staff at each site specifically to ask about any other activities in the area that might affect the site. Because management staff is very familiar with the area surrounding their respective facilities, this inquiry served to identify issues requiring further examination. The second step was to contact, as appropriate, organizations knowledgeable about the activities identified in the first step, largely to locate documents that might contain pertinent information about other impacts to consider. Those documents are referenced in the PEIS (see Tables 5.12, 5.13, and 5.14).

The two-step process described above augmented the public participation process associated with the preparation of the PEIS, most notably public scoping. This part of the NEPA process involved the notification of local, state, and government officials, local businesses, industries, environmental groups, interest groups, tribal organizations, the media, and interested individuals about the PEIS and the action being investigated, inviting their input on the document through a variety of mechanisms. Experience has shown that due to the broad focus of public scoping within the NEPA process, and the broad audience targeted, pertinent other activities that might affect the action being considered tend to be identified during the scoping period.

Comment 7

Appendix E; Page E-72; Sect. E.3.12; Bullet 2; Appendix J; Page J-39; Sect. J.3.8; Para. 1; Last sent.: Text states: "The impacts would be negligible." What methodology and analysis deem these impacts to be "negligible?" Where is a cumulative impacts analysis performed to make this decision?

No cumulative impacts analysis were seen for these determinations. These actions should be analyzed in this document, not in "connected actions" via a later NEPA document.

Response 7

The text of the PEIS was modified to more accurately describe impact areas considered but not analyzed in detail. The text in Section E.3.12 was modified by deleting reference to threatened and endangered species and wetlands — these impact areas were in fact evaluated in detail in Appendix E of the PEIS. In addition, the statement that "impacts would be negligible" has been deleted; the second bullet in Section E.3.12 now reads "Impacts to the visual environment, recreational resources, and noise levels would be expected to stay the same as they are because cylinder preparation activities would be similar to the cylinder management activities currently ongoing at the three sites." No cumulative impact analyses were conducted for impacts to ecological

and cultural resources, visual environment, recreational resources, and noise levels, because impacts from both continued cylinder storage and cylinder preparation would be expected to be the same as impacts in these areas from ongoing cylinder management activities (i.e., not add to current impacts) ; thus, these were not considered to be major cumulative impact issues.

Comment 8

Appendix F; Page F-72; Sect. F.3.10; Para. 1; Last sent.; Appendix G, H, I, J; Page G-63; H-34; I-72; J-39; Sect. G.3.10, H.3.10, I.3.10, J.3.8; Para 1; Last Sentence: Text states: "These impacts, although considered, were not analyzed in detail for one or more of the following reasons . . ." How can the "impacts would be negligible" be an accurate statement if the impacts were not analyzed in detail? Were these impacts analyzed for cumulative impacts? If so, where? How is the public going to connect effectively these actions back to this PEIS when the identification and technology analyses for siting, design, and construction are going to be performed in distinctly separate NEPA documents that will be generated at some undefined future dates? Also consider the rationale for the 1st and 2nd bullets.

Response 8

The PEIS is intended to provide an analysis of the potential environmental impacts of broad, programmatic strategies. The Record of Decision for the PEIS will announce the selection of a management strategy, after which DOE will evaluate potential facility sites and specific technologies. The sections referred to by the commentor address inherently site-specific areas of impact (e.g., cultural resources, environmental justice, visual environment, recreational resources, and noise levels) for conversion (Appendix F), long-term storage (Appendix G), manufacture and use (Appendix H), disposal (Appendix I), and transportation (Appendix J) options. For these options, the potential impacts were evaluated in the PEIS for representative or generic environmental settings (see Sections 3.4 and 4.2) because their future locations are currently unknown. The areas of impact listed were not evaluated in detail in the PEIS for these options because (1) they could not be meaningfully determined at a programmatic level without consideration of specific sites and (2) consideration of these impacts were not expected to differentiate between broad programmatic strategies. The phrase "the impacts would be negligible" has been deleted from each of the referenced sections. Site-specific areas of impact would be addressed after the overall management strategy has been selected, as documented in the Record of Decision for this PEIS.

Comment 9

How were the magnitude and significance of cumulative effects determined for the proposed action? What methodology was used to make this determination? Will it be included in an appendix for public review and or comments? What other methods were used to analyze cumulative effects?

Response 9

The methods used to assess cumulative impacts, including determining their magnitude and significance, are described in Section 5.8 of the PEIS and thus are available for public review and comment. Cumulative impacts were assessed only for continued cylinder storage and cylinder preparation for shipment, those activities which will occur at known locations (the three current depleted UF_6 storage sites). Both of these activities are components of all alternative depleted UF_6 management strategies except the No Action Alternative, which includes no cylinder preparation; thus they both are components of the proposed action. The cumulative impacts of conversion, long-term storage, and disposal activities could not be estimated in the PEIS because specific sites and technologies have not been designated for these components of alternative depleted UF_6 management strategies. As a result, the cumulative impacts of all activities in the proposed action could not be estimated in this PEIS. The calculation of cumulative impacts for all activities composing the management strategy ultimately selected will occur, as required, once that selection takes place and specific sites and technologies are identified.

Comment 10

Do the cumulative effects of any of the alternatives and the proposed plan exceed the carrying capacity of any resources, ecosystems, or human communities?

Response 10

Assessment of the cumulative effects for the site-specific portions of the management strategies did not identify any impacts which would threaten the carrying capacity of the environment at the three storage sites. The management strategies would result in only small incremental impacts to past, present and future impacts at the three current storage sites.

Comment 11

Throughout the PEIS, at the Paducah site, Bayou Creek is referenced as "Big Bayou Creek." This is in error, as the 1978 topographic map for Heath, KY shows the creek as Bayou Creek, not Big Bayou Creek.

Response 11

Although the Heath, KY topographic map (1978) identifies the creek as Bayou Creek, site documents for Paducah (e.g., the Annual Site Environmental Report for 1993 — Martin Marietta Energy Systems, Inc., 1994, Figure 4.1) identify the creek as Big Bayou Creek. In order to maintain consistency with this and other site documents for Paducah, the creek will continue to be referred to as Big Bayou Creek.

Comment 12

Is there any correlation between this PEIS and the "Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent

Nuclear Fuel," DOE/EIS-0251, Nov., 1996, specifically with concern to interim consolidated storage of spent nuclear material at some location such as Yucca Mountain or another site?

Response 12

The PEIS and the "Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel," (DOE/EIS-0251) are potentially indirectly related. The Record of Decision on the Navy container system EIS, published in December 1996, specifies that the Navy will use a dual-purpose canister system for the dry storage, transportation, and possibly disposal of naval spent nuclear fuel. It is possible that depleted uranium could be considered as a shielding material for such a dual-purpose canister system, similar to the representative shielding options considered in the use as oxide and use as metal alternatives in the PEIS.

Comment 13

The preferred alternative is not one of the alternatives described and compared in the body of this PEIS but is a combination of alternatives 4 and 5. Why wasn't there another alternative (say #7) that described and compared the use of the entire UF_6 inventory as the preferred alternative? It seems a little difficult to the reader to see that the preferred alternative isn't one of the described and compared alternatives in the body of the PEIS. In combining alternatives 4 and 5, were additive, countervailing, and synergistic effects evaluated? If so, where is this covered in the PEIS?

Response 13

The preferred alternative is described in Section 2.5.1 and in Section 5.7 of the PEIS. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. The discussion of the preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. Thus, the impacts of the preferred alternative may be the same as those presented for the use as oxide alternative (alternative 4) or the use as metal alternative (alternative 5), and may also include impacts from the storage of uranium oxide (see Sections 2.5 and 5.7 of the PEIS). The preferred alternative was not described as a distinct, separate alternative because it will, in practice, combine elements from several of the six alternatives evaluated.

The methods used to combine impacts for the preferred alternative are described in Section 5.7 and Appendix K, Section K.7. Impacts were combined according to the nature of the impact, assuming that facilities for conversion, storage, and manufacturing would be located at separate sites. (The assumption that facilities were located at separate sites was a fundamental

assumption in the PEIS and was intended to provide conservative estimates of impact for two reasons: (1) transportation would be required between facilities and (2) independent facilities would generally require greater amounts of land and resources compared to combined or co-located facilities.) Certain impacts, such as radiological impacts to workers and members of the public, were assumed to be additive. Other impacts, such as the maximum consequences of accidents, are not additive and depend only on the presence of specific facilities. Potential impacts to ecological, water, and air resources are location-specific and were thus discussed separately for each facility required (because facilities were assumed to be located at separate sites). Synergistic or countervailing effects would be unlikely when conversion, storage, and manufacturing are assumed to occur at separate sites. If, however, more than one of the three facilities were to operate at a single site, the occurrence of synergistic or countervailing effects would depend on the site layout and specific site characteristics. Because siting proposals will not be developed until after the Record of Decision, potential site characteristics are highly speculative and uncertain. Thus, the analysis of combined effects of multiple facility operations were considered to be additive.

Comment 14

Pages 5-109, 5-111, 5-113; Tables 5.12, 5.13, and 5.14: Tables are titled "Maximum Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Action at the . . ." The reader does not agree that these tables should be titled "Maximum Cumulative Impacts . . ." because cumulative impacts have not been analyzed in detail and appear to be based on a limited cumulative impacts methodology and evaluation. In addition, the "Impact Categories" are incomplete and do not include other potential impact areas.

Response 14

Cumulative impacts were assessed for those activities certain to occur at known locations, namely the three current depleted UF_6 storage sites. As discussed in Section 5.8, cumulative impacts included continued cylinder storage for some period for all alternatives, and cylinder preparation for shipment for all alternatives except the No Action Alternative. Where possible, the analyses were conservative, that is, they tended to overestimate cumulative impacts. For example, other existing or planned actions at each site were assumed to occur during the period of depleted UF_6 cylinder management operations, and to be collocated with cylinder management facilities to the extent that they affect the same off-site population and maximally exposed individual. Also, some of the impacts estimated for existing operations also are associated with the cylinder management activities assessed under Continued Storage in the PEIS; no adjustment was made for this overlap. In this sense, the cumulative impacts presented in Tables 5.12, 5.13, and 5.14 were maximum impacts, accounting for their "Maximum Cumulative Impacts ..." titles. However, because certain other activities whose locations presently are unknown ultimately may occur at the current storage sites once siting decisions are made, it is possible that cumulative impacts ultimately could be greater than presently estimated. To account for this possibility, the word "maximum" has been deleted from the titles of these three tables and from related text locations.

The cumulative impacts estimated in the PEIS cover a thorough list of key issues under continued storage and cylinder preparation. The issues included in the cumulative impact analysis are those affecting the Paducah, Portsmouth, and K-25 sites felt most likely to contribute to the selection of a long-term strategy for the management of depleted UF_6. Other potential site-specific issues contributing to cumulative impacts may be addressed in the future once locations and technologies are proposed for the depleted UF_6 management strategy selected in the Record of Decision for this PEIS.

Comment 15

Has this action been correlated with the Vortec Vitrification proposed action for the Paducah Site?

Response 15

The DOE Paducah Site is proposing to apply the Vortec Cyclone Melting System technology to vitrify hazardous wastes, such as soils and sludges. This proposal has been added to the cumulative impacts analysis in the PEIS in Section 5.8.2.1.

Commentor No. 16: Anonymous
Paducah Cylinder Handler

Comment 1

Use cylinder drop test results, crash tests and make it public to reassure the public. Put it in the PEIS. Do PR and capitalize on it. We've dropped full cylinders at Paducah from the P&H crane. Use data to show nothing bad will happen.

Response 1

The cylinders, as manufactured, qualify as Department of Transportation, Type A containers which means they have complied with all design criteria and testing for Type A packages, which includes a drop test. This qualification does not originate from the Department of Energy but from other agencies and standards committees.

In the past the Department and its operating and managing contractors performed drop tests when designing cylinder packages. The results of these drop tests, along with other data from the cylinder management program, were used to develop the release quantities for accident scenarios involving cylinder drops or spills (these amounts are given in the Facility Accident sections of the appendices addressing handling of UF_6 — Appendices D, E, F, and G). Discussion of the development of these release quantities is provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS).

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 2

Put on second skin for breaches-send to Paducah and feed out.

Response 2

The commentor's preference for placement of breached cylinders in overcontainers for transfer to the Paducah Gaseous Diffusion Plant to be emptied is noted.

Commentor No. 17: Robison, William A.
U.S. Fish & Wildlife Service

Comment 1

We have no comments at this time, but will remain involved in the public scoping process.

Response 1

Comment noted.

Commentor No. 18: Janaskie, Mark

Comment 1

Is there any consideration by DOE to measure the corrosion rate, and if it turns out that the corrosion rate is slow or benign, is there a chance that DOE will do no coating and simply wait until the date for beginning conversions (2006+)? If the corrosion rate is slow, could DOE consider the risk to cylinders low, and thus simply wait until conversion begins. Is this one of DOE's current options?

Response 1

External corrosion studies on the surface of the cylinders have been ongoing for several years. The rate of corrosion has been estimated from ultrasonic thickness testing data and modeled across the cylinder population. The cylinders that are believed to be the cylinders experiencing the greatest loss of wall thickness are being recoated first. This activity has already begun and will continue until the corrosion has been arrested with 1200 cylinders being recoated in 1997 and 1000 scheduled for 1998. DOE is committed to maintaining safe storage of the cylinders and the recoating program is an integral part of that commitment.

Commentor No. 19: Parrott, Robert C.

Comment 1

1) What does DOE plan to do with the cylinders after conversion occurs? Disposal as waste or decon and sale as scrap or re-use?

Response 1

As stated in section F.2 of the PEIS, it was assumed in the PEIS that the cylinders after conversion would be washed with water to remove any residual uranium, and that the treated cylinders with a very low residual radiation level would become part of the Department of Energy scrap metal inventory. Options for the final disposition of the empty cylinders are discussed in the document titled "Analysis of Options for Disposition of Empty Depleted UF_6 Cylinders," authored by Nieves et al. (1997).

The above-cited report by Nieves et al. analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 2

2) Does DOE have a credible technology to convert the DUF_6? Is it realistic that DOE can convert the material by 2028?

Response 2

Technologies currently exist to convert UF_6 into uranium oxides such as U_3O_8 and UO_2. One example is the defluorination process outlined in Section F.2.1 of the PEIS, in which UF_6 is reacted to form U_3O_8 and HF, which is currently practiced by COGEMA in France to convert their UF_6 into U_3O_8. Another example is the batch metallothermic reduction outlined in Section F.2.3 of the PEIS in which UF_6 is reacted with both hydrogen and magnesium metal to produce uranium metal; this process has been used in large-scale applications since the 1950s.

The time period for UF_6 conversion assumes 10 years for siting, design, and construction of any required new facilities, and 20 years for operations. These assumptions are based on experience with similar facilities in the past and are considered to be reasonable for the purposes of analyses in the PEIS; they do not represent a definitive schedule. With the additional consideration of up to 15,000 USEC-generated cylinders in the Final PEIS, the estimated period for

operations has been extended to 26 years. Therefore, for the purposes of analysis, it is assumed that conversion would continue through the year 2034. However, it can be done sooner depending on the number of conversion facilities constructed, the technology chosen for conversion, and the size of the conversion facility or facilities.

Comment 3

3) The current painting program seems inadequate to control corrosion. Does DOE plan to increase the rate of coating?

Response 3

DOE continues to evaluate the effects of external corrosion as well as the performance of the coating applied to cylinders during the current painting program. Any increase in rate will be determined by technical evaluation as more data are gathered.

Comment 4

4) How will DOE decide whether to transport cylinders in overpacks or transfer the contents to new cylinders?

Response 4

The decision as to whether cylinders would be transported in overpacks or the contents transferred to new cylinders would depend on a number of future considerations. The Record of Decision for the PEIS will specify a management strategy for the depleted UF_6 inventory. After the Record of Decision, additional planning and environmental analyses would be conducted as appropriate to select specific technologies and sites to implement the management strategy. If a site or sites were selected that required transportation of cylinders from the current storage locations, DOE would consider (1) the number of cylinders requiring transportation, (2) the number of cylinders that were in substandard condition, (3) whether the cylinders were being transported for purposes of storage or conversion, (4) the costs and impacts associated with the use of overpacks or cylinder transfer, and (5) regulatory and other considerations.

Commentor No. 20: Radcliffe, Donald W.
Nuclear Fuel Consultant

Comment 1

The cost of enrichment services is much lower and thus the viability of refeeding the DUF_6 at higher assays is much improved at some locations outside the U.S. The PEIS should address the issues of overseas shipping and disposal.

Response 1

As noted in Section 2.3.2 (Use) of the PEIS, the quantity of depleted UF_6 that would still require management after reenrichment would be essentially the same as it is now. Thus, options for the management of the depleted uranium remaining after reenrichment would still require resolution. The advantage of reenrichment is that it would conserve natural uranium resources. The long-term storage alternatives analyzed in the PEIS would preserve the option for future development of a more efficient enrichment technology.

Overseas disposal of UF_6 does not appear to be an option. Disposal of UF_6 is currently not practiced, due to its reactive form. Conversion of UF_6 into a less reactive chemical form (such as UO_2 or U_3O_8) would be required for disposal purposes.

Commentor No. 21: Taylor, Willie R.
U.S. Department of the Interior

Comment 1

The Paducah site's proximity to the Reelfoot Rift and the New Madrid fault zones would seem to indicate that an earthquake caused accident could be considerably greater at Paducah than at either the Portsmouth site or the Oak Ridge site. This area has experienced seismic activity within the last two to three months. This should be factored into the analysis.

Response 1

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Of the three storage sites, an earthquake which could cause more than slight damage is considered credible (though highly unlikely) only for the Paducah site.

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports (SARs) for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs were issued in February 1997 by the DOE's management and operating contractor, and were subsequently reviewed and approved by DOE in March 1997.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 2

S.1.3 Under Proposed action-Contaminants leaking into groundwater may not be detected for several hundred years. The rate of movement of contaminants in groundwater is variable. Because of the long period of time during which the radiation would still be potentially harmful, monitoring of ground-water contamination should continue as long as a risk exists and should cover a large enough area to capture the full geographic extent of possible contamination. The McNairy-Nacatoch aquifer is a very important source of drinking and domestic water for a number of towns in Missouri and Arkansas. Monitoring should be extensive enough to capture any incidence of contamination in these important water sources following a contamination event.

Response 2

In the event of a failure that produced groundwater contamination, it would be critical to monitor groundwater in locations as close to the source as possible in order to provide timely information for remediation. As discussed in the PEIS, groundwater is measured at the Paducah site (the nearest site that would affect groundwater aquifers in Missouri and Arkansas)in more than 200 monitoring wells, residential wells, and Tennessee Valley Authority wells (Section 3.1.5.2). It is very likely that any contamination from a failure would be detected by this monitoring well network. Monitoring would continue as long as necessary.

In addition, the direction of groundwater flow in the vicinity of the Paducah site is toward nearby surface waters such as Big Bayou Creek, Little Bayou Creek, and the Ohio River. Because shallow groundwater from beneath the Paducah site discharges to these surface waters, it is very unlikely that contamination would affect groundwater quality in the McNairy-Nacatoch aquifer in Missouri and Arkansas on the opposite side of the Ohio and Mississippi Rivers.

PEIS analyses for the no-action alternative and disposal alternative included long-term impacts from potential groundwater contamination. Text indicating that these analyses were conducted has been added to Section S.1.3 as well as to Sections 1.3 and 4.1

Comment 3

S.4.5- It is important to note that the Paducah site should be considered a "wet site." A disposal facility failure in this wet environment would impact the ground-water system with uranium concentrations in groundwater greater than 20 mg/L within 1,000 years after the failure.

Response 3

As discussed in the PEIS (Sections 2.4.5, 5.6.4.2.2, and Appendix I, Section I.4.2) and Tomasko (1997; the full citation is provided in Appendix I of the PEIS), uranium concentrations in groundwater would exceed the proposed guideline of 20 µg/L within 1,000 years after a failure of a disposal facility in a wet environment. (Note: The guideline used is 20 µg/L, not 20 mg/L as stated by the commentor). As noted by the commentor, the Paducah site can be considered as "wet," and a disposal facility failure in this area would produce uranium concentrations in groundwater

that would exceed the proposed guideline. It should be noted; however, that the disposal analysis was based on characteristics of generic wet and dry sites. Specific sites (including the Paducah site) were not considered for the disposal options.

Comment 4

The Paducah site is also vulnerable to changes in the biological and chemical composition of surface water caused by ground-water discharges into surface water streams. If contamination from such a discharge were to occur, it could affect the ecological stability of the surface water environment.

Response 4

For continued storage at Paducah (Appendix D, Sections D.2.4.1 and D.2.4.2), two scenarios were evaluated: direct discharge to surface water, and direct discharge to groundwater. As noted in the comment, no discussion was provided on the effects of contaminated groundwater discharging to surface water. This potential pathway was omitted because direct discharge of runoff from the yards to surface water bounds the calculation for surface water quality at the site. That is, direct discharge of contaminated runoff water to Little Bayou Creek would produce much higher concentrations in the creek than discharge from groundwater because of higher initial concentrations in the runoff water and greater dilution for the groundwater flux.

Comment 5

There is not sufficient information presented in the PEIS to permit an analysis or assessment of the validity of the models; therefore, we cannot confirm that the worst-case accident or other scenarios are reasonable assumptions.

Response 5

The assessment methods used in the PEIS are described in Chapter 4 and in Appendix C for each technical discipline. Additional information, including detailed assessment results, is provided in a series of backup reports that are cited throughout the PEIS. Specifically, supporting information for the various technical disciplines are presented in: Cheng et al. (1997) for the assessment of human health impacts during normal operations; Policastro et al. (1997) for the assessment of accident impacts; Tschanz (1997) for the assessment of air impacts; Tomasko (1997a, 1997b) for the assessment of water impacts; Biwer et al. (1997) for the assessment of transportation impacts; and Allison (1997) for the assessment of socioeconomic impacts. (See PEIS Appendix C for complete citations.) The intent of this presentation was to provide sufficient information in the PEIS to establish the applicability of the methods and assumptions, with detailed information provided in the supporting reports. The supporting reports are available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 6

Most of the strategies for disposing of the inventory or uranium would require construction of processing plants to convert UF_6 to other chemical forms, however, locations of these plants are not identified. The use of generic data for the proposed plant seems to be a weak link in the analysis because of the uncertainty about site location and lack of specific data. Therefore, we cannot confirm the validity of the potential environmental impacts that might be caused by this conversion process.

Response 6

The purpose of the PEIS is to provide an analysis of broad, programmatic alternatives. Consequently, the impacts of some management activities were evaluated using generic or representative environmental settings (see Section 4.2.3 of the PEIS). The characteristics of these settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the alternatives. In many cases, a range of environmental conditions, such as different population densities, precipitation rates, and soil characteristics, were considered in the assessment of impacts in order to address uncertainties related to future site locations. After the Record of Decision for the PEIS, potential facility locations would be evaluated and appropriate site-specific analyses would be conducted for any facilities required to implement the selected management strategy.

Comment 7

The units for measuring contaminant concentrations are reported differently in different parts of the document (e.g., mg/g, µg/mg, etc.) The same is true of hydraulic conductivity (cm/s, ft/d). Consistent unit of measure should be used throughout the PEIS.

Response 7

In general, a consistent unit convention is used in the PEIS, with English units presented first, followed in most cases by metric equivalents. However, in cases where the results of actual measurements were taken from a published source and used in the PEIS, the original units of measure were reported. This practice results in an apparent inconsistency between some sections of the PEIS. The PEIS was reviewed with respect to this comment and units were changed, as appropriate, to make them as consistent as possible throughout the document.

Comment 8

On page 3-28, the assertion that the high thallium concentrations may be caused by a problem in the laboratory analysis should be confirmed or denied, and explained if levels are confirmed to be as high as suggested.

Response 8

Although it was suspected that the high thallium concentrations were due to an analytical laboratory problem, this could not be definitively confirmed or denied. Text has been added to Section 3.2.5.1 indicating that subsequent sampling has not shown similar high levels of thallium.

Commentor No. 22: Zahn, Kenneth C.
Lawrence Livermore National Laboratory

Comment 1

Lawrence Livermore National Laboratory has no substantive comments to make on the content of the December 1997 Draft Programmatic Environmental Impact Statement (PEIS) for Alternative Strategies for the long-term Management and use of Depleted Uranium Hexafluoride. We wish to receive a copy of the Final PEIS when available.

Response 1

Comment noted.

Commentor No. 23: Arnold, William M.
ESP Eco-Pak Specialty Packaging, Division of CBC

Comment 1

It was a pleasure to meet you last night, at the DOE public meeting in Oak Ridge. Heather and I both feel that the preferred program to convert the stockpiled UF_6 to uranium oxide and uranium metal for future use is the most worthwhile alternative.

Eco Pak Speciality is very interested in assisting in the transport of this material to the future conversion facilities. I am enclosing a brochure on both Eco Pak Speciality Packaging (ESP) and our parent company, The Columbiana Boiler Company (CBC). I hope some of this information helps in the decision making process for this project.

Response 1

Comment noted.

Commentor No. 24: Fahey, Dan
Swords to Plowshares

Comment 1

Enclosed is a copy of the Depleted Uranium Case Narrative about the health and environmental consequences of depleted uranium munitions. I hope that you will carefully review the information presented here as part of your effort to determine the fate of uranium hexafluoride stockpiles.

Depleted uranium should be stored in safe containers away from humans, water, supplies, and the food chain. The use of depleted uranium in ammunition is an unwise use for chemically toxic and radioactive waste

Response 1

The Depleted Uranium Case Narrative was reviewed by preparers of the PEIS. As stated in Appendix H of the PEIS, the use options evaluated in the PEIS were intended to be representative only, and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses is considered beyond the scope of the PEIS. The impacts associated with specific uses will depend on what use or uses are ultimately identified, and would be considered and evaluated in more detail in future planning and environmental analyses. For instance, any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained. The impact analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions. As with the use of any radioactive material, careful consideration would be given to whether the benefits of the proposed use outweigh the potential risks.

Commentor No. 25: Quapp, William, P.E.
Starmet Corporation

Comment 1

Good afternoon, my name is William Quapp, from Starmet Corporation. I have been actively involved in evaluating the management issues associated with depleted uranium hexafluoride since May 1993. At that time and until June 1996, I was employed at the Idaho National Engineering Laboratory. My investigations were performed for DOE Environmental Management Program (EM50). Over these three years, we identified various management options and costs of their deployment. One of the major things we learned is that the management of the

depleted uranium inventory must be considered as a system in context with other DOE materials and waste management responsibilities. While the depleted uranium hexafluoride can be processed and useful fluorine byproducts extracted for the recycle value, the residual uranium material — oxide or metal — must be managed as a radioactive material. The fluorine product value will not pay for the total conversion and byproduct management costs. Consequently, DOE must either plan on disposal of the residual uranium materials or identify products that can consume the material and be manufactured at reasonable costs. Additionally, there must be customers for those products. The alternative to products and customers is to manage the depleted uranium as waste.

Response 1

Comment noted.

Comment 2

The INEL program developed and patented one technology — DUCRETE Shielding: A Depleted Uranium Concrete — which has been considered in the DOE PEIS as a potential use for depleted uranium. However, as will be pointed out later, because of the radioactive nature of depleted uranium, certain policies with respect to eventual disposal must be put in place to remove obstacles and encourage the use of depleted uranium in products.

Response 2

The commentor's observation is noted.

Comment 3

Disposal As Waste: The INEL studies addressed this issue in a parametric sense using published costs of conversion of UF_6 to oxide and the then current cost of disposal at the Nevada Test Site and Hanford. The studies showed that the potential cost range was somewhere between $3 to $11 billion assuming that either the Nevada Test Site or Hanford could accept the material and dispose of it in shallow land burial. Parameters considered included 1.) disposal as a compacted oxide and as stabilized oxide, 2.) disposal site locations and costs, and 3.) disposal as LLW versus Mixed LLW (RCRA controlled material).

Response 3

Comment noted. The PEIS and cost analysis teams were aware of the studies cited in the comment. In order to provide a consistent basis for comparison of alternatives, the cost analysis team calculated the costs of all options and alternatives, including the costs of disposal using a consistent set of assumptions and models. Cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 4

RECYCLE USES: We evaluated recycle uses with the recognition that the depleted uranium is a radioactive material and must be controlled, used, and ultimately disposed of in appropriate nuclear waste repositories. We did not consider uses that would allow unrestricted use and disposal.

Response 4

As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future, whether restricted or unrestricted. Consequently, discussion of issues related to specific types of use is considered beyond the scope of the PEIS. Any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained. In regard to ultimate fate of the material, the PEIS acknowledges that at the end of their useful lives products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4 and 2.2.5 of the PEIS).

Comment 5

After evaluating numerous concepts (nuclear shielding, flywheels, drill rods, blast shielding, etc.), we concluded nuclear shielding was the only viable use for depleted uranium since it was a controlled nuclear material and will be slightly radioactive forever. Additionally, because of the lower cost of competitive materials, depleted uranium was not an economic alternative for most other applications. Depleted uranium metal makes economic sense when the benefit of its very high density enables a solution that is otherwise not possible with traditional materials (steel, lead, concrete, etc.).

Depleted uranium has been used as metallic shielding in the past for various shipping casks and as shielding for radiation sources. In these applications, depleted uranium was selected because of its higher efficiency for gamma attenuation would allow cask weight limitations and/or size constraints to be met.

We found that one of the biggest impediments to the use of depleted uranium as metal in storage cask shielding applications is the high cost of converting from UF_6, to uranium metal. In a survey performed for DOE by Technics Corporation, the cost was identified to be about $11.70 per kg-U ($5.30 per lb-U) for conversion of UF_6, to metal and casting into a shape. Any forming or machining was additional and was priced at $4.40 to $22 per kg-U. Some cost reductions could be forecast through larger conversion facilities but these would not be expected to be sufficient to dramatically reduce the costs below those cited. Consequently, since casks could be made with

conventional materials at lower total cost, we believed that there was no economic application for depleted uranium metal in storage casks.

This economic reality spawned the invention of DUCRETE Concrete as a potentially economic alternative for using depleted uranium and avoiding the near term investment in disposal. This concept, while not directly cost competitive with conventional concrete, is much cheaper than using depleted uranium metal and has some performance values that can make it economically competitive to traditional materials on a life cycle cost basis. And, by recycling the material, DOE can avoid declaring the material waste.

DUCRETE SPENT FUEL AND HIGH-LEVEL WASTE STORAGE CASKS

1.) DUCRETE Concrete is a technically viable material for spent fuel and high-level waste dry storage casks. Smaller, lighter weight, and more versatile casks can be designed and fabricated. DUCRETE casks can be factory fabricated and shipped to the user facility and reshipped to the interim storage site or the geologic repository as required.

2.) DUCRETE Storage casks can be developed and deployed at DOE sites, commercial utility sites, the DOE Interim Spent Fuel Storage Site, and for shielding in Yucca Mountain. However, there is no industry incentive to independently finance DUCRETE cask demonstrations. Consequently, DOE must support such demonstration.

3.) DUCRETE Casks are competitive with traditional concrete IF DOE pays for conversion of the UF_6 into the depleted uranium aggregate (UF_6 to UO_2, to aggregate). DUCRETE concrete is not a competitive cask material if the cost for conversion from UF_6 to aggregate must be born by the cask fabricator.

4.) DUCRETE Casks will be acceptable to utilities and other users IF DOE agrees to accept them at end of life in a DOE disposal facility such as the NTS or the Spent Fuel Geologic Repository. Without a predefined disposal option, no commercial utility will accept ownership.

5.) DUCRETE concrete is a stable chemical form of material that meets the disposal criteria of the Nevada Test Site as-is. No further processing would be required for disposal.

6.) When used as shielding in casks or other radioactive material containers, DUCRETE concrete is managed by organizations already licensed to hold nuclear materials. Thus, the institutional control required for handling of depleted uranium is in place.

Response 5

As stated in Chapter 2 and Appendix H of the PEIS, the two use options evaluated in the PEIS, use as oxide and use as metal for shielding, were intended to be representative only, and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses is considered beyond the scope of the PEIS. Such issues will depend on what use or uses are ultimately identified,

and would be considered and evaluated in more detail in future planning and environmental analyses.

With respect to cost, cost estimates for the manufacture and use of the two representative shielding options are provided in the cost analysis report (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS. Assuming that the total inventory of depleted UF_6 is to be converted into casks over a 20-year period, the present worth costs of the metal shielding option is approximately $890 million, versus approximately $860 million for DUCRETE shielding. The majority of the costs for both options are operations and maintenance costs, which account for between 87% to 89% of the total shielding cost. These above-cited costs exclude the cost of converting UF_6 into uranium oxide for the DUCRETE option (between $350 to $820 million), and into metal for the metal shielding option (between $490 to $670 million). Thus the contention in the comment that the DUCRETE option is more cost-competitive than the metal shielding option may not be justifiable.

The six points made by the commentor are addressed individually as follows:

1. *Comment noted.*
2. *Comment noted.*
3. *Comment noted.*
4. *Comment noted.*
5. *Comment noted.*
6. *Comment noted.*

Comment 6

TIMELY ACTIONS REQUIRED: Driven by the need for spent fuel storage in the country, many fuel storage actions are underway by both DOE OCRWM and utility organizations. Since a cask demonstration and licensing program could take up to 4 years, if DOE NE is to be successful in its goal to recycle the depleted uranium into nuclear storage products, prompt funding of demonstration cask projects need to be undertaken. If prompt initiation of such programs is not undertaken, the window of opportunity for the deployment of depleted uranium in spent fuel storage casks will have passed. To take advantages of the unique characteristics of DUCRETE cask systems, the cask design must be compatible with other transportation systems being developed. This necessitates early integration of cask design with other parts of the transportation systems.

Response 6

Comment noted.

Comment 7

POLICIES THAT DOE SHOULD ESTABLISH TO ENCOURAGE DEPLETED URANIUM RECYCLING: 1. Any product manufactured from depleted uranium after the PEIS ROD should be accepted at the NTS or other DOE site for disposal, provided that, a) All depleted uranium products submitted to DOE for future disposal be in a chemical and physical which form meets the current Waste Acceptance Criteria at that DOE disposal site, or, b) DOE shall retain title to the depleted uranium material and, at end of product life, DOE will accept the product for disposal at the NTS provided that the depleted uranium product meets the NTS Waste Acceptance Criteria.

Response 7

The commentor's suggestion is noted. Issues such as these will be addressed in any forthcoming project analysis that follows the record of decision for the PEIS.

Comment 8

POLICIES THAT DOE SHOULD ESTABLISH TO ENCOURAGE DEPLETED URANIUM RECYCLING: 1. The Nuclear Waste Policy Act should be modified to allow disposal of depleted uranium casks or other depleted uranium materials in empty drift space between or other locations within the geologic repository. Presently, the Act restricts disposal of all materials other than spent fuel or high level waste.

Response 8

Modification of the Nuclear Waste Policy Act to allow disposal of depleted uranium materials in the geologic repository is not within the scope of the PEIS.

Comment 9

POLICIES THAT DOE SHOULD ESTABLISH TO ENCOURAGE DEPLETED URANIUM RECYCLING: 2. Empty depleted uranium storage casks in sound physical condition should be accepted at the NTS for re-use and at no cost to the owner. DUCRETE spent fuel or high-level waste casks would be very suitable as high integrity containers for the subsequent disposal of various Greater-than-Class C wastes from reactor decommissioning. DOE has responsibility for receiving such future wastes.

Response 9

The commentor's observation is noted.

Comment 10

OTHER DOE ACTIONS THAT WILL FACILITATE THE RECYCLE OF DEPLETED URANIUM: 1. DOE should stimulate the demonstration of low cost UF_6, conversion technologies to lower the cost of management. Low cost processes to convert the UF_6 to metal or to an oxide are needed to reduce the management cost to DOE and to support any recycle objective.

Response 10

The DOE has been conducting such projects since 1996, and will continue to participate with industry in the development of technologies that could contribute to the reduction of management costs, regardless of the strategy chosen.

Comment 11

OTHER DOE ACTIONS THAT WILL FACILITATE THE RECYCLE OF DEPLETED URANIUM: 2. DOE should support the development and licensing of DUCRETE storage casks and mandate their use on DOE storage projects where the total system life cycle cost can be shown to be advantageous to DOE.

Response 11

The commentor's preference for the development, licensing, and use of depleted uranium oxide concrete (DUCRETE) shielded storage casks is noted. The manufacture of DUCRETE shielded spent nuclear fuel and high level waste storage casks was evaluated as a representative depleted uranium use in Appendix H of the PEIS. The PEIS will not be used to select a specific end use for depleted uranium or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks.

Comment 12

OTHER DOE ACTIONS THAT WILL FACILITATE THE RECYCLE OF DEPLETED URANIUM: 3. DOE can consider the provision of DUCRETE storage casks to utilities for interim storage of spent fuel as partial compensation for being unable to receive spent fuel as required by law.

Response 12

The commentor's preference for the use of DUCRETE storage casks for interim storage of spent nuclear fuel is noted.

Comment 13

OTHER DOE ACTIONS THAT WILL FACILITATE THE RECYCLE OF DEPLETED URANIUM: 4. DOE should objectively evaluate the use of DUCRETE shielded storage casks for shielding the spent fuel and high level waste packages in the geologic repository as an alternative to operating the repository as a remote handled facility for the 125 year period during emplacement and post-closure monitoring.

Response 13

Designs and operating policies for a planned geologic repository are beyond the scope of the PEIS. The manufacture of depleted uranium oxide concrete (DUCRETE) shielded spent nuclear

fuel and high level waste storage casks is evaluated as a representative depleted uranium use in Appendix H of the PEIS.

Comment 14

CONCLUSIONS: Fifty years of nuclear activities in the US have left a large inventory of material with both unique and undesirable characteristics. To minimize the future cost of management in an environmentally and economically responsible manner, a system solution is needed to assure that the beneficial attributes of depleted uranium are recognized and used while the negative impacts of being a nuclear material are minimized.

During the studies I managed for the DOE, we defined such a system solution where DUCRETE casks were used for spent fuel storage at reactor sites, at the interim storage facility, and for disposal containers in the geologic repository. That concept still appears to me to be the most environmentally responsible solution achievable at the least cost to the US taxpayers.

Response 14

The commentor's preference for use as oxide in the form of DUCRETE is noted.

Commentor No. 26: Dietz, Leonard A.

Comment 1

Remediation of the depleted uranium (DU) storage problem is an important and urgent task of Herculean proportions. My choice of the six options presented is No. 2: Long-Term Storage as UF_6-storage of UF_6 cylinders in yards, buildings, or a mine at a consolidated site. This choice has the least potential to pollute the environment with more DU. I suggest that each cylinder of DU hexafluoride should be placed in a permanent overcontainer filled with one atmosphere pressure of an inert gas such as argon to retard corrosion by preventing water vapor and oxygen from entering the containers. The overcontainers should be sealed hermetically and designed to last for 100 years or more.

I believe that at this time we as a nation do not possess sufficient wisdom or foresight needed to decide on the final disposition of this enormous stockpile of waste uranium. It would be prudent to wait a few decades more before deciding on a final course of action.

Response 1

The commentor's preference for long-term storage of depleted UF_6 cylinders in hermetically sealed overcontainers and deferral of a decision on the final disposition of depleted UF_6 is noted.

Comment 2

Under no circumstance should DU be allowed in a commercially-manufactured consumer goods or be made available to the general public as has been hinted in a New York Times article by Matthew Wald. He mentions industrial use of DU flywheels to store energy and use as a substitute for lead weights. Elsewhere it has been suggested that DU should be used as ballast in the keels of sailboats. Imagine a long-forgotten sailboat sunk in a storm and unretrieveable, its hulk polluting a deep freshwater lake with uranium that slowly becomes soluble and pollutes the water. I became even more convinced that DU should be banned from commercial use when I saw an advertisement for a new driver golf club that contains a sphere of DU metal in its head so that a golf ball can be driven farther. These suggested commercial uses of DU are irresponsible and reckless, and will be dangerous to public health if they are implemented. The average person knows nothing about the technical aspects of uranium or radioactivity and is totally unprepared to deal with this radioactive and pyrophoric material that is highly toxic both chemically and radiologically. Uranium in any chemical form presents significant dangers to health and safety, if it is not handled with scrupulous care.

Response 2

Any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained from the NRC. The NRC analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions. As with the use of any radioactive material, careful consideration would be given to whether the benefits of the proposed use outweigh the potential risks. Because of the regulatory climate in the United States, it is highly unlikely that products containing depleted uranium would be available for large-scale, unrestricted use at this time. Potential impacts from restricted uses, such as use as shielding in the nuclear industry, would likely be small.

Comment 3

"Design of the DU Processing Plant and its Containment Efficiency": The processing of DU hexafluoride into uranium oxide or uranium metal requires extensive chemical processing, melting and casting operations. The pyrophoric nature of uranium makes it inevitable that significant quantities of uranium oxide aerosol particles will be formed. There does not have to be an accident at a DU processing plant for the public to be exposed to dangerous concentrations of aerosol micrometer particles of uranium oxide. Exposure can occur from DU aerosol particles released into the atmosphere during normal operations. To illustrate this, we assume that a well-designed and super-efficient processing plant can be built that would contain 99.99999% of all the uranium it processes. In such a plant only 1 gram in 10 million grams of DU would escape into the environment. We examine how this relates to the large amount of DU proposed to be processed from the years 2009 through 2028 and then compare it with an actual experience in New York State.

Using the data given on page S-2, Vol I, The depleted UF_6 cylinders managed by DOE plus the cylinders produced by the United States Enrichment Corporation total approximately 54,422. They contain about 600,000 metric tons of DU hexafluoride. Continued operation of the Portsmouth and Paducah diffusion plants could double this amount by the year 2028. Therefore, the DU hexafluoride that must be processed each year for 20 years beginning in 2009 is approximately 60,000 metric tons, of which two thirds is the element uranium. Thus, it appears that up to 40,000 metric tons of DU will be processed per year.

Containment of DU within the processing facility or facilities will be a major problem, even with the very best technology available. For example, if as postulated, 99.99999% of the DU can be contained successfully, then in 40,000 metric tons of DU processed each year, 4,000 grams will escape at an average rate of 333 grams per month.

"The New York State Experience with a DU Processing Plant": The estimated rate of 333 grams of DU escaping into the atmosphere per month must be compared with the New York State experience with National Lead Industries, a former DU processing plant near Albany, NY. At NL Industries DU was processed into DU metal penetrators for 30 mm cannon rounds and into airplane counterweights made of DU. In February 1980, a court order by NY State citing public health reasons shut down NL Industries for exceeding a NY State Department of Environmental Conservation monthly radioactivity limit of 150 microcuries (387 grams of DU) for airborne emissions. Recently the highly contaminated plant was razed and a large quantity of radioactively contaminated structural material and soil has been prepared for shipment to a disposal site.

The NL Industries plant caused massive contamination to the residential area and commercial properties outside the perimeter of the plant. In 1984, 1985 and 1988 a total of 950 cubic meters of radioactively contaminated soil were removed by DOE from 53 of 56 vicinity properties (DOE Report No. DOE/OR/21950-888; "Engineering Evaluation/Cost Analysis (EE/CA) for the Colonie Interim Storage Site (CISS) Buildings," June 1993, p. ES-1). My hypothetical super-efficient plant would release 333 grams (129 microcuries) of DU airborne particles per month into the environment. This amount of DU is not significantly different from the 150 microcuries of DU per month limit set by New York State. It is highly unlikely that a release rate of 150 microcuries of DU per month into the atmosphere will ever again be allowed by a local government or by citizens affected by the fallout. The containment efficiency of a DU processing plant would have to be at least 10 times better than I have assumed, allowing less than 1 gram of DU in 100 million grams (100 metric tons) of DU to escape into the environment. This extremely high requirement may be impossible to meet. The control and containment of DU emissions inside the plant would have to be even more stringent. When processing such huge quantities of DU it will be extremely difficult if not impossible to keep workers inside the plant from becoming contaminated with it.

Response 3

The PEIS examined potential doses to workers, doses to the general public, and air emissions that would be associated with the conversion of depleted UF_6 to either U_3O_8, UO_2, or metal under normal operations, and with the manufacture and use of metal products. The results are summarized in Sections F.3.1.1 and F.3.3 of Appendix F (for conversion options), and in Sections H.3.1.1 and H.3.3 of Appendix H (for manufacture options). Doses to workers and members of the public from normal operations at the representative facilities evaluated were estimated to be well below all applicable regulatory limits.

If conversion and/or manufacturing were required under the alternative management strategy selected by DOE, any required facilities would meet all applicable limits and regulations. Future planning and environmental analysis will address issues related to selection of sites and technologies for the depleted UF_6 management strategy selected in the Record of Decision for this PEIS.

Comment 4

"Transport of DU Particles in the Atmosphere": Another serious issue is what happens to the uranium particles that escape into the atmosphere and become dispersed far and wide by wind action. In the fall of 1979 I worked at the Knolls Atomic Power Laboratory in Schenectady, NY. The laboratory was operated by the General Electric Company for the Department of Energy. While troubleshooting a problem for the radiological group, my colleagues and I accidentally discovered DU aerosols collected in environmental air filters exposed at the Knolls site. The source of the uranium contamination was the NL Industries plant in Colonie, 10 miles east of the Knolls site, outside Albany, NY. We also discovered DU in air filters exposed at the Kesselring site in West Milton, NY, where crews for the nuclear Navy are trained, 26 miles NW of the NL plant. This is by no means the maximum fallout distance for uranium aerosols. A radius of 26 miles encompassed an area of more than 2,000 square miles around Albany where this fallout occurred. In January, 1980 I wrote and issued an internal technical report that documents our mass spectrometer measurements (L.A. Dietz, CHEM-434-LAD, "Investigation of Excess Alpha Activity Observed in Recent Air Filter Collections and Other Environmental Samples," Jan. 24, 1980; unclassified technical report, Knolls Atomic Power Laboratory, Schenectady, NY 12301; obtained under the Freedom of Information Act. Copies available from L.A. Dietz. If desired, a certified copy should be available from Schenectady Naval Reactors). Airborne uranium aerosol particles act like dust and can go everywhere that dust goes. The scientific explanation of how micrometer-size uranium particles can easily travel such large distances when airborne is given in a survey paper that is available on the Internet (L.A. Dietz, "How Gulf War Veterans and Others became Contaminated by Depleted Uranium," available on the world wide web at the WISE Uranium Project home page: http://www.nl/~wise/uranium/).

Response 4

In the PEIS, the radiation doses to the off-site public from airborne emissions of depleted uranium were estimated by considering an area within a 50-mile radius of the release point. Further details on the methods of analysis for dose from airborne uranium emissions are given in Appendix C of the PEIS, Section C.4.1

Comment 5

"Use of DU Metal in Large Commercial and Military Airplanes": The use of DU metal counterweights in commercial and military airplanes should be banned. Until about 1980 each Boeing 747 passenger jet contained 1,500 kilograms of DU metal counterweights use for dynamic flight control (Lowenstein, P., "Industrial Uses of Depleted Uranium," photocopy in "Uranium Battlefields Home and Abroad: Depleted Uranium Use by the U.S. Department of Defense," Bukowski, G. And Lopez, D.A., March, 1993, p.136.) In a crash and ensuing intense fire DU metal will begin to oxidize rapidly and sustain slow combustion when it is heated in air at a temperature of 500°C. This can cause DU oxide particles to be formed that can become airborne and poison large numbers of people and their surroundings (Parker, R.L., "Fear of Flying," Nature, Vol 336 22/29 Dec. 1988, p. 719.). This scenario has already happened. In 1977 two Boeing 747s crashed into each other and burned on a runway at Tenerife, Canary Is. In 1988 a Boeing 747, Pam Am Flight 103, crashed and burned at Lockerbie, Scotland. And in 1992 an El Al Israeli Boeing 747 crashed into an apartment building and burned in Amsterdam, Holland.

Fire and safety personnel exposed to the combustion products of DU are at risk. How many fire and safety emergency crews at airports or in cities have been trained and provided with equipment that will protect them from uranium particles that have been generated in intense fires?

Response 5

Any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained from the NRC. The NRC analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions. As with the use of any radioactive material, careful consideration would be given to whether the benefits of the proposed use outweigh the potential risks. Because of the regulatory climate in the United States, it is highly unlikely that products containing depleted uranium would be available for large-scale, unrestricted use at this time. Potential impacts from restricted uses, such as use as shielding in the nuclear industry, would likely be small.

Commentor No. 27: Resnick, Paul
DuPont Nafion® Products

Comment 1

We are interested in the Depleted Uranium Hexafluoride Management Program and the safe disposal of this material. Our major interest is in the utilization of the fluorine contained in the depleted uranium hexafluoride.

A number of proposals for the chemical conversion for the UF_6 have been made. At present, the conversion of UF_6 into elemental fluorine and uranium metal proposed by BNFL Inc. appears to be the most promising scheme. The preparation of high value fluorine (F_2) makes the most economic sense. We have had and continue to have discussions with BNFL Inc. about this process and our uses for the fluorine product. Although we do not anticipate any interest in the uranium coproduct this may also be its most desirable form for ultimate use or disposal by others. We will continue our discussions and contacts with BNFL Inc. and the Department of Energy.

Please do not hesitate to contact us if we (can) be of any help to you in your work on the Depleted Uranium Hexafluoride Management Program.

Response 1

Commentor's preference for conversion to metal using the BNFL's process and utilization of the fluorine contained in the depleted uranium hexafluoride is noted.

Commentor No. 28: Owsley, John
Tennessee Department of Environment and Conservation

Comment 1

The Tennessee Department of Environment and Conservation DOE Oversight Division (TDEC/DOE-O) would like to request an extension on the comment period for the "Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride." This is an important issue for the State of Tennessee, and we would like additional time to complete a thorough review of this document. An extension of the comment period to May 7, 1998, will be sufficient. Please let us know if this is acceptable.

Response 1

DOE announced a 120-day public comment period upon publication of the Draft PEIS in December 1997. This comment period was much longer than the 45 days required by Council on Environmental Quality and DOE regulations implementing the National Environmental Policy Act. As part of the public review process, DOE held public hearings in Oak Ridge, Tennessee; Paducah, Kentucky; Portsmouth, Ohio; and Washington, D.C.

DOE believes the comment period was of sufficient duration to allow review of the draft PEIS and submittal of comments by government agencies, potentially affected communities, and other individuals and organizations. The DOE Program Manager (Charles Bradley) contacted a representative of the State of Tennessee (Rebecca Charles) and discussed the issue of extension. It was agreed that the comment period would not be changed. Additional comments from the State of Tennessee are addressed under Commentor No. 87.

Commentor No. 29: Moseley-Braun, Carol / Dubrin, Richard / Poshard, Glenn
U.S. Senate and House of Representatives

Comment 1

We are writing to express our interest in the important work underway at the Department of Energy (DOE) to evaluate strategies for the long-term management and use of depleted uranium hexafluoride. As you know, there are over 1 billion pounds of this uranium enrichment by-product stored at the enrichment plants in Ohio and Kentucky, as well as in Oak Ridge, Tennessee. We are aware that the Department is currently soliciting public comments on a Draft Programmatic Environmental Impact Statement on various uranium hexafluoride management strategies. We commend you for moving to address this health, safety and environmental issue for the employees and neighbors of these facilities.

Response 1

Comment noted.

Comment 2

One of the options under consideration by DOE is a technology which can convert uranium hexafluoride to a safe and stable form of uranium suitable for long-term storage, retrievable disposal, or further use. This process is essentially the reverse of the uranium conversion process performed by AlliedSignal in Metropolis, Illinois. The technology, which is being tested through a joint DOE-industry partnership in Metropolis, offers two key benefits.

First, it converts the uranium to a solid, or oxide state, making it safer to store and available for possible future use. Secondly, it captures the Hydrogen Fluoride contained in the uranium hexafluoride which can then be recycled for use in the ongoing uranium conversion process, and for other manufacturing processes such as the production of non-ozone depleting refrigerants.
The benefit to DOE and the country is that the danger posed by the existing uranium hexafluoride containers can be removed and the government can be compensated for the value of the captured Hydrogen fluoride.

We realize that DOE will not make a final decisions on a uranium hexafluoride management strategy until early next year. Our hope is that the time between now and then can be

used productively to fully demonstrate this technology so its full costs and benefits can be determined. In order for this to happen, DOE funding needs to continue through fiscal year 1999. We hope that sufficient funding for the current fiscal year is available within the Department's FY 1998 appropriation. Please inform us of the current and future funding plans for this important environmental management program.

Response 2

The commentors' statements regarding benefits of the UF_6 conversion technology being demonstrated in Metropolis, Illinois, are noted. Funding plans for this technology demonstration project are not within the scope of the PEIS.

Commentor No. 30: May, W. G.
University of Illinois

Comment 1

I am interested to see that things are moving ahead much as you told us they would, when we were preparing our National Research Council Report, "Affordable Clean Up." (Dr. Fred Schneider and I wrote the chapter on "Disposition of the UF_6).

At the time we saw little to suggest that conversion to metal made any sense, but I see that mentioned as one of DOE's ambitions. I wonder if you are really serious about that.

Response 1

After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Sections S.5.1 and 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under the revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal product become available. The impacts of the preferred alternative are discussed in Sections S.5.2, 2.5.2, 5.7, and 6.3.7 of the PEIS.

Comment 2

In your PEIS (Summary version, page S-44) you indicated that DOE is "committed to continuing its support for the development of applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted UF_6 cylinder inventory." Now that position bothers me! We have had this material in storage for 50 years and have been studying options for using the stuff for a large number of those years. Continued storage and study is just a way of avoiding a decision in my opinion. Only DOE would consider such an option!

Response 2

The DOE is committed to managing the depleted UF_6 cylinder inventory in a safe and responsible manner. The PEIS will be used, along with cost, engineering, and other data, to select

a long-term management strategy that will be announced in the Record of Decision. The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use.

Comment 3

I read where the money allotted to DOE clean-up activities is well below that required for expeditious clean-up. But the UF_6 ought to be on the list somewhere, not just relegated perpetually to the future.

Response 3

Issues of DOE program funding are beyond the scope of the PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Commentor No. 31: Fulkerson, William
Friends of Oak Ridge National Laboratory

Comment 1

Roughly 46,000 cylinders containing depleted UF_6 (not counting 8000 under management of the United States Enrichment Corporation) are stored at the three gaseous diffusion sites, about 4,700 of them in Oak Ridge. Each is partially filled with 10 to 14 tons, solid at ambient temperature, for a total in the neighborhood of 500,000 tons. DOE plans between 2009 and 2028 to convert the material to HF and a solid form of uranium, likely U_3O_8. There is an established market for HF, and the hope is to find beneficial uses for the uranium. Barring the breeding of nuclear fuel, not likely in the next few decades, prospects for use of a substantial fraction of it are dim.

Response 1

As explained in Section 2.5.1 of the PEIS, DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products.

Comment 2

There does not seem to be agreement in estimates of the costs of conversion, except that they will be large. If we assume for discussion, $3 a pound, net of HF value, a total of about $3 billion would be required. Quoted current costs for management of the inventory range from fifteen to thirty million/year. If there were no significant risks involved and if the maintenance costs

were to track inflation, there would be no particular urgency for getting on with conversion, because interest on the conversion investment would easily exceed present annual outlays. We have serious doubts about both premises.

Response 2

The context of the statement concerning the premise of the costs of conversion and continued storage is unclear. However, the document, "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS) presents the present-worth costs for the various alternatives considered in the PEIS. The present-worth costs for depleted UF_6 conversion ranges from approximately $270 million to $830 million, depending upon the final form (either uranium oxide or metal) and conversion process. The present-worth cost of continued storage at the three current storage sites is approximately $330 million. A comparison of the costs of conversion versus continued storage (with consideration of the costs of other options such as cylinder preparation, etc.) would indicate that the present-worth costs of conversion are similar to continued storage. The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS. The costs associated with various management alternatives are beyond the scope of the PEIS. However, cost will be one of the factors considered in selecting the long-term management strategy in the Record of Decision that will be issued after the publication of the Final PEIS.

The risks associated with continued cylinder storage are discussed in detail in Appendix D of the PEIS. Continued storage is a part of every alternative analyzed. Therefore, risks associated with continued storage are included in the consideration of risks for every alternative. The results indicate that continued storage does not pose a significant risk over the approximately 40-year assessment period considered in the PEIS.

Comment 3

The cylinders are constructed of carbon steel, of nominal thickness 0.312 inches (older ones were of twice this thickness). Although internal corrosion from UF_6 appears small, so long as integrity of containment is maintained, there is abundant evidence of general external corrosion from exposure to the elements, particularly of those in Oak Ridge, which tend to be older. Of more concern, there is pitting and crevice corrosion. Seven of the cylinders are known to have developed cracks, five involving handling, but two from corrosion alone. In these cases, atmospheric moisture has hydrolyzed the uranium hexafluoride to UO_2F_2, which has acted as a seal. The HF produced has dissipated harmlessly, and the contamination of water with soluble uranium compounds has not yet caused serious embarrassment. The benign effects of these failures seem to have lulled policy makers about untoward events during the thirty years projected before completion of conversion to a form safe for indefinite storage.

Response 3

DOE is aware that, unless certain mitigating actions are undertaken, more breaches will occur in the future. These actions, which have already begun, include placing all cylinders in acceptable storage facilities and establishing a coating on all cylinders which will arrest the rate of external corrosion. The internal corrosion rate has been evaluated and is negligibly small. At a steady temperature of 140 °F, a 5/16-in.-thick steel plate with a roughness factor of 2.5 would be predicted to be corroded through in about one million years. DOE is committed to continuing the safe management of its depleted UF_6 cylinder inventory for as long as necessary.

Comment 4

However, even if events having serious consequences are discounted, steep rises in the annual costs of custodial care and in the eventual costs of conversion seem inevitable. As corrosion worsens, there will be increasing numbers of breaches requiring patches. The weakening of the cylinders will increase the costs and dangers of handling them in periodic painting or in removing the contents for conversion. If all are to be converted at a single site, more and more will have walls that do not meet the minimum 0.25-inch walls DOE specifies for safe transportation by highway or rail.

Response 4

DOE is aware that, unless certain mitigating actions are undertaken, more breaches will occur. These actions, which have already begun, include improving the cylinder storage conditions and establishing a cylinder painting program to control the corrosion of cylinders. As indicated in response to comment 2 above, the cost of alternatives is beyond the scope of the PEIS. Cost will be considered in the ROD in selecting the long-term management strategy for the depleted UF_6.

In regards to converting all of the material at a single site, the location(s) and number of conversion facilities are beyond the scope of the PEIS and will be addressed in future planning and environmental analyses.

Comment 5

Confidence that there is small risk of more damaging events may be misplaced. The cylinders support about 250,000 pounds force from the atmosphere (25000 in^2 times 10 psi differential). In addition to this evenly distributed stress is that from resting on the surface and, for the bottom layer, from those stacked on top. Many of the cylinders are forty years old. The program to clean and paint the outer surfaces lags deterioration.

Response 5

DOE plans to paint about 6800 cylinders at Paducah and 2950 at ETTP over the next five years. This number represents the sum of the cylinders from former G- and F-yards at Paducah and K-yard at ETTP which have been determined to be at risk of corroding to the point that they would have a minimum wall thickness less than the ASME Code allowable for unfired pressure vessels.

If this schedule can be met, DOE will, on a statistical basis, save the most mils of cylinder wall thickness lost due to corrosion and also maintain those cylinders as a code-approved population. Based on the corrosion modeling, the other populations of cylinders do not need painting for some time or possibly not at all to maintain ASME minimum wall thickness. If DOE accelerates disposition of the depleted UF_6, then more painting or faster painting may not be necessary.

Comment 6

There are a number of conceivable scenarios for catastrophic failures of containment, beyond what uranyl fluoride could seal, from an earthquake or transportation accidents, for example. Over the interval before planned conversion, with the number involved, stacked as they are, collapse in place of some is hard to exclude. If such an event occurred in a wet situation, a dangerous plume of HF could be produced. In Table S.2 on page S-17 of the referenced summary, it is estimated that such a failure might occur in 1 to 10 years under dry conditions; on the next page, the frequency of a more serious accident, involving three cylinder apparently being transported, is given as 1 in 100,000 years under wet conditions. Chemical exposure from the latter is projected to have adverse effects on 1900 of the public, and on 1000 non-involved workers (of which 300 would suffer irreversible effects). With the climate here and the difficulty of reaching cylinders in the middle of storage areas, the 1 to 10 year single-cylinder failure might well occur under wet conditions, perhaps with less, but still unacceptable, effects.

Response 6

The PEIS analysis considered a range of potential accidents that could occur at the facilities required by each alternative, as shown in Table D.6 of the PEIS. Three cylinder yard accidents have been analyzed in the PEIS in which corroded cylinders containing solid depleted UF_6 rupture during handling, either during dry conditions, or in two cases, under wet conditions. (In Table D.6, these three accident scenarios are referred to as "Corroded cylinder spill, dry conditions, "Corroded cylinder spill, wet conditions — rain," and "Corroded cylinder spill, wet conditions — water pool.") These accidents involve cylinder failure during handling and movement, activities which are (generally) performed under dry conditions, and do not reflect accidents that could occur during cylinder yard storage.

The frequency of the accident scenario of a corroded cylinder spill under dry conditions takes into account the historical experience at the three current storage sites. This historical experience indicates that the potential for accidents is greater during cylinder handling than during simple storage. The lower frequency for the accident scenario of a corroded cylinder spill under wet conditions takes into account the unlikeliness of a severe rainfall occurring during cylinder handling.

Comment 7

There seems to be general agreement that conversion is eventually necessary. We advocate acceleration. We recommend that conversion begin in Oak Ridge as the pilot. The cylinders here

are in the worst condition and are likely most risky to transport. We believe that work should not be delayed until a market for the uranium develops, a long shot at best. We encourage research to lower costs of conversion, but not at the expense of timely action. In the meantime a major overhaul of the cylinder storage situation at Oak Ridge should be a high priority.

Response 7

The commentor's preference for an accelerated conversion program beginning with a pilot in Oak Ridge is noted. DOE's preferred alternative includes prompt conversion of depleted UF_6 to depleted uranium oxide for storage and use.

Cylinders at Oak Ridge (East Tennessee Technology Park) are subject to an active maintenance program that includes visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, cylinder coating maintenance, and cylinder yard maintenance.

Comment 8

As we understand it, the cylinders are not considered waste, and as a result, conversion is not on the table when remediation priorities are set. If funding for conversion is not available in the appropriate category, we believe DOE should rise above administrative barriers and assess the possible problems from the cylinders in comparison with the risks from delays of other remediation projects.

Response 8

Issues of DOE program funding are beyond the scope of this PEIS. DOE has managed its depleted UF_6 inventory as a resource with value for future use, rather than as a waste. An alternative management strategy involving conversion of depleted UF_6 to an oxide and disposal of the oxide is evaluated in the PEIS (see Section 5.6). DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Commentor No. 32: **Comments from the Paducah, Kentucky hearing**
See Section 4.2 for comments and responses

Commentor No. 33: **Comments from the Oak Ridge, Tennessee hearing**
See Section 4.3 for comments and responses

Commentor No. 34: **Comments from the Portsmouth, Ohio hearing**
See Section 4.1 for comments and responses

Commentor No. 35: Comments from the Washington D.C hearing
See Section 4.4 for comments and responses

Commentor No. 36: Ortoiger, Thomas W.
State of Illinois Department of Nuclear Safety

Comment 1

The Illinois Department of Nuclear Safety (IDNS) hereby submits its comments on the Department of Energy (DOE) Preliminary Environmental Impact Statement (PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (UF_6). IDNS applauds DOE's early recognition of Illinois' unique situation relative to this issue and appreciates the opportunity to comment on the Draft. IDNS considers itself a stakeholder in this process for two reasons. Clearly, IDNS is interested in any environmental impacts from changes in the mission of the Paducah Gaseous Diffusion Plant (PGDP) facility because of its proximity to Illinois. However, IDNS is also interested for a reason not reflected in the PEIS; the close proximity to the subject facility of the AlliedSignal Metropolis Works in Illinois.

Response 1

The Illinois Department of Nuclear Safety's interest is noted.

Comment 2

Fundamentally, IDNS supports the general strategy of converting UF_6 to more chemically stable forms such as U_3O_8 as soon as possible. We agree that DOE needs a longer-term plan for management of UF_6 that goes beyond inspections and repairs of leaking cylinders in storage yards. We also agree with the general strategy of trying to find markets for the by-products of the conversion process, although we have some concerns about radioactive contaminants in these by-products which we will discuss below.

Response 2

The Illinois Department of Nuclear Safety's support and concerns are noted.

Comment 3

The major shortcoming of the PEIS in our view, however, is its failure to recognize that the AlliedSignal Metropolis Works does exist and that there is a reasonably high probability that it will have an important role to play in DOE's UF_6 management strategy. DOE must recognize that given AlliedSignal's experience in the conversion business and the existing infrastructure at Metropolis, the Metropolis Works may be the only facility in the United States capable of handling the UF_6 to oxide conversion at a reasonable cost.

Response 3

The PEIS does not consider the potential role that the AlliedSignal facility might play in the conversion of depleted UF_6 to oxide because the decision has not yet been made to pursue conversion as a depleted UF_6 management strategy. That decision will be made in the Record of Decision (ROD) for the PEIS. After the ROD, should DOE choose to pursue conversion, specific technologies and sites would be evaluated and appropriate site-specific analyses would be conducted for any facilities required to implement the selected management strategy (as discussed in Section 1.4 of the PEIS).

Comment 4

IDNS understands that given the method that DOE generally employs to develop a PEIS, siting issues are not addressed until the second phase of the NEPA approach. However, we feel that the decision to recognize or ignore AlliedSignal, even at this early stage, has significant impact on evaluating the risks and benefits of DOE's management options.

Response 4

Until a long-term management strategy for depleted UF_6 is selected and announced in the Record of Decision for the PEIS, DOE will not know what actions will require selections of technologies or sites. Future planning and environmental analysis will address issues related to selection of sites and technologies for the depleted UF_6 management strategy chosen — including, if appropriate, the AlliedSignal, Inc. facility in Metropolis, Illinois, referenced in the comment.

Comment 5

Page 2-5 — This section describes the option of long-term storage as depleted UF_6. This option is the least desirable from IDNS' point of view. Associated with this option would be all the risks of transportation with none of the benefits of conversion to oxide. We suggest that this option be given no further serious consideration.

Response 5

Comment noted.

Comment 6

Section 3.1.7 — The description of the affected environment surrounding the PGDP fails to recognize the presence of the AlliedSignal Metropolis Works as another major uranium processing facility in the immediate vicinity. AlliedSignal's effluent releases and impacts on the environment are thereby not considered in this review.

Response 6

Section 3.1.7 focuses specifically on the Paducah site and considers neither the AlliedSignal, Inc. UF_6 conversion facility at Metropolis, Illinois, nor other facilities in the vicinity of the site that might have implications for public and occupational health and safety. However,

Section 5.8.2.1 of the PEIS has been modified to incorporate impacts from the AlliedSignal, Inc. facility (and other nearby facilities) in the cumulative impacts for the Paducah site (see Table 5.12).

Comment 7

Page 3-14 — The region of influence includes Massac County, Illinois (not Massaic).

Response 7

The commentor is correct; Massac County (IL) not Massaic County (IL) is part of the region of influence at Paducah. The text has been corrected.

Comment 8

Page 3.4 — Check the map scale. 3000 km is not roughly equivalent to 2 miles.

Response 8

The scale of miles was incorrect. It has been changed to show 3 km roughly equivalent to 2 miles.

Comment 9

Table F.2 — If AlliedSignal were considered as a site for a conversion facility, most of the health risks and potential benefits would need to be evaluated. Risks and benefits from construction activities would be particularly impacted. While on one hand, ecological and land use impacts would be smaller, economic benefits from increased employment would also be smaller.

Response 9

The PEIS evaluates the potential environmental impacts of broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory. In evaluating these impacts, it considers all of the activities that would be necessary to implement each of the alternatives (as discussed in Sections 2.1 and 2.2). Because of the programmatic, non-site-specific nature of the PEIS, most of these activities are evaluated for representative sites — the exceptions being continued storage and cylinder preparation for transportation, which would necessarily occur at the three current depleted UF_6 storage sites.

Conversion is one of the activities that is not evaluated for a particular site or facility in the PEIS, and as a result it would be inappropriate at this time to include the AlliedSignal, Inc. UF_6 conversion facility in Metropolis, Illinois, in Table F.2. As discussed in Section F.1, as appropriate a more detailed site- and technology-specific analysis of potential environmental impacts would occur in a subsequent NEPA document once DOE selects a long-term management strategy to pursue. If conversion is a component of that strategy, and if the AlliedSignal, Inc. UF_6 conversion facility is judged to be a potential conversion facility, the impacts of using it would be evaluated at that later date.

Comment 10

Page F-11 — Anhydrous HF may have been a valuable product at one time, however, given the glut of UF_6 on the market, one questions the value of a product whose primary use is the production of more UF_6 from ore.

Response 10

The largest use of anhydrous hydrofluoric acid (AHF) is in the manufacture of fluorocarbons, and not in the production of UF_6. The fluorocarbon market accounts for about 65-70% of AHF demand. Only in the unlikely event that AHF produced during UF_6 conversion could not be sold for unrestricted use would it be recycled in the nuclear fuel industry.

It should be noted that the aqueous HF produced by COGEMA in France during the conversion of depleted UF_6 into U_3O_8 is marketed to outside buyers in the glass and steel industries, due to its high purity.

Comment 11

Page F-12 — IDNS is concerned about the depleted uranium content of the anhydrous HF that could be produced by a conversion process. IDNS would be interested in any uncertainties associated with the 1 ppm figure quoted. In any case, we do not believe it is certain that the material will have commercial value if it is known to be contaminated at any level.

Response 11

The PEIS assumed an upper bound limit of 1 ppm uranium in the anhydrous HF produced during conversion of depleted UF_6. Defluorination of depleted UF_6 to produce U_3O_8 and HF is practiced on a large scale industrial basis by COGEMA in France. The uranium content of this high purity HF is below the 0.1 ppm uranium instrument detection levels, well within the 5 ppm specification for aqueous HF sales in Europe.

In the unlikely event that the anhydrous HF recovered during UF_6 conversion could not be sold for unrestricted use, it could still be sold for use in the nuclear fuel industry.

Comment 12

Table F.25 — We assume that the source of the figures in this table are from (LLNL 1997) which is an estimate based on theoretical considerations. We suggest that actual historical low-level radioactive waste generation figures from AlliedSignal would be more useful.

Response 12

Information on commercial uranium facilities were used in the development of the engineering analysis report (EAR) (LLNL 1997; the full citation is provided in Appendix F of the PEIS), which is the source for the waste volumes shown in Table F.25 of the PEIS. Waste generation data from UO_2 fuel fabrication facilities (Columbia, SC; Wilmington, NC; and Hanford, WA) and UF_6 plants (Metropolis, IL; Gore, OK) were reviewed. The data were used as guidelines, but extrapolation was not possible due to different plant design, process, and off-gas treatment.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 13

Page J-7 — The failure to consider existing facilities has led to inconsistencies in making assumptions. In Appendix J, the analysis of transportation risks is based on the assumption that the distance between the storage and conversion facilities is 1000 km. However, in Appendix F, it assumed that the facilities are co-located.

Response 13

The assumptions made in the PEIS are that the empty cylinders are stored at the conversion facility until they are treated at a cylinder treatment facility, which is assumed to be co-located with the conversion facility. The PEIS does consistently assume throughout that storage and conversion facilities are not co-located.

Commentor No. 37: Nurmela, Lillian

Comment 1

The only responsible course for the Department of Energy to follow regarding the huge DU inventory is to establish safe, long-term storage of this material, which remains radioactive for what amounts to eternity.

Response 1

The commentor's preference for long-term storage of depleted uranium has been noted.

Comment 2

DU should definitely NOT be used for military purposes. We must not be responsible for blanketing battlefield areas with this long-lived radioactive material.

Response 2

The commentor's objection to the use of depleted uranium for military purposes is noted. DOE's PEIS for selecting a management strategy for its depleted UF_6 inventory does not establish policy or requirements for depleted uranium uses by the U.S. Department of Defense in munitions or other military equipment. As described in Section 2.2 and Appendix H of the PEIS, the two use options evaluated in the PEIS, use as depleted uranium oxide and use as depleted uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks.

Commentor No. 38: Gilliland, R. G.
Oak Ridge National Laboratory

Comment 1

1. Retain adequate depleted UF_6 to support the Surplus Plutonium Disposition Program under the "No action alternative" long-term management strategy for depleted UF_6.

One of the options for dispositioning the surplus weapons-grade plutonium is for use as mixed-oxide (MOX) fuel in light water reactors. A small portion, less than 0.3% of the available supply of the depleted UF_6 (ORNL/TM-13417 Rev. 1), should be set aside and reserved for use in the Surplus Plutonium Disposition Program. The required UF_6 to be removed from inventory is approximately 1400 MT as indicated in ORNL/TM-13466, Rev. 1, which is a Data Report to be released concurrently with the Surplus Plutonium Disposition Environmental Impact Statement.

The depleted UF_6 should be stored at the Portsmouth site since that is the only facility with operating transfer autoclaves for emptying the depleted UF_6 from the 12.7 MT (14 ton) storage cylinders into 2.28 MT (2.5 ton) feed cylinders. The smaller cylinders are required for transporting the depleted UF_6 by truck to commercial conversion facilities where the depleted UF_6 will be converted to uranium oxide and subsequently blended with oxide derived from surplus plutonium to make MOX fuel at a proposed government-owned fuel fabrication facility. The UF_6 cylinders will be selected based on a depleted uranium assay specified by the consortium selected to provide MOX fuel fabrication and reactor irradiation services. The feed requirement for the depleted uranium expected to be required by the Surplus Plutonium Disposition Program is approximately 0.25 wt % as indicated in ORNL/TM-13466, Rev. 1.

The PEIS (Section S.5.1 and Section 1.6) acknowledges that other DOE programs, such as the Surplus Plutonium Disposition Program, have requirements for small amounts of depleted UF_6. It is stated that this small fractional requirement of the UF_6 inventory would not affect the selection of a long-term management strategy in the Record of Decision (ROD) to be issued following the publication of the final version of the PEIS. However, the comments under Item 1 above are relevant in that specific cylinders of excess depleted UF_6 should not be considered surplus to all government programs and will be requested to be stored at Portsmouth for potential use in the disposition of surplus plutonium.

Response 1

The commentor's preference for retaining adequate depleted UF_6 to support the Surplus Plutonium Disposition Program is noted. Any decision for long-term management of depleted UF_6 that includes conversion does not preclude the availability of some amount of the material for specific identified uses. Due to the significant size of the depleted UF_6 inventory and the amount of time (20+ years) required to complete conversion, sufficient depleted UF_6 would be available to support future Departmental decisions regarding the Surplus Plutonium Disposition Program.

Comment 2

2. Consider the benefit of using the depleted uranium in geological disposal sites such as Yucca Mountain and the Waste Isolation Pilot Plant (WIPP) under the "Use as Uranium Oxide" long-term management strategy for depleted UF_6.

Depleted uranium can be used to improve the performance of the repository for disposal of spent nuclear fuel (SNF). Depleted uranium reduces the radionuclide release rate from a SNF waste package and minimizes the potential for long-term nuclear criticality. In this context, the U.S. Nuclear Waste Technical Advisory Panel-the Congressionally-mandated scientific review panel for the DOE Yucca Mountain project- stated (U. S. Nuclear Waste Technical Review Board, Report To The Congress And The Secretary of Energy: 1995 Findings and Recommendations, Arlington, Virginia, April 1996): "The Board suggests that DOE consider increasing the criticality control robustness of the EBS (Engineered Barrier System)... In particular, the use of depleted uranium in filler, invert, or backfill material, or in all three, is a concept the program has not yet explored adequately. Conceivably, increasing the criticality control robustness of the EBS could turn a potentially intractable analysis of external criticality into a comparatively easy one."

The recommendations of nationally recognized, congressionally-mandated scientific review boards on uses of depleted uranium should be explicitly considered in the PEIS. It is also noted that the Spanish repository program is investigating the use of depleted uranium to improve repository performance. This use of depleted uranium is receiving attention worldwide.

Additional information on this option can be found on pages 8-9 of the paper "Beneficial Uses Of Depleted Uranium," authored by Colette Brown of DOE and Allen Croff and M. Jonathan Haire of ORNL. The paper was prepared for the Beneficial Re-Use '97 Conference held in Knoxville, Tennessee, on August 5-7, 1997.

Response 2

The PEIS evaluates two representative use options, use as uranium oxide and use as uranium metal as radiation shielding. These options were intended to be representative only, and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. DOE plans to continue its support for the development of government applications for depleted uranium products, including evaluating potential uses in the repository program. In fact, a workshop was held on July 15-17, 1997 in Las Vegas, Nevada, specifically on this subject (see DOE/EM-0349, Proceedings of a Workshop on Uses of Depleted Uranium in Storage, Transportation and Repository Facilities). The subjects discussed at the workshop were consistent with the recommendations made by the Nuclear Waste Review Board as mentioned in the comment. Specific uses would be considered and evaluated in more detail in future planning and environmental analyses.

Comment 3

3. Expand the discussion in the PEIS of potential "Use Options" of the depleted UF_6, either as Uranium Oxide or Uranium Metal.

The primary use of the depleted UF_6, discussed in the PEIS, either as uranium oxide used to make high density concrete (Section 2.2.4) or as uranium metal (Section 2.2.5), is as shielding for spent nuclear fuel or high-level waste (HLW) storage containers. The detailed discussion should be expanded to include other options which could potentially use substantial amounts of the depleted UF_6, such as its use in industrial counterweights for forklift trucks. Another potential option would be the use of the depleted UF_6 in the manufacture of casks for low-level wastes (LLW), as recently proposed in a Technical Development Initiative for Fernald. The discussion of each "use option," including the use of the depleted UF_6 as shielding, should address the economic and technical viability of each option since these issues have been challenged in the public hearings for this PEIS held in Paducah and Oak Ridge. Additional information on these options can be found in the paper "Beneficial Uses of Depleted Uranium," referenced in Item 2.

Response 3

Descriptions of the various current and potential uses for depleted uranium are presented in the second paragraph of Appendix H. As noted at the end of the paragraph, the PEIS analyzes in detail the potential use of depleted uranium as radiation shielding material because the largest potential market for depleted uranium currently appears to be shielding applications. As described

in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future.

Comment 4

4. Account for the end of life disposal requirement for any application under the "Use Options" for long-term management strategy for depleted UF_6.

DOE is considering using depleted uranium in the manufacture of casks for spent nuclear fuel or high-level waste (HLW) storage containers. One application is to convert the depleted UF_6 to an oxide which in turn would be used as the aggregate to make depleted-uranium concrete. The high density of the uranium allows the same shielding effectiveness with approximately half the thickness of conventional concrete. This concrete would then be used to manufacture oxide-shielded casks.

Another option would be to chemically-convert the depleted UF_6 to uranium metal which could be enclosed between the stainless steel shells making up the body of the casks. The uranium metal would be the primary shielding material in the casks which could be reduced in thickness relative to casks using only steel as the shielding material. The PEIS (pages 2-14 and 2-15) states that no assumptions were made regarding the fate of depleted uranium-concrete casts or the uranium metal casks following use. However, the disposal requirements for depleted uranium at end of life have a major impact on "use options." When the depleted uranium is used for an application such as shielding, at the end-of-life it must be converted into an acceptable waste form. The end-of-life costs to convert depleted uranium into an acceptable form may far exceed manufacturing costs. The consequence of this requirement should be evaluated in the PEIS.

Response 4

The present-worth costs of the various alternative considered in the PEIS are provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The costs associated with the ultimate disposition of the depleted uranium metal or oxide shielding casks were not considered as they are highly speculative. As discussed in Section 5.9 of the PEIS, at the end of their useful lives products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level radioactive waste.

Comment 5

5. Consider disposal of the depleted uranium at the Yucca Mountain repository for spent nuclear fuel and high-level waste under the "Disposal Alternative" long-term management strategy for depleted UF_6.

The Draft PEIS (Section 2.2.6) lists three options under the "Disposal Alternative": shallow land earthen structures, below ground vaults, and mine disposal. At least two of these three options, shallow-land earthen structures and below ground vaults, do not meet regulatory requirements for protection of public health and safety according to the detailed analysis in Appendix I of the Draft PEIS. The detailed analysis within the Draft PEIS on page 1-23 states:

"The maximum dose to an individual, assumed to live at the edge of the disposal site and use the contaminated water, was estimated to be about 110 mrem/yr which would exceed the 25 mrem/yr limit specified in 10 Code of Federal Regulations Part 61. Possible exposures (on the order of 10 rem/yr) could occur for shallow earthen structures and vaults if the cover material were to erode and expose the uranium material . . ."

The detailed technical analysis within the Draft PEIS Appendix I is consistent with the U.S. Nuclear Regulatory Commission (NRC) analysis that near surface disposal of large quantities of depleted uranium is not acceptable (J. W. N. Hickey, Letter from J. Hickey, Chief Fuel Cycle Safety Branch, U. S. Nuclear Regulatory Commission To Louisiana Energy Services, L.P., Docket No. 70-3070, U. S. Nuclear Regulatory Commission, Washington D.C., September 22, 1992). It is also consistent with DOE performance assessments for near surface disposal at specific sites (Martin Marietta Energy Systems, Inc.; EG&G Idaho, Inc.; and Westinghouse Savannah River Co., Radiological Performance Assessment for the E-area Vaults Disposal Facility, WSRC-RP-94-218, Oak Ridge National Laboratory, Grand Junction, CO., 1994). Additional analysis is necessary to determine the viability of mine disposal of the depleted uranium to meet regulatory requirements for protection of public health and safety.

At the current time, the only facility being planned in the United States that would meet the requirements for disposal of this material is the proposed Yucca Mountain repository for spent nuclear fuel and high-level waste. Because this is the only current option that meets the regulatory requirements for safe disposal of this material, it should be included as a disposal option in the PEIS.

Response 5

The purpose of the PEIS is to provide an analysis of broad, programmatic alternatives. The evaluation of disposal options in the PEIS considered disposal in representative facilities, including shallow-earthen structures, vaults, and mines. Because the PEIS is not intended to identify sites for future management activities, the potential impacts of the disposal options were evaluated using generic environmental settings, and considered both "wet" and "dry" sites. The characteristics of these settings were selected to provide as substantive an assessment as possible and to allow for a

comprehensive comparison of the alternatives. After the Record of Decision for the PEIS, DOE would evaluate potential facility locations and conduct appropriate site-specific analyses for any required facilities.

The detailed analysis presented for disposal in Appendix I of the PEIS does indicate that the dose to a hypothetical receptor from contaminated groundwater would exceed regulatory limits for a disposal facility in a "wet" environment for all three disposal options considered, including disposal in a mine. The analysis also indicates that groundwater impacts would be less than regulatory limits for a disposal facility located in a "dry" environment. For disposal in shallow-earthen structures and vaults, the analysis also indicates that surface erosion could potentially result in large external exposures; however, this scenario would not be likely for thousands of years and could be eliminated by engineering design and replacement of cover material. It must be stressed, as noted in Appendix I, that such calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required.

In response to the consideration of the potential repository being evaluated at Yucca Mountain, the Nuclear Waste Policy Act (42 USC 10101 et seq.), as amended, authorizes the disposal of only spent nuclear fuel and high-level radioactive waste in the first repository. However, the use of depleted uranium in some fashion to improve the performance of the repository is under consideration as discussed in the response to comment 2 above.

Comment 6

6. Clarify the "no action alternative" long-term management strategy for depleted UF_6 in the PEIS with the preferred waste form for final disposition of depleted uranium favored by the U.S. NRC.

The no action alternative as initially announced in the "Notice of Intent" to prepare this PEIS included eventual chemical conversion of the UF_6 to oxide followed by storage. However, after public scoping and internal DOE reviews, it was determined that the no action alternative should consider the continued storage of UF_6 cylinders indefinitely at the three current storage sites, as indicated on page 2-2 of the PEIS. The NRC stated that the preferred waste form for final disposition of depleted uranium is U_3O_8 (J. W. N. Hickey, Letter from J. Hickey, Chief Fuel Cycle Safety Branch, U.S. Nuclear Regulatory Commission To Louisiana Energy Services, L.P., Docket No. 70-3070, U. S. Nuclear Regulatory Commission, Washington, D.C., September 22,1992). The NRC, in the referenced license application for the private Louisiana Energy Services enrichment plant, further stated that conversion of the depleted UF_6 to uranium oxides should be done on a specific schedule.

It is ORNL's recommendation that the two points of view on the storage form of depleted UF_6 be reconciled between the DOE and NRC.

Response 6

It is unclear from the comment what points of view need to be reconciled between the DOE and NRC. The no action alternative in the PEIS considers the continued storage of depleted UF_6 in cylinders at the three current storage sites through the year 2039. This definition of the no action alternative is intended to provide a baseline against which other management strategies can be measured. In addition, this definition is consistent with CEQ guidance (CEQ's "40 Most Asked Questions") that states that the no action alternative may be thought of in terms of continuing with the present course of action until that action is changed. The no action alternative does not consider conversion or disposal of depleted uranium in any form. With respect to preferred waste forms for storage or disposal, the PEIS considers as alternatives both the storage and the disposal of uranium oxide (both U_3O_8 and UO_2) in several facility types. In fact, conversion to oxide followed by use or storage is part of DOE's preferred alternative. The information from the PEIS will be used, along with other information, to select a strategy for the long-term management of DOE's depleted uranium inventory in the Record of Decision to be issued after the publication of the Final PEIS.

Commentor No. 39: Palau, Gerald L.
City of Oak Ridge, Environmental Quality Advisory Board

Comment 1

The City of Oak Ridge has a strong interest in the future management of the DOE depleted uranium hexafluoride UF_6 inventory, since about 10% of this inventory is stored at the East Tennessee Technology Park (ETTP, formerly K-25 Site) in Oak Ridge. As explained in the draft programmatic environmental impact statement (PEIS), the continued storage of depleted hexafluoride in steel cylinders in outdoor storage yards does not pose an imminent threat to workers, public, or the environment. However, continued safe storage requires an ongoing program of surveillance and maintenance, and the job of assuring safe storage will become more difficult as time passes. Furthermore, the continued presence of this material at ETTP may adversely affect ongoing site reuse initiatives, both by presenting a negative aesthetic image to prospective ETTP tenants and by preventing new uses of the areas occupied by cylinder storage yards.

Response 1

DOE appreciates the City of Oak Ridge's strong interest in the future management of the DOE depleted uranium hexafluoride UF_6. The City's concerns regarding the continued presence of the depleted UF_6 cylinders at the ETTP (formerly K-25) are noted. DOE has also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the UF_6 stored at the ETTP. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review,

either remove all known depleted UF_6 cylinders from ETTP or complete the conversion of their contents by December 31, 2009. In the meantime, the depleted UF_6 Management Program is committed to working with the Reindustrialization Program at the East Tennessee Technology Park to resolve any issues that may come up with respect to cylinder storage at the site.

Comment 2

Environmental Quality Advisory Board (EQAB) members support the concept, embodied in most of the alternatives considered in the PEIS, of converting the depleted UF_6 to a more stable form (either uranium oxide or metal) that would be suitable for long-term storage, reuse, or disposal. However, we think the timetable for action that is presented in the PEIS is much too slow. Instead of waiting until 2009 to start converting this material (and finishing the job in about 2028), DOE should act now to start the conversion process as soon as feasible. (There appear to be no technical barriers to starting the conversion process.) The Oak Ridge Gaseous Diffusion Plant operated for about 40 years (1945 to 1985); the federal government owes it to this community not to wait an additional 43 years (1985 to 2028) to deal responsibly with the byproducts of gaseous diffusion.

Response 2

The timetable presented in the PEIS was developed to provide a basis for the calculation of potential impacts (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. For the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory. In fact, as explained in Section 2.5.1 of the PEIS, the preferred alternative in the PEIS has been revised to clarify this point. It now calls for beginning prompt conversion of the depleted UF_6 into depleted uranium oxide.

With respect to the ETTP (formerly K-25 site), DOE's Consent Order with the Department of Environment and Conservation of the State of Tennessee stipulates that, if any action alternative is chosen as the outcome of this PEIS, DOE shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from ETTP or complete the conversion of their contents by December 31, 2009.

Commentor No. 40: Dortch, Jotilley

Comment 1

A PEIS for UF_6 strategies and management must take all available information on the subject into consideration. This PEIS does not cite the following:

1. "Draft Preliminary Report-DOE Independent UF_6 Cylinder Assessment Team;" DOE draft; 25 March 1992;
2. "Integrity of Uranium Hexafluoride Cylinders," DNFSB Technical Report; 5 May 1995;
3. "Affordable Cleanup?-Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities"; National Research Council, 1996.

Why weren't these studies used as a basis for addressing this problem and its solutions?

Response 1

Except for the draft preliminary report, all the reports referenced in the comment were reviewed and used in preparation of the PEIS and supporting documents (for example, the engineering analysis report). A brief discussion of these reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided. The draft preliminary report was never finalized, so it is not cited in the PEIS.

Comment 2

The above-ground cylinder storage is risky. There are many styles of containers of varying wall thicknesses. Rust, both visible and under the paint, has weakened many. Improper storage-too close to the ground, too close together to be inspected all around, stacking incompatible styles, damage to cylinders in transport all add to the danger. Leaky or degraded valves and cylinder ID tags missing or unreadable are a problem.

Response 2

Previous substandard storage conditions, such as cylinders stacked too close together and cylinders in ground contact, as well as the lack of a regular maintenance program to recoat the exterior of the cylinders, have resulted in some cylinders experiencing accelerated external corrosion.

The UF_6 cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS) was developed to eliminate substandard conditions and to eliminate the effects of corrosion through a recoating program. The management plan addresses all phases of the current UF_6 cylinder management project and is based on risk analysis and technical evaluations which determine the activities to be performed. Under this management plan, all cylinders must be stored out of ground-contact. Any cylinders discovered through periodic

inspections to be in ground contact are relocated. Additionally, there are relocation plans to eventually restack all cylinders which will allow cylinder inspectors accessibility between cylinder rows. These plans are being implemented in a graded approach by relocating cylinders in the poorest storage conditions first. This plan is being implemented concurrently with extensive construction and recoating projects which will provide well drained storage yards for the cylinders and also provide protection for the exterior of the cylinders by recoating.

The sites have also implemented an extensive cylinder inspection program to allow identification of any damaged or breached cylinders. This inspection program also identifies those cylinders requiring maintenance activities such as valve replacement and nameplate replacement. Annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of pitting or heavy corrosion. All other cylinders must be inspected once every four years. Most of this work has already been completed at the three sites or is planned for completion by the year 2002.

The DOE is committed to maintaining adequate safety of the depleted UF_6 cylinder inventory through use of the UF_6 cylinder project management plan. The plan is discussed and referenced in the Introduction to Appendix D of the PEIS. The plan was used in the PEIS as the basis for assumptions to estimate possible adverse environmental impacts of continued storage of UF_6. For example, the cylinder painting and relocation schedules from the plan were used to estimate worker radiological doses, and also to estimate future cylinder breach rates.

Comment 3

How full the cylinders are presents another problem. Many were filled before the current limits were established.

Response 3

The current fill-limit of solid depleted UF_6 within a cylinder for offsite transportation is 62%, and was reduced from 64% in 1987. Appendix E of the PEIS provides information concerning the options that could be used to meet the transportation requirements for depleted UF_6 given by the U.S. Department of Transportation.

Comment 4

The geology of the area at PGDP includes high risk earthquake zones. It is not a stable place to store or reprocess UF_6. It is not a good place to store the produce until a market opens up or a use is discovered.

Response 4

The safety of current storage of depleted UF_6 cylinders was addressed in the safety analysis reports (SARs) recently prepared for each of the three storage sites. The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including

natural phenomena events such as earthquakes and tornadoes. The accidents considered in the PEIS for continued cylinder storage (Appendix D) were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 5

A viable long-term solution is to convert the cylinder contents to U_3O_8, a more stable oxide that can be reconverted if the need arises. France does this very thing.

Response 5

The conversion of depleted UF_6 to uranium oxide (U_3O_8) followed by storage of the oxide is one of the alternatives considered in the PEIS. This alternative will be evaluated along with the other PEIS alternatives, with the ultimate decision on a management strategy being announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 6

The problems that have surfaced since we have come off the "production-at-all-cost" mentality do not need bandaids. They need real and permanent solutions based on sound technology and upon sound geologic grounds.

Response 6

The commentor's preference for a technology- and geology-based permanent solution to depleted UF_6 management is noted. The process to select a long-term management strategy for depleted UF_6 is based on the need to identify sound technology that is consistent with environmental, health, safety, and cost considerations. The process began with the identification of feasible technologies for conversion, storage and disposal. The PEIS evaluated those technologies for environmental impacts. Additional comparisons based on cost will be undertaken prior to the selection of a strategy for implementation. Technologies and geologic conditions will be given further consideration as appropriate in future reviews supporting implementation of the management strategy announced in the Record of Decision for this PEIS.

Commentor No. 41: Lorimer, A. J.
British Nuclear Fuels plc

Comment 1

You will note that one of the main concerns that we have is the omission of an option for depleted uranium metal as a medium for long-term storage/disposal. As you are aware the technology BNFL is currently developing to process our own tails has as products, uranium metal and fluorine gas. BNFL's view is that uranium metal is feasible for long-term storage and disposal and could have clear cost and environmental advantages. This has not been adequately recognized or assessed in the report.

Response 1

Long-term storage of depleted uranium metal was considered but not analyzed in detail in the PEIS. Due to its high density, depleted uranium metal would require less storage space than the other uranium forms considered in the PEIS. This advantage has to be compared against disadvantages of depleted uranium metal which include its higher conversion cost, lower chemical stability than the uranium oxides, and uncertainty about the suitability of the depleted uranium metal form for eventual disposal.

The PEIS also considered, but did not analyze in detail, disposal of depleted uranium metal because of the large uncertainties that currently exist concerning its suitability and acceptability for direct disposal. Reactive waste forms such as depleted uranium metal are specifically excluded from disposal by the Nevada Test Site and Hanford waste acceptance criteria and Department of Energy Orders. Relaxation of current waste acceptance criteria would likely be needed for disposal of uranium metal to occur. The oxide forms considered in the PEIS are more favorable for disposal.

Further details are provided in Section 4.0 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 2

BNFL supports the strategy of safe storage as UF_6 pending the development of suitable uses. These uses would be most likely within the nuclear fuel cycle.

Response 2

The commentor's preference for storage pending development of uses is noted. The commentor's opinion as to eventual use is also noted.

Comment 3

The Engineering Analysis has several significant omissions and inaccuracies which although unlikely to affect the overall environmental impact, could weaken the conclusions of the PEIS and the Cost Analysis.

The Engineering Analysis uses conservative assumptions resulting in excessive rather than realistic costs and tending to preclude meaningful comparison of the options. Examples are: taking 7 years to build a facility, not considering use of several existing facilities in the USA, and the high projected manning levels.

Response 3

As noted in Section 1.5.4 of the PEIS, representative or generic environmental settings were used for conversion, long-term storage, manufacturing, transportation, and disposal activities. The engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) assumes that any new facilities would have to be constructed and operated at greenfield site locations. A summary of the Engineering Analysis Report is provided as Appendix O to the PEIS.

The assumptions in the PEIS were made uniformly among the management options so that the comparison of alternatives are meaningful. To provide a conservative estimate of impacts, it was assumed that new facilities would be constructed for conversion, consolidated long-term storage, manufacturing and disposal. The assumptions were based on industry or government experience with similar facilities or on engineering judgment.

Comment 4

The approach taken for the assessment of the environmental impacts arising from the various management options is good and the methodologies are suitably transparent to scrutiny. However, there are a number of general areas where the assessment methodologies could be improved and these are detailed below.

The treatment of uncertainty in any kind of assessment methodology is a vital issue, especially where generic (non site specific) settings have been used. The uncertainties in the input parameters and assumptions in conceptual models, and their effect on the predicted consequences, need to be determined, usually by a sensitivity analysis technique. Measures can then be taken to reduce the uncertainties.

Uncertainty has been recognized as important in the PEIS but little has been done to analyze the issue. Instead, assumptions have been made with the intention that the various anticipated environmental impacts result in conservative rather than realistic estimates. As it turns out, in most cases (except groundwater contamination in the disposal option) the impacts are still low enough to be acceptable. However, this approach tends to obscure meaningful comparison between the

alternatives and is not always appropriate. When a management option and suitable site are chosen, the environmental impacts for that site should be assessed on a realistic basis.

One exception to this conservative approach is the assumption that manufacture of shielded containers would bound any impacts associated with other products. In this case, the shielded containers are as large a product as can be reasonably imagined. Smaller products would require more operators per unit weight of uranium processed, and would be less self-shielded, giving much larger total involved worker doses.

Response 4

As correctly noted by the commentor, the general approach for dealing with uncertainty in the PEIS was to uniformly apply common assumptions to the alternatives and choose assumptions intended to produce conservative and yet realistic estimates of impacts. This approach is intended to enhance the ability to make valid comparisons among the alternatives. A comprehensive sensitivity analysis was not conducted primarily for two reasons: (1) the purpose of the PEIS was to evaluate and compare potential environmental impacts on a broad programmatic level, and (2) the conceptual nature of facility designs and processes at this stage generally does not readily support sensitivity analyses for most parameters. However, uncertainties related to the environmental settings of future management sites was addressed in the PEIS by evaluating a range of conditions for a small number of factors known to significantly affect the magnitude of impacts (i.e., sensitive parameters). These factors included population densities, precipitation rates, and soil characteristics (for disposal sites). It is not expected that more detailed sensitivity analyses would alter the conclusions reached in the PEIS.

After the Record of Decision for the PEIS, DOE would evaluate potential facility locations and conduct appropriate and more detailed site-specific analyses for any required facilities. The uncertainties associated with such analyses would be less and the estimated impacts would be more realistic.

As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected as representative options to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to bound the impacts associated with any future use, but rather to identify the types and general magnitude of impacts associated with manufacturing products containing depleted uranium. The impacts associated with specific uses will depend on what use or uses are ultimately identified, and would be considered and evaluated in more detail in future planning and environmental analyses.

Comment 5

The methodologies used in the Cost Analysis are considered to be sound. However the report is based on the Engineering Analysis and the comments made for that report will also have cost implications and might alter the conclusions of the Cost Analysis. In particular, the basis for the revenues or credits for the sale of AHF, CaF_2 and radiation shields require robust justification.

Response 5

Comment noted. The basis for the potential revenue from sale of by-product AHF and CaF_2, and the potential credit for depleted uranium radiation shielding is provided in the cost analysis report (1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 6

Long-term storage as uranium metal has not been analyzed even though it was a feasible recommendation in the Technology Assessment Report and there are significant volume and cost benefits which might make the economics of this route more attractive than U_3O_8 or UO_2.

Response 6

The technology assessment report (LLNL 1995; the full citation is provided in Chapter 8 of the PEIS) considered uranium metal as a potential form of uranium for long-term storage. Long-term storage of depleted uranium metal was not analyzed in depth in the PEIS. Due to its high density, uranium metal would require less storage space than the other forms considered in the PEIS (i.e., UF_6, UO_2, and U_3O_8). However, as noted in Sections 2.3.3 and 2.3.4 of the PEIS, this advantage is outweighed by the higher conversion cost, lower chemical stability than the oxides, and uncertainty about the suitability of the metal form for eventual disposal. In addition, the reactivity of uranium metal would necessitate specialized packaging and storage due to the evolution of hydrogen during the reaction between moisture and uranium metal.

Further information is provided in Sections 4.4 and 4.5 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 7

Disposal as uranium metal has not been analyzed even though it was a feasible recommendation in the Technology Assessment Report and there are significant volume and cost benefits which might make the economics of this route more attractive than U_3O_8 or UO_2. The PEIS shows that reducing the volume of the material disposed significantly reduces the impacts on the

environment, suggesting that uranium metal, which has the minimum volume, would minimize the environmental impacts. Although current DOE Orders restrict such disposal, there is no equivalent restriction at the commercial disposal sites.

Response 7

The PEIS did consider but did not analyze in detail the disposal of uranium metal because it is very reactive. Water attacks bulk uranium metal at room temperature and rapidly at higher temperatures. UO_2 and UH_3 are formed, heat is evolved, and the metal swells and disintegrates. Uranium oxides such as U_3O_8 are chemically stable, insoluble, and of low toxicity in drinking water, all of which are desirable properties for disposal. Also, the following document, which was one of the references consulted when deciding on the reasonable range of alternatives to analyze in the PEIS, concluded that no commercial disposal facility would be a potential candidate for disposal of DOE's depleted uranium: "Depleted Uranium Disposal Options Evaluation," by T.J. Hertzler, D.D. Nishomoto, and M.D. Otis, EGG-MS-11297, May 1994. In addition, correspondence from the U.S. NRC to DOE in response to DOE's request for recommendations published in the November 10, 1994 Federal Register recommended that depleted UF_6 be converted to U_3O_8 for purposes of disposal. Any commercial facility constructed for disposal of depleted uranium in the U.S. would have to be licensed by the U.S. NRC. Because of these reasons direct disposal of depleted uranium metal was not evaluated in the PEIS, either at DOE sites or commercial sites.

Appendix A (Low-Level Waste Disposal at DOE Sites) of Chapter 6.13 (Disposal Options for Depleted Uranium Management) of the engineering analysis report indicates that currently only three commercial low-level radioactive waste (LLW) disposal sites are in operations in the U.S. The Richland, Washington commercial LLW disposal site is accepting waste from the northwest compact generators only (which includes the states of Washington, Oregon, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, and New Mexico). The Barnwell, South Carolina LLW commercial disposal site is accepting waste from members of the southeast compact only (i.e., the states of Virginia, South Carolina, Tennessee, Mississippi, Alabama, Georgia, and Florida). It is unlikely that these two commercial disposal sites would be available for the disposal of depleted uranium metal provided by DOE, especially given the large quantities of material to be disposed. The waste acceptance criteria for the Envirocare site in Clive, Utah does allow disposal of depleted uranium, but generally in the form of an oxide.

The current waste acceptance criteria for the Hanford and Nevada Test Site are provided in Appendices F and G of the EAR. It would be highly speculative to consider revision of the waste acceptance criteria for these sites to allow disposal of depleted uranium metal. It should however be noted that these sites would allow disposal of depleted uranium oxides.

Comment 8

The environmental impacts of disposing of, or recycling, the products containing uranium metal or oxide at the end of their useful life should be analyzed.

Response 8

The PEIS acknowledges that at the end of their useful lives, products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4 and 2.2.5 and Section 5.9 of the PEIS). At this time, any analysis of disposal after use would be too speculative as it is not known when and at what rate the material would be declared surplus and would be disposed of. These issues are discussed in Section 5.9 of the PEIS.

Comment 9

The suggestions for the Pre-transport Preparations of UF_6 Cylinders appear to be compliant with the recommendations in IAEA Safety Series 6, 7, 8, 37 and 80. An overcontainer used for a cylinder which does not meet DOT requirements would need to contain any leakage from the cylinder. To achieve this, the overcontainer would need to meet the requirements of a Type A Package, as defined by the IAEA. An overcontainer "slightly bigger than the cylinder" which meets DOT regulations may not achieve this. It would be more prudent to plan for the transfer of the UF_6 to a new cylinder to cater for the instance of an over-pressure and damaged cylinder which could not be transported even in an overcontainer.

Response 9

The commentor's preference for the cylinder transfer option for transportation of cylinders is noted by DOE. However, it should be noted that if the overcontainer option were selected, the overcontainer would meet the same safety requirements as the conforming cylinders. Therefore, the safety basis for transportation of the cylinders would be the same irrespective of the option chosen for cylinder preparation. For further details on the preconceptual design of the overcontainer, see the (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 10

The engineering required to deal with some of the severely degraded cylinders has been underestimated. It is not reasonable to assume that these cylinders can be placed into overcontainers nor that their contents can be transferred in the manner described.

Response 10

The overcontainer concept was developed as a protective overpack that would meet the U.S. DOT requirements for shipping cylinders. Currently ten-ton product cylinders containing solid UF_6 with an assay greater than 1% are enclosed in specially designed overpacks called "Paducah Tigers."

The PEIS assumes that the contents of depleted UF_6 from cylinders would be transferred by sublimination (going from solid to gas) rather than by liquefaction (going from solid to liquid).

This process called "coldfeeding" allows transfer of the contents of even the severely degraded cylinders. The technical feasibility for cylinder transfer of UF_6 is well established.

Further information concerning the cylinder overcontainer concept and the cylinder transfer process are provided in Sections 6.1 and 6.2 of the engineering analysis report (LLNL 1997; the full citation is provided in Appendix E of the PEIS) and in Appendix E of the PEIS. The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 11

Accidents considered for the Cylinder Preparation Options involving cylinders of solid UF_6 assume releases of UF_6 in dry conditions and HF in wet conditions (rain). Accidents involving UF_6 vapour assume releases of UO_2F_2 and HF. Releases of any physical form of UF_6 result in reaction with water vapour in the air, producing UO_2F_2 and HF vapour. The PEIS therefore has underestimated the impacts of such accidents.

Response 11

For PEIS accident analyses it was generally assumed that UF_6 released to the atmosphere would react with moisture in air, or with water vapor generated by combustion (for accidents involving fires) to form airborne UO_2F_2 and HF. In the Appendix tables addressing accidents for options involving UF_6 handling (i.e., Tables D.6, E.4, F.7, and G.6), accident analyses for accidents listing UF_6 as the chemical form addressed both UO_2F_2 and HF releases.

The postulated accident involving a corroded cylinder spill, wet conditions (rain) was an exception to the above, because the UO_2F_2 generated under wet rainy conditions would not be airborne but would deposit as a solid on the ground surface near the cylinder. Therefore, for this accident, only release of HF was evaluated. As a result, the concern raised by the commentor has been addressed in the PEIS and the impacts of such accidents have not been underestimated.

Details on the assumptions used to generate source terms for the accidents are provided in the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The EAR and other supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 12

Emptied Cylinder Treatment: The residue remaining after the cylinder has been washed out and the water has evaporated will be UO_2F_2, rather than a "mixture of uranium and fluorine."

The cleaned cylinders could be cleaned further and monitored for free-release, or could be recycled to fabricate other containers for use in the nuclear industry.

Response 12

The text within the PEIS has been reviewed and the statement "a mixture of uranium and fluorine" has not been identified.

The management of empty cylinders was addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). Options considered for disposition of the emptied cylinders included recycle, reuse, disposal (i.e., burial), and free release. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses. The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 13

Conversion Module: The vast majority of process and other buildings use reinforced concrete in their construction. The use of reinforced concrete for the conversion process buildings cannot in itself be considered a safety feature.

Response 13

Reinforced concrete is a safety feature in that it provides containment to limit potential releases to the environment from energetic process mishaps (such as explosions) and also to protect process equipment from failure due to natural phenomena effects such as airborne missiles from tornadoes, etc. As explained in Section 1.2.2 of the conversion reports (Sections 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, and 6.10) of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), the facility designs were based on the criteria included in the applicable DOE orders and standards. The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 14

Control of HF vapour by limiting the temperature of the building will not work. The vapour pressure of HF at 32 °F is nearly half an atmosphere so even at this low temperature HF will vaporize quite quickly. Control of vapour in the manner described is analogous to saying that a cup of coffee does not give off water vapour because it is below the boiling point of water.

Response 14

Limiting the building temperature is not intended as a primary control of HF releases. The temperature of the HF storage tanks and building are assumed in the PEIS to be cooled to about 50 degrees Fahrenheit, to minimize the amount of HF that would vaporize if a spill should occur. Primary control of HF releases is by the HF Storage Building HVAC system (which will shut down if a HF spill occurs) and by the HF Storage Building water spray system, which is activated when a HF spill occurs to absorb any HF vapor in the building.

Comment 15

Upgrading the concentrated HF as described in both the U_3O_8 and UO_2 options will produce approximately equal quantities of esotropic HF, a highly corrosive liquid, and AHF. The esotropic HF has relatively little value, and no disposal or use route is described. However, the reduction of UF_6 to UF_4 with hydrogen or cracked ammonia to produce metal does indeed produce just anhydrous HF as a by-product.

Response 15

Reduction of UF_6 to form uranium oxides such as U_3O_8 and UO_2 will produce a hot off-gas stream containing HF. The PEIS assumes that this stream is sent to a distillation column for HF purification and recovery. The distillation column produces an anhydrous HF product and an azeotropic mixture of approximately 45 wt% HF and 55 wt% water. This esotropic stream is recycled back in the overall process, to react with the incoming UF_6 to form UO_2F_2. No disposal of the esotropic HF-water mixture is needed.

Comment 16

U_3O_8 Option: A dry conversion process could produce dense U_3O_8.

Response 16

The dry conversion process as evaluated in the PEIS would not produce dense U_3O_8. Production of dense U_3O_8 is possible, potentially through a process similar to that used to produce dense UO_2 (i.e., the U_3O_8 powder would be milled, compacted and granulated, mixed with a dry lubricant, pressed, and sintered under a reducing gas atmosphere). The dry conversion process evaluated in the PEIS to produce U_3O_8 was generally based upon the existing industrial COGEMA process practiced in France. Therefore, it was selected as a representative process for conversion of depleted UF_6 to U_3O_8 and provides an appropriate basis for comparison of alternatives.

Comment 17

UO_2 Option: UO_2 is a metastable oxide which could react with oxygen or air to form U_3O_8, with an increase in volume.

Sintering in a hydrogenous atmosphere is required to achieve the densities quoted (9 gm/cc). The hazards associated with hydrogen have not been addressed.

Response 17

As noted in Section A.1.5 (Uranium Dioxide) of the PEIS, UO_2 will gradually convert to U_3O_8 at ambient temperatures.

Hydrogen is used in a number of conversion options, primarily to convert UF_6 to UF_4. Hydrogen is also used in the sintering process for UO_2, in which UO_2 pellets are heated in a reducing atmosphere containing 6% hydrogen, to produce a final density on the order of 9.8 grams per cubic centimeter.

The PEIS did analyze the potential hazards associated with hydrogen, including the potential for a hydrogen explosion (see Table F.7 in Appendix F). A number of accident scenarios were postulated, as identified in Sections 6.5, 6.6, 6.7, and 6.8 of the engineering analysis report (LLNL 1997; the full citation is provided in Appendix F of the PEIS).

The engineering analysis report LLNL (1997) is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 18

Uranium Metal Option: A continuous metallothermic reduction process produces a uranium/iron compound with a lower melting point than that of pure uranium, allowing the operating temperature of the process to be lower. This is necessary to control the magnesium evaporation rate since magnesium has a significant vapour pressure at temperatures well below the melting point of pure uranium. The uranium/iron compound is much less dense than uranium metal and would be a relatively inefficient gamma radiation shielding material. The two metallothermic reduction processes are not therefore equivalent for the production of metal for use and should not be compared.

Response 18

The uranium alloy from the continuous metallothermic process only contains 3 wt% iron, which would not significantly reduce its density and gamma shielding characteristics compared to pure uranium. Besides, the PEIS does not compare the two technologies but evaluates both of them to provide a basis for a potential range of impacts that would result from conversion of the depleted UF_6 to depleted uranium metal.

Comment 19

The Unlikely Accident during Conversion to Metal "Uranium metal fire" would be better described as a conventional fire causing some oxidation of the adjacent uranium derbies. The large size of the uranium derbies would prevent them from catching fire.

Response 19

Depleted uranium is a combustible metal. When the specific surface area of depleted uranium is high, the material is pyrophoric, i.e., capable of self-ignition when exposed to air. Uranium metal burns in air at temperatures around 150 to 175 degrees Centigrade with formation of U_3O_8.

Comment 20

Pressurization of the metallothermic reduction vessel caused by vaporization of excessive magnesium has not been considered. This should be a "Likely Accident."

Response 20

It is assumed that the comment concerns the batch metal reduction process; as stated, pressurization of the metallothermic reduction vessel with some loss of U_3O_8 containing vapor is a likely accident which was not considered in the engineering analysis report or the PEIS. Were this accident considered, a conservative screening-level estimate of the source term results in a release estimate of 0.00165 lb of U_3O_8 through the plant stack (1400 lb uranium metal × 0.1% release oxidizes to 1.65 lb U_3O_8, which is then reduced by the 99.9% HEPA filter efficiency). It is not necessary to add this accident to the likely accidents considered in the PEIS, because the likely accidents already included for conversion to metal involve greater releases (see Table F.7 of the PEIS).

Comment 21

The estimated quantity of uranium released to atmosphere from the conversion facility is very small given the throughput of the facility.

Response 21

The estimated air emissions during conversion (and other options) were determined based upon historic releases from similar facilities, taking into account current best practices for emission reduction (e.g., HEPA filtration for uranium particles). It was assumed in the PEIS that gaseous effluents would be treated as necessary to meet applicable effluent standards. Further information concerning the emission rates for the various PEIS options is provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report and other supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 22

Use Module: For shielding gamma radiation, it is not only the material's density which makes it an effective shield, but, as in the case of uranium, a high atomic number is also significant. There are alternative dense metals such as tungsten for applications which need solely high density

and mass: in such applications, uranium is usually preferred only when particular mechanical properties are required in addition to density.

The number of UO_2 shielded casks and the number of uranium metal shielded casks seem to be derived by dividing the weight of uranium in the tails UF_6 by the weight of uranium in each cask. This number should be compared with the number of casks needed by the US nuclear power program for the storage/disposal of irradiated fuel.

Response 22

A comparison of the amount of uranium needed for annular shielding in spent nuclear fuel containers with the number of casks required for the U.S. nuclear power program indicates that the entire DOE inventory of depleted UF_6 would be consumed. Further information is provided in section 6.13 (Potential Shielding Applications of Depleted Uranium in Metal and Oxide Forms) of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 23

Uranium metal is a much more effective gamma shield than UO_2, and so more spent fuel could be loaded into each metal-shielded cask, thereby reducing the transport and final disposal costs of the spent fuel.

Response 23

The PEIS analyzes two options for radiation shielding applications using depleted uranium. The uranium metal option would result in a spent nuclear fuel (SNF) disposal package, primarily as part of a Multi-Purpose Unit (MPU). The uranium oxide option would produce a concrete-like material, which has been proposed for use in SNF storage applications at commercial nuclear power plant sites. The existing PEIS analyses address the shielding property differences of the two forms of depleted uranium that are considered. (See Sections 5.4 and 5.5 and Appendix H of the PEIS.)

Comment 24

The proposed method of fabricating the casks with uranium metal shielding is not practicable and is hazardous. Molten uranium forms low melting point eutectics with Fe, Cr and Ni, therefore the molten uranium will dissolve the steel shells, liberating large quantities of heat and resulting in a major spillage of uranium. There are, however, other, methods available to fabricate casks from depleted uranium that do not have these safety problems.

Response 24

It is stated on p. 6.11-1-8 of the engineering analysis report (1997a; the full citation is provided in Chapter 8 of the PEIS) that high stainless steel, nickel or titanium alloys with sufficient strength and melting point margins to accommodate the molten uranium metal without deformation would be used. The shell could be zone cooled during pouring to minimize alloying and to maintain integrity of the shell. As suggested by the commentor, it is possible to develop alternative methods to fabricate the casks, however, the method described in the EAR and used by the PEIS is expected to be representative of and in some cases, bound the impacts of the cask fabrication process. The EAR is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 25

No reason is given why solidified ash waste from the facility producing uranium metal shielding components should require disposal in a special cell or mine.

Response 25

The solidified ash waste from the uranium metal shielding facility is expected to be categorized as LLW Class A by the NRC, and should be suitable for near-surface disposal. The empty DUCRETE casks, after storing spent nuclear fuel, may require disposal in a special cell or a mined cavity because the uranium concentration would be on the order of 200,000 pCi per gram. Further information about the potential waste streams from the shielding applications considered in the PEIS is provided in Section 6.11 of the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The EAR, as well as other supporting reports, are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 26

The estimated quantity of uranium released to atmosphere from the manufacturing facility is very small given the throughput of the facility.

Response 26

It is assumed that the comment concerns the two use options. The oxide shielding application relies upon simple, low-temperature mixing techniques similar to concrete mixing, and significant releases would not be expected. The second use route uses depleted uranium metal which requires high temperature operations. Furnace discharging of molten metal into annular casks results in the majority of the radioactive emissions from the depleted uranium metal route. The analysis in the PEIS applies an airborne release fraction of 0.006, two sets of HEPA filtration (a decontamination factor of 2×10^{-6}), for an overall release fraction of 1.2×10^{-8}. These parameters are judged to provide a representative assessment of the impacts of these use options. Further

information concerning the airborne release fractions and decontamination factors applied in estimation of the emission rates is given in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS).

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 27

The release from accidental mishandling/drop of drum/billet inside the plant should be more for the oxide case than the metal case since the oxide is at this stage a loose and powdery material and the metal is in massive billet form.

Response 27

It is assumed that the comment is referring to accident scenarios postulated to occur during potential shielding applications of depleted uranium (see Table H.5 of Appendix H). One shielding application considers using UO_2 in the form of a sintered pellet, which is similar to a ceramic, and is not a loose and powdery material. Uranium metal would have an oxide layer surrounding it, which could be described as a tarnish layer. The amount of uranium released when dropped onto a hard surface would be less for the ceramic-like UO_2 than for the uranium metal, as reflected in the release amounts shown in Table H.5.

Comment 28

One factor which limits the useful market for uranium is its radioactivity which means that at the end of life it cannot be disposed of by the user in a straightforward manner. The Engineering Analysis considers the manufacture and use of the depleted uranium in both oxide and metal forms for the shielding of spent nuclear fuel. However there is only a disposal route defined for the oxide form since uranium metal is not considered suitable for disposal. The environmental impacts of disposing of, or recycling, the products containing uranium metal or oxide at the end of their useful life should be analyzed, including impacts from disposal of the shielding with the spent fuel still in it.

Response 28

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for a 40 year assessment period for all alternatives. In addition to this analysis, an evaluation of the long-term impacts for the disposal as oxide alternative was included in the PEIS because such impacts can be reasonably predicted. A life-cycle analysis for the alternatives other than disposal was not performed at this time because actions to be taken beyond the 40 year assessment period are considered highly uncertain and speculative. For instance, products containing depleted uranium potentially could be stored, recycled for other uses,

or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Comment 29

Long-Term Storage Module: Recommendations from the Technology Assessment Report to store the uranium as metal have not been analyzed even though they were considered feasible. Storage of bulk metal does not produce metal flakes so the pyrophoricity issue is not relevant. Corrosion of uranium metal by moisture can produce hydrides in the metal, but these are only a hazard if oxygen (or air) are excluded. The possibility of an explosion if the hydrogen from corrosion is collected in closed containers only arises when the containers are opened and air is admitted. Storage of bulk uranium metal in a building in air, as opposed to closed containers, is entirely practicable and safe. Should the consequent slow corrosion be unacceptable, it is feasible to consider development and application of a protective coating.

Response 29

As explained in the response to comment number 1 by this commentor, long-term storage of depleted uranium metal was considered but was not analyzed in detail in the PEIS. Due to its high density, depleted uranium metal would require less storage space than the other uranium forms under consideration in the PEIS. However, as noted in Sections 2.3.3 and 2.3.4 of the PEIS, this advantage must be weighed against disadvantages such as higher conversion cost, lower chemical stability than the uranium oxides, and uncertainty about the suitability of the uranium metal form for disposal.

Further information concerning options not analyzed in depth in the PEIS (such as long-term storage of depleted uranium metal) is provided in Section 4.0 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 30

In a response to a comment on the storage of uranium in forms other than oxide, received during the scoping process for the PEIS, it was stated that "the rationale for the selection of these chemical forms for analysis will be presented in the PEIS." The same response questions the suitability of uranium metal, as opposed to uranium oxide, for storage on the grounds of "higher conversion cost, lower stability and uncertainty of the suitability of the metal form for eventual disposal." The Engineering Analysis, Cost Analysis and PEIS fail to justify any of these assertions. No account is taken of the introduction of new technologies which would produce uranium metal at significantly lower cost.

Response 30

The engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) provides the rationale for why depleted uranium in the form of metal was considered but not analyzed in detail in the PEIS. The EAR is incorporated into the PEIS by reference and summarized in Appendix O of the PEIS. The rationale for considering but not analyzing in detail the long-term storage and disposal of depleted uranium metal is also summarized in Sections 2.3.3 and 2.3.4 of the PEIS.

Section 4.4 of Chapter 4 of the EAR (Summary of Principal Options Not Analyzed in Depth) states that depleted uranium metal storage would require specialized packaging and enhanced facility maintenance compared with depleted uranium oxide storage, because depleted uranium metal slowly oxidizes and releases hydrogen. In addition, Section 1.2 (Background on the Disposal of Depleted Uranium) of Chapter 6.13 (Disposal Options for Depleted Uranium Management) of the EAR states that finely divided uranium metal is pyrophoric and is restricted from disposal by site-specific waste acceptance criteria.

The EAR considered technologies primarily based upon the recommendations received in response to the Request for Recommendations (59 FR 56324). These recommendations were reviewed by a panel of independent technical experts. The EAR analyzed in detail only those technologies that met the criteria used by the independent technical reviewers. One of the criteria was the technical maturity of the technologies reviewed. If in the future new technologies became available that would outperform the technologies analyzed in the EAR and the PEIS, they would be considered as part of the future planning and analysis process that would take place after the Record of Decision is issued for this PEIS.

Comment 31

Disposal Module: Using 30 gal drums for UO_2 disposal is not an optimum solution. There are no real reasons why 55 gal drums (about 2,000 kg weight) cannot be used and handled efficiently. This would reduce the number of drums to be disposed with consequential lower environmental impacts.

Response 31

UO_2 is usually stored in 30-gallon drums, because of the density of UO_2 (a 30-gallon drum of UO_2 weighs about 2,350-lb [1,070 kg] filled). A 55-gallon drum of UO_2 would weigh about 4,300 lbs (1,950 kg), and would have to be specially-made so as to not to fail or deform due to the weight of the contents.

Comment 32

Recommendations from the Technology Assessment Report to dispose of the uranium as metal have not been analyzed even though they were considered feasible. Uranium metal is accepted at commercial disposal sites in the USA, and there are no NRC regulations which would prevent

such disposal. The DOE Orders which specifically exclude fluorides and metal from the Nevada Test Site and Hanford should be comprehensively reviewed to identify the adverse consequences/impacts, if any, which lead to the dismissal of U metal as a suitable form for disposal.

Response 32

For reasons explained in the responses to comment numbers 1 and 7 from the commentor, disposal of uranium metal was considered but not analyzed in detail in the PEIS. Review and revision of DOE Orders are beyond the scope of the PEIS.

Comment 33

The U oxides are stated to be the preferred forms for disposal because of their stability and slow dissolution rates in water. Uranium metal is slow to dissolve in water, and therefore should be considered for disposal especially when the much smaller volume of metal is taken into consideration.

Response 33

For reasons explained in the responses to comment numbers 1 and 7 from this commentor, disposal of uranium metal was considered but not analyzed in detail in the PEIS.

Comment 34

The reduced volume of the uranium metal would significantly reduce the impacts on the environment as the PEIS shows that most environmental impacts tend to be proportional to volume. The observations that impacts for the denser UO_2 are less than for U_3O_8, and the impacts for ungrouted waste forms are less than for grouted waste forms because the volumes are lower (about 50%) should enhance the case for disposal as U metal because metal volumes will be even lower. Disposal as U metal blocks would not involve grouting and would therefore also have lower environmental impacts through the avoidance of the long term effects of grouting.

Response 34

Please see responses to comments 1, 7, 32, and 33 by this commentor.

Comment 35

It is not correct to describe surface oxidation of U metal as "similar" to HF formation from reaction of uranium fluorides with water. The consequences of the two are very different.

Response 35

It is unclear as to which section of the PEIS that the comment is referring to. The surface oxidation of uranium metal can form a pyrophoric surface because of reaction with air and moisture, which can spontaneously ignite. UF_6 reacts with water to form the soluble reaction products uranyl fluoride (UO_2F_2) and hydrogen fluoride (HF), both of which are toxic.

Comment 36

Areas where the Assessment Methodologies could be improved: Radiation and chemical effects are analyzed by considering the maximally exposed individual (MEI) in three groups, "involved workers," "noninvolved workers" and "members of the general public." However, no account seems to have been taken for cumulative exposures between groups (the MEI in the involved worker group could also be the MEI in the general public group if he/she lives near the site). This approach has resulted in some anomalies, such as in the case of the manufacturing facility where the MEI radiation dose and hazard index of a member of the general public are predicted to be greater than those for a noninvolved worker, under normal operating and certain accident conditions. A preferable approach would be to use a larger number of critical exposed groups, chosen to be mutually exclusive.

The chemical and radiation risk to the MEI for the involved worker group during normal operations has not been quantified. The reason given is that worker activities are uncertain at this stage. However, uncertainties such as this have not stopped the authors from making conservative assumptions in order to quantify environmental impacts in many other areas of the PEIS. The PEIS approach must be consistent.

Response 36

Risks to the maximally exposed individual (MEI) member of the public and the MEI among workers were calculated separately because different exposure pathways and durations apply to each individual. For example, the general public MEI was assumed to be present at the off-site location of highest concentrations of materials released from cylinder management operations for 24 hours per day, 365 days per year. Workers were assumed to spend 8 hours per day, 200 days per year at the on-site location of highest concentrations of materials. Additional exposure pathways are also included for the general public MEI, such as ingestion of contaminated water and food. If a person lived near the site and worked at the site, that person's exposure and risk could be estimated conservatively by adding the MEI public dose to the MEI worker dose. With respect to instances where the dose and risk to the general public MEI are estimated to be greater than the dose and risk to the non-involved worker, this situation is due to the physical behavior of some airborne substances released from stacks. Due to buoyancy effects, substances released from stacks may rise further in the atmosphere prior to deposition on ground surfaces. Where this effect occurs, it causes a receptor at a location closer to the stack to have a lower exposure than a receptor further away. The concentrations of contaminants of concern at various locations away from the assumed release points (stacks) were calculated using verified computer models in wide use in the scientific community. See Section C.1 of Appendix C for more information and references to these computer models.

Radiological impacts were evaluated in the PEIS for involved workers, but the evaluation was limited to external radiation exposure. Radiation doses and chemical exposures from inhalation would be expected to be small because (1) processes would be enclosed, (2) ventilation controls

would be in place to inhibit airborne emissions within facilities, (3) indoor air would be monitored to ensure concentrations were below applicable standards, and (4) workers would be provided with appropriate personal protective equipment (e.g., respirators) if internal exposures were possible. Furthermore, the conceptual nature of the conversion, storage, manufacturing, and disposal facility designs does not allow for an accurate estimate of potential indoor air concentrations at this time. The sites where depleted UF_6 management activities would occur would have approved radiation protection programs in place before the activities begin. Worker exposures would be kept below applicable administrative and regulatory limits and would be subject to the ALARA principles.

Comment 37

The impacts to the involved workers of clearing up from the assumed accidents have not been considered. The amount of material released inside the plant which the involved workers would have to clean up is likely to be significantly more than the amounts quoted in the PEIS, which are presumably the amounts released to the environment outside the process buildings.

Response 37

After an accident, many precautions would be taken to limit the exposure of clean-up workers, including wearing of protective clothing, use of respirators, and limiting the time spent in the vicinity of released radioactive materials. Additionally, the exposures of clean-up workers would be carefully monitored to ensure that their exposures were kept within regulatory limits. Because of these protective measures, exposures of individual cleanup workers would generally be low. At the programmatic level such as the case for this PEIS, the facility designs are preliminary and many of the sites where the facilities would be constructed are not known. Therefore, any estimates for exposure and intake of clean-up workers would be highly speculative.

Comment 38

The environmental impacts due to human intervention (deliberate and inadvertent) do not appear to have been addressed. While human intervention is most applicable for the disposal option (post-closure phase), where mining and construction activities could bring material back to the surface, there are also human intervention scenarios plausible for all of the other options. No mention is made of any institutional controls likely to be in place to help prevent such occurrences. Assessment of the risks resulting from human intervention is usually carried out by an expert elicitation process to determine the probability and consequences of various human actions.

Response 38

In the PEIS it was assumed that the long-term storage facilities would be monitored throughout their use, and that the disposal facilities would be monitored and maintained (i.e., have institutional controls) for some period of time after placement of the materials. During the monitoring period, any deliberate or inadvertent human intervention would be quite limited and not of significant consequence with respect to the impacts estimated in the PEIS.

The environmental impacts during the post-closure phase of disposal are discussed in Section I.4.1.1 of Appendix I in the PEIS. After the institutional control period, it was assumed that the disposal facilities would fail (that is, release waste to the environment). The analysis of this failure generally assumed that it was due to natural causes (i.e., percolation of groundwater through the disposal facilities). However, Section I.4.1.1 also discusses the radiological impacts that could be caused by external radiation and inhalation of contaminated dust particles if all the cover materials above the disposal site were removed and containers of U_3O_8 or UO_2 disintegrated. This type of analysis could be likened to the analysis of human intervention scenarios in waste disposal where it is assumed that the waste is dug up by individuals and brought up to the surface. The text of Section I.4.1.1 has been modified to acknowledge that human intervention could be the cause of such a scenario. However, detailed analysis of human intervention scenarios, including an assessment of their probability of occurrence, would be performed if site-specific disposal analyses were to be conducted.

Comment 39

The environmental impacts due to the disposal of secondary wastes such as MgF_2 from the conversion options have not been fully addressed. The only impact addressed is the extra burden on the capacity of the disposal sites and the environmental impacts due to the construction of new disposal sites to cope with the increase in demand. The post-closure impacts of such sites are not addressed in the PEIS.

Response 39

All secondary wastes generated from depleted UF_6 management alternatives would be required to be disposed in state- or federally-licensed disposal facilities. The licensing process for such facilities would examine the potential post-closure impacts. The analysis of post-closure impacts on separate licensed disposal facilities is beyond the scope of the PEIS.

Comment 40

The prediction of groundwater contamination is highly site-specific. Most of the calculations in the PEIS connected with this issue have to make large assumptions over the geochemical and hydrological characteristics of generic sites and the value of environmental impacts calculated in this way is questionable. Only site-specific data should be used when calculating risks from a groundwater pathway.

Response 40

Because this PEIS is programmatic, no site-specific groundwater calculations were performed except for continued storage and cylinder preparation in which site-specific data for Paducah, Portsmouth, and Oak Ridge were used (See Table 4.1 and Section 4.2.3 of the PEIS). In addition, the environmental settings of the three current storage sites were used to create a representative range of environmental conditions for conversion and long-term storage options (except for storage in a mine). In order to provide a broad base for alternative comparisons and to

address the potentially large range of groundwater variables, calculations were performed for generic "dry" and "wet" sites for the other management options (long-term storage in a mine, manufacture and use, and disposal). Values for the groundwater parameters used in these calculations were derived from data for sites in these bounding environments. The use of representative and generic sites provides a consistent basis for comparing the strategic management program alternatives at this level of NEPA analysis. Prior to selection of an actual site, more detailed, site-specific calculations would be required, as noted in the comment.

Comment 41

Specific Comments on the Storage Option: Cylinder yard doses do not seem consistent with a strict care, maintenance and inspection regime. Portsmouth at 2 Mev (196 mrem/yr) is most realistic (probably plausible if a large number of personnel are used, and/or remote inspection equipment or shielding is implemented).

Response 41

The radiation doses listed in Chapter 3 (Table 3.3, 3.8, and 3.13) are the measurement data for the cylinder yard workers and uranium material handlers at the three cylinder storage sites. They are the average doses among the radiation workers who, in addition to working in the cylinder yards, might also work in other places.

The radiation doses listed in Appendix D for the continued storage period and Appendix G for the long-term storage options are estimates based on the assumption that (1) strict, vigorous maintenance activities will be conducted in the future, and (2) all the radiation workers work full time (250 days per year and 8 hours per day) in the storage yards. Because of these two assumptions, the estimated doses are greater than the measurement data listed in Chapter 3. However, they are still below the regulatory limits (5,000 mrem/yr) for radiation workers.

Comment 42

Assumption of 0.0041 breaches per cylinder move (Appendix B, Section B3) would result in $2 \times (28{,}351+13{,}388+4{,}683) \times 0.0041 = 380$ breaches if all containers were moved for painting. This does not seem consistent with number of breaches quoted in Table B1.

Response 42

An incorrect handling breach rate was stated in Section B.3 of the Draft PEIS. The value should have been 0.00014. This value was based on 5 breaches initiated by handling damage and the estimated number of 50,000 cylinder moves during storage to date (i.e., 5/50,000 = 0.0001), plus an additional factor added to account for the possibility of a cylinder breach during handling caused by the cylinder being weakened due to previous corrosion (2/50,000 = 0.00004). Thus, the estimated number of breaches at all three sites assuming each cylinder was painted only once (as assumed by the commentor) would be $2 \times (28{,}351+ 13{,}338 + 4{,}683) \times 0.00014 = 13$. However, the number of breaches assumed to occur through the cylinder management period up to year 2040 was actually

59 (see Table B.1). The value of 59 breaches was arrived at using the assumption that cylinders would be painted every 10 years, and that cylinder breaches due to accelerated corrosion would continue until all the cylinders had been painted (completion of painting scheduled for year 2009). The value for the handling breach rate given in Section B.3 has been corrected.

Comment 43

Comprehensive wall thickness testing at time of refurbishment would aid future decision making. However corrosion rates will be difficult to estimate if initial wall thickness is unknown.

Response 43

There is documentation with each cylinder at the time of purchase that the steel plate used to make the cylinder met or exceeded the minimum wall thickness required. DOE has made some attempts at measuring noncorroded areas of cylinder bodies to get some idea or feel for the initial wall thickness for use in the corrosion modeling. While this is not a "perfect" measurement, it routinely has indicated that the minimum wall thickness was apparently exceeded with some tolerance range to spare on a large number of cylinders.

The rate of corrosion has been estimated based on the measurement of a statistically significant number of cylinders from each subpopulation of cylinders. Using the minimum wall thickness and assuming a statistical distribution of initial thicknesses based upon the minimum required, a wall thickness loss over the age of the cylinder has been calculated. From this, an associated corrosion rate can be calculated. The corrosion rate of exposed steel tends to decrease slightly with time because some amount of protection of the substrate is provided by the rust layer(s). Using curve fitting models, penetration depth as a function of time can be calculated. For cylinders spending some time in substandard storage conditions (e.g. in ground contact), these models produce a rate of 1.6-1.7 mils/year. This value is skewed on the high side due to the condition of ground contact no longer existing. For most other cylinders, the corrosion rate is 0.5 to 0.6 mils/year at the spots of highest corrosion at the location of highest corrosion areas. On very large areas of cylinder surfaces, the corrosion rate is closer to 0.25 mils/year.

Comment 44

Thorough inspection, testing and painting will result in high doses potentially.

Response 44

Dose estimates were made in the PEIS for inspection, painting, and other cylinder maintenance activities. Estimates for involved workers range from 260 to 740 mrem/yr, as detailed in Appendix D, Tables D.2 and D.22. These levels are below the regulatory limit of 5,000 mrem/yr and also below the DOE administrative control limit of 2,000 mrem/yr. In practice, the doses to individual workers could be lowered if more workers were used and time spent on cylinder maintenance activities were limited to less than 40 hours per week.

Comment 45

In the event of aircraft crash on any of the UF_6 storage areas, the environmental impact would be far greater than for any storage option, e.g. UO_2.

Response 45

These differences have been taken into account in the PEIS and are reflected in the data presented in Tables G.7-G.10 of Appendix G, which show far greater impacts for the aircraft crash in UF_6 storage areas than oxide storage areas.

Comment 46

Uranic oxide powders stored in 200 litre drums expose operators to higher dose rates than UF_6 cylinders. Thin drums are stored indoors to prevent corrosion but periodic inspection is required.

Response 46

These differences are reflected in the PEIS analyses. Based on dose rate data provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), U_3O_8 and UO_2 stored in drums would result in higher doses to workers than UF_6 stored in cylinders. For example, surveillance of U_3O_8 and UO_2 drums in warehouse storage would result in a dose rate of 1.7 mrem/hr, while surveillance of UF_6 cylinders would result in a dose rate of 0.95 mrem/hr. Doses from periodic inspection of the stored drums or cylinders were included as part of the worker dose from activities required for normal operations.

Comment 47

Specific Comments on the Disposal Option: There is no description of the methodology used for estimating post-closure risks for the UF_6 disposal option in the PEIS.

Response 47

The assessment methods used in the PEIS, including those applied for disposal impacts, are summarized in Chapter 4 and in Appendix C for each technical discipline. Detailed assessment results and further discussion of the methodologies is provided in a series of backup reports that are cited throughout the PEIS. For the impacts considered in the post-closure phase, supporting information for the various technical disciplines are presented in: Cheng et al. (1997) for the assessment of human health impacts and Tomasko (1997a, 1997b) for the assessment of water impacts. (See PEIS Appendix C for complete citations.) The intent of this presentation was to provide sufficient information in the PEIS to establish the applicability of the methods and assumptions, with detailed information provided in the supporting reports. The supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 48

The term "indefinite period" needs to be defined in the context of monitoring and maintaining a disposal facility post-closure. Monitoring and maintenance in perpetuity is not a realistic scenario.

Response 48

The sentence containing the term "indefinite period" in the introduction to Appendix I has been revised to indicate that monitoring and maintenance would not occur for perpetuity, but would take place in accordance with regulatory and licensing requirements.

Comment 49

The impact of post-closure peak doses from uranium daughters at 1,000 years is not sufficiently long since peak doses from uranium daughters occur much later. A more reasonable assumption would be 10^8 years.

Response 49

Evaluation of disposal impacts over the first 1,000 years after failure provides a consistent, valid basis for comparing UF_6 strategic management alternatives involving disposal. If the strategy selected in the ROD involved disposal, and specific sites were to be evaluated for site suitability in the future, time periods appropriate for the analyses (which may extend beyond 1,000 years after failure) would be considered.

Comment 50

The PEIS finds that groundwater contamination in the post-closure phase of a disposal site in a wet location could lead to both the radiation dose to the public exceeding regulatory limits and the concentration of uranium causing adverse health effects. These effects are dismissed by stating that the water could be treated or an alternative source used. Given that this is one of the few instances in the PEIS that such limits are exceeded, this is neither a scientific nor a publicly-reassuring stance and does not fit in well with the general environmental impact assessment approach used in the PEIS. This is an example where the PEIS would have benefitted from utilizing a full treatment of uncertainty/sensitivity analysis to give realistic rather than conservative estimates.

Response 50

The detailed analysis presented for disposal in Appendix I of the PEIS does indicate that the dose to a hypothetical receptor from contaminated groundwater would exceed regulatory limits for a disposal facility in a representative "wet" environment for all three disposal options considered (the analysis also indicates that groundwater impacts would be less than regulatory limits for a disposal facility located in a "dry" environment). The statement that water could be treated or an alternative source provided was not intended to "dismiss" these potential impacts, but rather to indicate that mitigation measures are available and that the health impacts could be avoided.

The PEIS stresses in Appendix I that long-term disposal calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. These uncertainties were addressed in the PEIS by evaluating a range of conditions for a small number of factors known to significantly affect the magnitude of impacts (i.e., sensitive parameters). These factors included precipitation rates, depth to groundwater, and soil characteristics. A comprehensive uncertainty and sensitivity analysis was not conducted primarily for two reasons: (1) the purpose of the PEIS was to evaluate and compare potential environmental impacts on a broad programmatic level, and (2) the conceptual nature of facility designs and processes at this stage generally does not readily support sensitivity analyses for most parameters. After the Record of Decision for the PEIS, DOE would evaluate potential facility locations and conduct appropriate and more detailed site-specific analyses for any required facilities.

Comment 51

Vaults appear to perform less well than shallow trenches in terms of human health impacts. Does this imply that vaults should be dismissed in favour of shallow earthen structures? Some clarification is needed as to the reasons why ". . . the concentrations from the vault would be greater than those from shallow earthen structure by a factor of 1.2."

Response 51

The PEIS results are not meant to imply that vaults would be dismissed in favor of shallow earthen structures. As stated in Section I.1 of the PEIS, the potential impacts from disposal were considered to be very similar for shallow earthen structures, vaults, and a mine. In addition, Section I.1 states that vault and mine disposal facilities would be expected to last longer than shallow earthen structures before failure and would therefore provide a greater amount of protection. The selection of a specific disposal facility type must take into account all factors considered in an EIS, as well as other information, such as engineering design requirements, cost, and regulatory requirements.

The detailed analysis presented for disposal in Appendix I of the PEIS does indicate that the groundwater concentration beneath a vault would potentially be greater than the concentration beneath a shallow earthen structure for disposal in a "wet" environment. The factor of 1.2 is discussed in Tomasko (1997; the full citation is provided in Appendix I of the PEIS) as mentioned in Section I.4.2 of the PEIS and is associated with design considerations. Briefly, the factor 1.2 comes from increased dilution for the shallow earthen structure as a result of its smaller size (the length of the shallow earthen structure parallel to direction of groundwater flow is 1.2 times less than that for the vault). However, it must be stressed, as noted in Appendix I, that the PEIS analysis is based on generic environmental settings and is subject to a great deal of uncertainty. Actual groundwater impacts would depend greatly on the specific disposal facility design and site-specific

factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility.

Comment 52

The chemical form of a release due to failure of a uranium metal furnace should be U_3O_8 and not UO_2.

Response 52

U_3O_8 is formed when bulk uranium metal burns at temperatures above 700 degrees Centigrade. The postulated accident considering the failure of a uranium metal furnace assumes spontaneous reaction with air (but, not combustion), to form fine UO_2 particles. Therefore, for the conditions postulated for the accident, formation of UO_2 is more appropriate than formation of U_3O_8.

Commentor No. 42: Karpin, Timothy L., CHMM

Comment 1

In summary, I agree with the DOE's position that depleted UF_6 can and should be reprocessed into either a uranium oxide or uranium metal form for use in commercial or industrial settings. The American public, whether they care to or not, has spent significant funds during the last 50 years on the mining, milling, processing, and enrichment of uranium. It would be economically negligent to reprocess and dispose of depleted UF_6 into a form and location, respectively, that can no longer be of use or benefit to American citizens or industry. Such a process would also be in contrast with America's recognition of the value of recycling valuable raw materials.

Response 1

Comment noted. DOE recognizes the value of depleted uranium based on its unique qualities, the size of the inventory, and history of uses already implemented. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products.

Comment 2

Comments related to Volume II, Appendix E: 1. Why not ship all casks in clamshell cases?

- No UF_6 transfer facility would be needed, which would reduce potential environmental impact and permitting activities.
- The use of clamshell cases could possible reduce the number and cost of ultra-sonic wall thickness tests.
- Clamshell case costs would not go up if a local facility is used to process UF_6 (i.e. it may be more economical to build 2 or 3 facilities near each gaseous diffusion plant).

- Public perception would be more favorable toward the DOE if the DOE shows demonstrated caution by using clamshell cases. The DOE's decision tree would be reduced by one layer, and one area of judgment/opinion would be eliminated.
- Accident scenarios would decrease with regard to potential environmental and health impacts.
- Consider modifying nearby runways and flying MD-17s in and out with clamshell cases. (MD-17s are civilian versions of the new C-17 military transport.) Of course, an economic study would be required to validate this concept.
- The costs and energy/resource consumption of a transfer facility would be very high in comparison to clamshell case use.
- One important issue was not directly discussed. You would need a separate facility or partitioned area at the UF_6 processing facility to decontaminate the clamshell cases (if necessary).

Response 2

The PEIS did consider shipment of all depleted UF_6 cylinders in overcontainers, as noted on page E-2. The environmental impacts associated with cylinder overcontainer operations are provided in Table E.3. With regards to permitting activities, the overcontainers would be designed, tested, and certified to meet all DOT shipping requirements.

The PEIS analysis assumed that the overcontainers would be used primarily for offsite shipment of depleted UF_6 cylinders. The overcontainers could presumably be used for extended, enhanced storage of the cylinders. It would however be expected that the cost of a single overcontainer would be much greater than the annual costs of cylinder inspection by ultrasonics.

It was assumed that the third comment relates to potential conversion of UF_6 at the three current storage sites. The decision of where to site any required conversion facilities would be made in future planning documents. This subsequent analysis would establish the location(s) where any required overcontainers would be fabricated.

The accident scenarios considered for the cylinder preparation options are provided in Table E.4. The use of cylinder overcontainers could potentially reduce the consequences of an offsite transportation accident.

Current U.S. Department of Transportation guidelines (e.g., 49 CFR 172, 49 CFR 173.27) do not allow transport of low-specific-activity radioactive material like depleted UF_6 by cargo or passenger aircraft.

As shown in Table E.2, there would be no impacts on a local or national scale, due to resource requirements for any of the three cylinder preparation methods.

As noted in Table E.16 of the PEIS, it was assumed that decontamination of the overcontainer surfaces would be performed at the conversion/storage facility prior to it being sent back for reuse.

Commentor No. 43: Versgrove, Tom
See responses to Commentor No. 51

Commentor No. 44: Thompson, Thomas
See responses to Commentor No. 51

Commentor No. 45: Donham, Mark / Hanson, Kristi

Comment 1

We are concerned about the failure of DOE to reference or mention the 3 studies and/or reports which specifically address the cylinder problem. These are "Draft Preliminary Report — DOE Independent UF_6 Cylinder Assessment Team," from the Oak Ridge Field Office, Mar. 25, 1992; "Integrity of Uranium Hexafluoride Cylinders" and "Affordable Cleanup? — Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities," National Research Council, National Academy Press, 1996.

Response 1

Except for the draft preliminary report, all the reports referenced in the comment were reviewed and used in preparation of the PEIS and supporting documents. A brief discussion of these reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided. The draft preliminary report was never finalized, so it is not cited in the PEIS.

Comment 2

One of the first key issues which must be addressed is the earthquake risk at Paducah from the New Madrid fault/rift zone. Any strategy for dealing with the cylinders has to address this problem, as well over half the cylinders are in Paducah. Most of these cylinders are stored on soils with liquefaction potential. Due to the close stacking of the cylinders, and the configuration of the stacks, breach of cylinders due to puncturing from other cylinders in the event of a seismic event strong enough to move the cylinders is probable. Any punctures in the cylinders would result in the slow release of hydrogen fluoride and uranium and other radionuclides, which would then accelerate the further corrosion of the cylinders. Because the tens of thousands of cylinders are stacked in a configuration which makes it virtually impossible to access cylinders in the center of the stacks in a timely fashion. These factors are why the seismic risk at Paducah has to be considered in any long term strategy to deal with the cylinders.

Response 2

The safety of current storage of depleted UF_6 cylinders was addressed in the safety analysis reports (SARs) recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including earthquakes. The potential for soil liquefaction was also considered. The accidents considered in the PEIS for continued cylinder storage (Appendix D) were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Recent safety literature indicates that cylinders would not be subject to any significant damage due to earthquake loadings. Due to the weight of the cylinder, some movement may result in enough force to cause failure by physical impact from other cylinders. However, with the UF_6 being solid and the impact area being relatively small, only limited releases of material would be expected.

The stacking configuration is only considered a seismic problem if cylinders have been stacked stiffening ring to stiffening ring (as opposed to stiffening ring to cylinder body), thus allowing a small surface area to support the upper tier cylinder. For those conditions, the operating contractor has placed support wedges between the cylinders providing more surface area support of the upper cylinder. As cylinders are restacked and relocated into the approved stacking configuration, this condition will be eliminated.

Comment 3

In considering the long term seismic risk at Paducah and its effect on cylinder management, the first question to ask is, will any future conversion/storage take place at Paducah. If the answer is yes, and if the plans are to bring cylinders in from Portsmouth and Oak Ridge, then these facilities have to be built to highest earthquake standards available. In addition, transportation risks from Portsmouth and Oak Ridge to Paducah must be considered.

If the answer is yes, but only for the Paducah cylinders, then either three conversion facilities will have to built or the facility will have to be mobile, which means it will have to be transported contaminated or will have to be completely decontaminated. None of these alternatives is looked at in the PEIS.

If the answer is no, there will not be conversion/storage at Paducah, then the massive transportation burden to get the 40,000 cylinders at Paducah, some of which it is doubtful could be

moved, from Paducah to wherever the conversion/storage would take place. This is not considered properly in the PEIS.

Response 3

An analysis of the impacts of preparing cylinders for transportation at any of the three storage sites is provided in Appendix E of the PEIS. However, the purpose of the PEIS is to provide an analysis of broad, programmatic alternatives, and not to select sites. The location(s) and number of conversion facilities are beyond the scope of the PEIS and will be addressed in future planning and environmental analyses. Site selection activities would evaluate site characteristics, such as potential response to seismic events, potential for flooding, and site geology to ensure that suitable locations were chosen. Following site selection, any new facilities would be designed and built to meet engineering and construction standards and requirements appropriate for the selected location and the mission of the facility.

Comment 4

Connected Actions/Cumulative effects: To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include: (a) Actions (other than unconnected single actions) which may be:

(1) Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they:

(i) Automatically trigger other actions which may require environmental impact statements.

(ii) Cannot or will not proceed unless other actions are taken previously or simultaneously.

(iii) Are interdependent parts of a larger action and depend on the larger action for their justification.

(2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

(3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

It is clear that the UF_6 DPEIS is inadequate in both its scope and its cumulative effects analysis, and that this flaw is serious.

Certain alternatives for dealing with the DUF_6 cylinders are provided in the DEIS. Those alternatives include conversion to Uranium oxide, conversion to uranium metal, and long term storage.

In order to convert to either uranium metal or uranium oxide, several unavoidable, connected steps must be undertaken. These include (1) building the facilities which will empty the cylinders and convert the DUF_6; (2) the cylinders will have to be moved to the facility; (3) the material will have to be defluorinated; (4) the emptied cylinders will have to be washed and dealt with, and a wastewater treatment plant will need to be built to treat the effluent, which will contain small amounts of transuranics; (5) the hydrogen fluoride will have to be placed into cylinders and stored or disposed, which will require facilities; (6) the empty DUF_6 cylinders will have to be dealt with; (7) the converted material will have to be disposed or stored.

If one of the conversion alternatives is chosen as the preferred alternatives, there is no avoiding any of the above steps. These are all clearly "connected actions" as described above. Yet, the DEIS defers analysis of the effects of the conversion process until a future NEPA document. This future NEPA analysis would come at a time when a decision has already been made committing to one of these alternatives. NEPA requires that information be made available to decision makers and the public before decisions are made and actions taken.

Response 4

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. In evaluating potential environmental impacts of these alternatives, the PEIS does indeed consider all of the activities that would be necessary to implement each of the alternative strategies (see Sections 2.1 and 2.2 of the PEIS). However, as a programmatic EIS, it does not propose any site-specific activities — apart from those that can only occur at a current storage site for depleted UF_6 (continued storage and cylinder preparation for transportation). Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to enable a comprehensive comparison of the strategy alternatives (see Section 3.4 of the PEIS). The potential impacts from construction and operation of such representative facilities are included as best possible in the PEIS, given the information that currently is known. Upon implementation of a depleted UF_6 management strategy, which will be selected in the Record of Decision for the PEIS, site-specific evaluations will be performed — including the effects of site-specific projects and range of alternative actions, including a No Action Alternative.

Comment 5

In addition, at all of the facilities involved (Paducah, Portsmouth, and Oak Ridge) there are other cleanup activities ongoing, either under the WM or ER programs of DOE. These activities are clearly "proposals" and could have cumulative effects in regard to releases of radionuclides and other hazardous substances. The cumulative effects analysis of this DEIS (and the segmented NEPA

analysis of the other cleanup projects ongoing at the sites) needs to be looked at in combination. The DEIS fails to make this important analysis.

Response 5

Sections 5.8 and 6.3.8 of the PEIS present cumulative impact analyses for each of the three current depleted UF_6 storage sites. As summarized in Tables 5.12, 5.13, and 5.14 for the Paducah, Portsmouth, and K-25 sites, respectively, the calculation of cumulative impacts included impacts of existing operations (both at the sites and close enough to affect them), impacts of the two depleted UF_6 management activities known to occur at those locations (continued storage and cylinder preparation for transportation), and impacts of other reasonably foreseeable future actions (once again, both at and near the sites). The latter are identified in footnote "a" of each of the aforementioned tables and include waste management activities. The topic of impacts resulting from environmental restoration activities has been reexamined. Impacts of recent and current environmental restoration activities whose magnitude can be identified clearly have been added to the cumulative impact calculations for each site, appearing under existing operations and identified in footnote "a" in the tables listed above. As discussed in Section 5.8.1, the impacts of future environmental restoration activities were not included in the cumulative impact analysis because of insufficient characterization of the contamination or because proposals for particular actions were not yet final when the PEIS was prepared; these impacts would be included in pertinent site-specific CERCLA or RCRA program documents.

Comment 6

As is true is most DOE NEPA documents, there are sweeping impact assumptions based upon referenced material, mostly internal DOE information. NEPA requires that agencies which incorporate by reference material in an EIS make that material readily available to the public for review. Yet there is no mention where such referenced material (such as the GENII model) could be reviewed or obtained. This is a serious and blatant flaw in the DEIS.

Response 6

All reports and materials referenced in the PEIS are readily available to the public. As noted on the cover sheet of the PEIS, documents prepared specifically in support of the PEIS are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), or by contacting the DOE program manager (identified on the cover sheet of the PEIS). In addition, other references that are cited in the PEIS can be obtained by directly contacting the program manager at the toll-free number listed on the PEIS cover sheet. This approach is consistent with guidance provided by the Council on Environmental Quality (CEQ) that states: "Material that is not directly related to preparation of the EIS should be incorporated by reference. This would include other EISs, research papers in the general literature, technical background papers or other material that someone with technical training could use to evaluate the analysis of the proposal. These must be made available, either by citing the literature, furnishing copies to central locations, or sending copies directly to commentors

upon request (Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations)."

Comment 7

NEPA does not allow conclusory assertions of no impact to suffice for a hard look. Assumptions in an EIS must be supported by objective or empirical data. By DOE making sweeping, conclusory statements of no impact (for example, of the environmental impact of the release of radiation from the activities associated with DEIS) based upon internal studies, which are not explained or described and which are not readily available to the public, DOE is violating one of the main tenants of NEPA — to inform the public of their proposed actions.

Response 7

The assessment methods used in the PEIS are described in Chapter 4 and in Appendix C for each technical discipline. Chapter 4 also provides a detailed table that describes the general criteria used to summarize and describe the magnitude of environmental impacts for each area of impact considered in the PEIS. The main body of the PEIS provides a discussion of the types and magnitude of potential environmental impacts for each alternative, with additional supporting technical information provided in the appendices. Detailed assessment results and further discussion is provided in a series of backup reports that are cited throughout the PEIS. Specifically, supporting information for the various technical disciplines is presented in: Cheng et al. (1997) for the assessment of human health impacts during normal operations; Policastro et al. (1997) for the assessment of accident impacts; Tschanz (1997) for the assessment of air impacts; Tomasko (1997a, 1997b) for the assessment of water impacts; Biwer et al. (1997) for the assessment of transportation impacts; and Allison (1997) for the assessment of socioeconomic impacts. (See PEIS Appendix C for complete citations.) The computer models, and exposure and risk assessment methods used in the PEIS are in wide use in the scientific community and are referenced as appropriate in Appendix C and the backup reports.

The intent of the PEIS presentation of results was to provide sufficient information to establish the applicability of the methods and assumptions, with detailed information provided in the supporting reports. The supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Commentor No. 46: Barnwell, Carlene
See responses to Commentor No. 51

Commentor No. 47: Jones, Carol Westerman / Jones, Anthony E.
See responses to Commentor No. 51

Commentor No. 48: Klueter, Karla
See responses to Commentor No. 51

Commentor No. 49: Mobley, E. V.
Coalition 21

Comment 1

I agree with and support the DOE preferred alternative i.e., use rather than disposal of the UF_6.

Response 1

Comment noted.

Comment 2

Vol 1, S.5.1, contains an informative summary of possible uses for converted UF_6 in addition to cask shielding, but its location in the document makes it a surprise. I suggest that other possible uses be mentioned in paragraph S.2.

Response 2

By necessity, the summary contains only an overview of the alternatives and analyses conducted in the PEIS. Additional information on use options is provided in the main body of the PEIS, specifically Sections 2.2 and 2.3 and Appendix H.

Comment 3

The radiation effects calculations are based on the linear-no-threshold (LNT) hypothesis (Vol 1, S.4.3.1.1.2 and Vol.2, C.4.2.2). A number of studies, for example those cited in the Scientist, March 3, 1997 and in Nuclear News, June 1997, indicate the LNT hypothesis is excessively conservative and in some cases is detrimental. I suggest an improved analysis practice that includes evaluating the magnitude of the conservatism instead of merely stating that the result is conservative. Data are available for derivation of best-estimate or most-probable health effects. A more realistic presentation in the UF_6 PEIS would result if there were comparison of best-estimate and conservative health effects.

Response 3

Considerable debate exists within the national and international radiation protection communities concerning the appropriateness of the linear, no threshold model for low doses of

radiation typical of environmental and occupational exposure levels. However, it is generally recognized that the linear, no threshold model provides conservative estimates of impact in the low dose range. Consequently, the use of the linear, no threshold dose-response model is a well-established risk management policy throughout the U.S. government, including the Department of Energy, the Environmental Protection Agency, and the Nuclear Regulatory Commission, as well as throughout the world. The health risk conversion factors used in the PEIS, which are based on the linear, no threshold model, are specified in DOE's "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements (1993)" (commonly referred to as the DOE "green book").

In addition, it is important to recognize that one of the primary purposes of the PEIS, as well as any EIS, is to provide a comparison of impacts among alternatives. Although the linear, no-threshold model likely results in an overestimate of radiological impacts for low doses, the choice of this model would not effect relative comparisons among the PEIS alternatives.

Comment 4

In Volume 2, paragraphs C.4.1.5, C.4.2.2, and C.4.2.3, it appears that four different dose to health effects conversion standards were used. I suggest some additional explanation to avoid the appearance of confusion.

Response 4

Please see Volume 2, Section C.4 which has been revised to clarify the use of health effects conversion standards.

Commentor No. 50: Wheeler, Norma S.
See responses to Commentor No. 51

Commentor No. 51: Whayne, Sue / Roberts, Mary Lee / Ray, Betty

Commentors No. 43, 44, 46, 47, 48, 50, 52, 54, 63, 66, 67, 68, 69, 70, 73, 74, 77, 78, 79, 83, and 86 submitted the same comments as Commentor No. 51.

Comment 1

The scope of the DPEIS is inadequate to cover the activities required to deal with the cylinders. Implementing either of the conversion alternatives will trigger a series of events which will have to take place in order to complete the conversion. These include building factories to do the conversion and for cleaning the highly radioactive residues out of the emptied cylinders. The DUF_6 will have to be defluorinated, which is a highly dangerous activity. The converted material

and the empty cylinders will have to disposed or stored, as will the hydrogen fluoride which is separated from the DUF_6.

Response 1

For each of the alternatives, the PEIS considered all of the activities that would be required during implementation, as shown in Figure S.2 and Figure 2.1. The types of activities considered included continued storage of the cylinders for some period of time (Appendix D); preparation of cylinders for shipment (Appendix E); conversion (including defluorination activities) and treatment of emptied cylinders (Appendix F); long-term storage (Appendix G); manufacture and use (Appendix H); disposal (Appendix I); and transportation (Appendix J). The evaluation of potential environmental impacts for these activities included both the construction and operation of facilities during normal and accident conditions. The overall environmental impacts of an alternative were found by summing the impacts from each of the required activities, as appropriate, as described in Section 2.1. Consequently, the analysis in the PEIS addresses all of the events that would be triggered by the selection of a specific management strategy.

Comment 2

These activities are all connected actions which require a hard look in combination with the ongoing cleanup activities at the three facilities where the cylinders are stored — Paducah, Portsmouth, and Oak Ridge. There are clearly cumulative effects from these proposals and projects which are not adequately addressed in the draft.

Response 2

Section 5.8 presents calculations and evaluations of cumulative impacts for each of the three depleted UF_6 storage sites mentioned in the comment. With regard to the management alternatives considered in the PEIS, the only activities considered in cumulative impact calculations were those associated with known locations (where the impacts would accumulate) — namely continued storage and cylinder preparation for transportation (both of which would occur at the three storage sites). Added to those impacts are the estimated impacts of waste management activities at each site as well as other activities associated with DOE and non-DOE organizations (see Tables 5.12, 5.13, and 5.14 for a listing of activities and the results of cumulative impact calculations).

The subject of environmental restoration (presumably synonymous with the "cleanup" activities noted in the comment) impacts has been reexamined in the context of cumulative impacts. When adequate information has been available on the impacts of recent and current environmental restoration efforts, those impacts have been added to the aforementioned tables under Existing Operations, and documented accordingly. As discussed in Section 5.8.1, the impacts of future environmental restoration activities were not considered in the calculation of cumulative impacts because of insufficient characterization of the contamination and because proposals for specific actions were not yet final as of the development of the PEIS.

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As noted in Section 1.4, the PEIS uses a two-phase approach to NEPA evaluation which is consistent with DOE's implementation of a strategy for the long-term management of depleted UF_6. Cumulative impacts are evaluated as completely as possible within the context of this programmatic document. Once DOE decides which depleted UF_6 management strategy to pursue (the decision supported by the PEIS and to be documented in the Record of Decision), and makes decisions on site- and technology-specific issues, NEPA documents will be prepared to evaluate potential site- and technology-specific impacts. These future NEPA documents will provide more thorough examinations of cumulative impacts associated with particular places and activities at those places.

Comment 3

Although the largest majority of cylinders, some 40,000, are at Paducah, they are inadequately stacked and stored presently. These are vulnerable to the high seismic risk at Paducah from the New Madrid fault. Because it will be decades or longer before this material can be converted, the risks from earthquake damage go greater as time goes on. Any conversion facilities planned for Paducah have to fully consider the earthquake potential at Paducah, and any construction of conversion facilities at Paducah would have to be made to an earthquake standard. The extra costs of this need to be disclosed.

Response 3

The Department of Energy is currently pursuing improvements to depleted UF_6 cylinder storage conditions at the Paducah site. These improvements include both refurbishment of existing storage yards and construction of a new storage yard.

The potential risks from earthquake damage may be expected to decrease with time, as the DOE implements the above improvements. In addition, activities such as a comprehensive cylinder monitoring and maintenance program, with routine cylinder inspections, ultrasonic thickness testing of cylinders, and cylinder painting to prevent corrosion are designed to ensure continued safe storage of the cylinders.

The construction by DOE of any new facilities that result from this PEIS would follow the general design basis provided in DOE Order 6430.1A, "General Design Criteria." This order covers design criteria (including natural phenomena-related standards) for the design of DOE facilities. Any facilities to be constructed at Paducah would take into account the seismic characteristics of the site. If the facilities are constructed by a commercial entity, applicable NRC or other agency codes and regulations would be followed.

The present-worth costs of the various PEIS alternatives are provided in the cost analysis report (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS), which is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program

manager identified on the cover sheet of the PEIS. The costs presented in this document are based upon a generic site location, to agree with the PEIS. The intention of the PEIS is to determine the most appropriate management strategy for DOE's depleted UF_6 inventory. Future planning and environmental analysis will address issues related to the selection of sites and the associated costs.

Comment 4

If cylinders are going to be transported for conversion, then the risks transportation needs to be considered carefully. This would require many thousands of shipments. Many of the older cylinders may not be capable of being lifted or loaded for transportation. Some may not be able to be heated to be emptied. All of these problems could significantly increase the cost. The DOE needs to be more up-front about the real dollar costs of this problem.

Response 4

As discussed in detail in Appendix E of the PEIS, some fraction of the cylinder inventory may not meet Department of Transportation requirements for shipment and may require some type of preparation if transported. Therefore, in order to estimate the potential health and environmental impacts from transportation activities, the preparation of substandard cylinders for transport was considered in the PEIS. The PEIS considered two cylinder preparation options: the use of overcontainers for substandard cylinders, and the construction and operation of a cylinder transfer facility to transfer substandard cylinder contents to new cylinders prior to transportation (see Appendix E of the PEIS for details on cylinder preparation). The design of the transfer facility assumed that the cylinders would not be heated.

The number of shipments that potentially could be required under each alternative are summarized in Appendix J, with additional details of the transportation assessment given in the supporting report by Biwer et al. 1997 (see Appendix J references for full citation). If transportation of cylinders is required by the selected alternative, several thousand shipments could indeed be required over the duration of the program.

The cost of the various cylinder preparation and transportation options is beyond the scope of the PEIS, but cost estimates are provided in the cost analysis report (LLNL 1997b; the full citation is provided in Chapter 8of the PEIS). The Record of Decision will consider the results of the PEIS, along with other information such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

The cost analysis report and other PEIS supporting reports are available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 5

Although it appears that the best alternative is converting the material from the reactive UF_6 form to the more stable uranium oxide form, the DPEIS doesn't give enough information for the commentors to decide where the best place for conversion would be and the best methods.

Response 5

The purpose of the PEIS is to provide an analysis of broad, programmatic alternatives. Consequently, the impacts of some management activities, such as conversion, were evaluated using representative environmental setting information. The characteristics of these settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the alternatives. However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. Future planning and environmental analysis will address issues related to selection of sites and technologies for the depleted UF_6 management strategy selected in the Record of Decision for this PEIS. This would include technology selection and siting for one or more conversion facilities, if conversion is part of the strategy selected.

Comment 6

Finally, it seems ill-advised to continue to fill more cylinders daily with more DUF_6 while this huge problem of disposal continues to accumulate. If the nuclear industry cannot manufacture its product without creating huge amounts of toxic waste, it should strongly consider ceasing production.

Response 6

Issues regarding the need for uranium enrichment to support fuel fabrication for the nuclear industry are beyond the scope of this PEIS.

Commentor No. 52: Rhodes, Craig / Brown, Charlene
See responses to Commentor No. 51

Commentor No. 53: Hoffman, Eugene E.

Comment 1

How will comments on the Draft PEIS be documented by DOE?

Response 1

All comments received by DOE during the public comment period are presented in this volume of the PEIS (Volume 3). The written documents provided by commentors are found in Section 2.2. Individual comments from those documents are found together with DOE responses in

Section 3.2. Indexes by commentor are included in Section 2.1 and 3.1. Additionally, comments and responses to oral comments from the four public meetings are provided in Chapter 4.

Comment 2

What is the status of the sale of the enrichment plants to USEC?

Response 2

On July 23,1998, USEC stock was made available for public purchase. The privatization was completed on July 28, 1998 with the transfer of the federal government's entire ownership in USEC to the private sector. This was the final step in the USEC privatization process. The gaseous diffusion plants in Portsmouth, Ohio, and Paducah, Kentucky, are leased by USEC and remain the property of the U.S. Government.

Comment 3

The DOE "preferred alternative" (see PEIS, pp. S-42-44) is to "use the entire inventory of material" based on market demand for uranium oxide (UO_2), uranium metal and fluorine products. "Safe management of the cylinder inventory would continue until 100% of the inventory had been converted for use." --- This DOE preferred alternative would be supported by everyone if the DOE assumed use potential had any basis in fact. Every documented evaluation of potential use of the DUF_6 by independent investigators, DOE contractors, and commercial firms in the uranium business during the past ten years has concluded that future use of only a small fraction of the 1,200,000,000 plus pounds of the depleted UF_6 can be projected.

Response 3

Based on the comments received on the draft PEIS, DOE has modified its preferred alternative to include "prompt conversion of the depleted UF_6 into uranium oxide." DOE's revised preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. This would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and metal products for use.

Comment 4

In the PEIS, DOE evaluated six alternative management strategies (see page S-6). However, an option to continue storage of a reasonable (small) fraction of the DUF_6 (only the best cylinders, under shelter) for future use and begin conversion of the most degraded cylinders to the safe, stable form (U_3O_8) was not considered. WHY??

Response 4

The strategy the commentor describes would fall into the category of a "combination of alternatives," specifically, a combination of continued cylinder storage (a.k.a. No Action Alternative) and long-term storage as oxide. As discussed in Section 2.3.7 of the PEIS, the alternatives assessed in the PEIS were based on the assumption that all facilities would be designed to process 100% of the inventory; this approach was intended to provide a conservative estimate of the impacts that could result from each of the alternatives considered. However, DOE did recognize that it would be possible to select a management strategy that is a combination of the alternatives (e.g., 50% continued cylinder storage and 50% long-term storage as oxide). Therefore, the PEIS includes an analysis of potential environmental impacts for a range of facility sizes to allow for an evaluation of combinations of alternatives. Appendix K presents the potential environmental impacts for facilities designed to process between 25 and 100% of the depleted UF_6 inventory. Section K.7.1 presents an example of how to estimate the impacts for any combination of alternatives. The actual schedule or order in which the cylinders would be converted (if conversion is identified in the Record of Decision) is beyond the scope of the PEIS. However, such considerations would be the subject of follow-on studies and reviews.

Comment 5

The 1100-page draft PEIS did not cite or reference the three independent reports that directly relate to the subject of the PEIS. These are listed below:

a) Draft Preliminary Report — DOE Independent UF_6 Cylinder Assessment Team, "DOE Oak Ridge Field Office, dated March 25, 1992 (never published).

b) "Integrity of Uranium Hexafluoride Cylinders," Defense Nuclear Facilities Safety Board Technical Report DNFSB/TECH-4, May 5, 1995.

c) "Affordable Cleanup? — Opportunities For Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities," National Research Council, National Academy Press, 1996, Chapter 7, Disposition of DUF_6.

Response 5

Except for the draft preliminary report, all the reports referenced in the comment were reviewed and used in preparation of the PEIS and supporting documents (for example, the Engineering Analysis Report). A brief discussion of these reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided. The draft preliminary report was never finalized, so it is not cited in the PEIS.

Comment 6

The draft PEIS presents brief and totally inaccurate statements regarding the New Madrid earthquake safety issue, which is of particular importance to the Paducah plant site which has in excess of 28,000 of the DUF_6 cylinders. (PEIS reference — page 3-7)

Response 6

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Of the three storage sites, an earthquake which could cause more than slight damage is considered credible (though highly unlikely) only for the Paducah site. The text of Section 3.1.4.1 of the PEIS has been revised to be consistent with information presented in the safety analysis report for the Paducah Gaseous Diffusion Plant.

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports (SARs) for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs were issued in February 1997 by the DOE's management and operating contractor, and were subsequently reviewed and approved by DOE in March 1997.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the safety analysis reports. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the safety analysis reports are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 7

The French have been converting hundreds of millions of pounds of their depleted UF_6 to the safe, stable oxide and stored it in steel containers in metal framed, earthquake resistant buildings since 1977 to avoid the hazards, associated with storing UF_6.

Response 7

The PEIS considers in Appendix F an option similar to that suggested in the comment, which incorporates the conversion of UF_6 to U_3O_8 practiced on a large scale industrial basis by COGEMA in France. In the PEIS, the U_3O_8 product from the conversion step is then compacted and stored in readily-available 55-gallon drums in a seismically-qualified building, prior to being transported for storage or disposal.

Comment 8

At least 17,475 of the DUF_6 cylinders exhibit accelerated corrosion (Reference: DOE/ORO Work Agreement document, dated 10/30/96). The current DOE schedule for cleaning, inspecting, and re-painting of the cylinders will require at least 30 years, especially when the fact is considered that many of the cylinders will have to be re-cleaned and re-painted at least three times during that

period. Each handling operation risks rupture. (Reference: Letter, S.J. Pawel to M.S. Taylor, Feb. 10, 1997, ORNL/CST-SP-021097-05, "Update on Development Activities," page 4, "The life of the paint system presently in use is not analytically known, but current estimates suggest that a 12-year life (on average) prior to significant maintenance or re-painting is reasonable.")

Response 8

The assumptions used to assess the impacts of continued cylinder storage included painting of the cylinders every 10 years. The risks from handling the cylinders were included in the analysis. See the Introduction to Appendix D of the PEIS for further details on the assumptions used to assess the impacts of continued cylinder storage.

Comment 9

The DUF_6 safety and accident concerns presented in the Defense Nuclear Facilities Safety Board report (DNFSB/TECH-4, May 5, 1995) are not cited in the Draft PEIS.

Response 9

The DNFSB's TECH-4 report was followed by their Recommendation 95-1, which requested, among other things, that the safety analysis reports (SARs) for the three sites be updated. These reports (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS) have now been updated and the results were incorporated into the accident analyses conducted for the PEIS. See Appendix D, Section D.2.2, for a discussion of accident impacts under current storage conditions. If the SARs are revised in the future, DOE's cylinder management program at the three storage sites would be revised accordingly and the safety of the cylinders would be maintained.

Comment 10

On February 18, 1998 a USAF B-1 supersonic bomber weighing in excess of 200,000 pounds crashed and burned approximately 40 miles from the Paducah cylinder storage yards. The Barkely Regional Airport is located approximately 2 miles from these storage yards. Has the accident scenario of a large plane crash on a rainy day been analyzed? Under such circumstances a number of cylinders would be ruptured and large quantities of hydrofluoric acid gas would be generated which could cause additional ruptures and make control of the accident very difficult.

Response 10

Plane crashes were considered but only for small planes. Large planes have flight patterns that do not pass close to any of the three sites and as a result, impacts would be considered in the beyond incredible probability range ($<1 \times 10^{-7}$) for those large planes.

Commentor No. 54: Hanson, Kristi / Donham, Mark
See responses to Commentor No. 51

Commentor No. 55: Volpe, John A., Ph.D
Kentucky Radiation Health & Toxic Agents Branch

Comment 1

DOE must immediately move to convert the entire inventory of DU to the oxide for long term storage.

Response 1

The commentor's preference for converting UF_6 to uranium oxide for storage as soon as possible is noted.

Comment 2

Conversion can not wait for ten years or any period of time.

Response 2

The timetable presented in the PEIS was developed to provide a basis for the calculation of potential impacts (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. Actions were not assumed to be delayed until 2009, rather, for the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory. In fact, as explained in Section 2.5.1 of the PEIS, the preferred alternative in the PEIS has been revised to clarify this point. It now calls for beginning prompt conversion of the depleted UF_6 into depleted uranium oxide.

Comment 3

DOE must conduct the conversion to the oxide at its present storage location. No transportation of DU to a conversion facility.

Response 3

The commentor's preference for conversion of UF_6 to oxide at the current storage sites is noted.

Comment 4

All cylinders must be checked for integrity prior to moving to the on-site conversion facility. All oxide must be stored on-site under cover.

Response 4

The commentor's preference for conversion and storage of the oxide under cover is noted by DOE.

Under the cylinder program management plan, the requirements for moving cylinders on-site are documented in the Cylinder Project's 3-Site Procedure EMEF/EF-P2400 Handling and Inspection of 48" Cylinders. Cylinders are required to be inspected for cylinder integrity prior to being lifted and after they have been relocated. This is to ensure that the cylinder may be lifted safely and that no damage to the cylinder occurred during relocation. The procedures conducted prior to lifting a cylinder are summarized in the Introduction to Appendix E of the PEIS.

Commentor No. 56: Gawarecki, Susan L., Ph.D.
Oak Ridge Reservation Local Oversight Committee

Comment 1

The Citizen's Advisory Panel (CAP) concurs that the alternatives considered in the PEIS are appropriate, but the assumptions which delay action to 2009 with completion in 2028 are not acceptable. We understand that the continued storage of the UF_6 cylinders does not pose an immediate health or environmental threat. However, as time passes, the task of assuring safe storage will become more demanding, with increasing cost for surveillance and maintenance of the deteriorating cylinders.

Response 1

The commentor's preference for beginning actions sooner than 2009 is noted. With regard to the statement that the PEIS assumption that actions begin in 2009 is unacceptable, the timetable presented in the PEIS was developed to provide a basis for the calculation of potential impacts (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. Actions were not assumed to be delayed until 2009, rather, for the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental

reviews. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory. In fact, as explained in Section 2.5.1 of the PEIS, the preferred alternative in the PEIS has been revised to clarify this point. It now calls for beginning prompt conversion of the depleted UF_6 into depleted uranium oxide.

In addition, DOE has entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the UF_6 stored at the ETTP. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from ETTP or complete the conversion of their contents by December 31, 2009.

Comment 2

The condition of the oldest cylinders at Oak Ridge and Paducah should be considered when planning for decontaminating and decommissioning (D&D). The toxicity of the fluorine component is the primary concern with regard to health risk, although release of depleted uranium to the environment could result in a costly public relations disaster.

Response 2

Prior to handling, all cylinders will be evaluated to determine their baseline condition. The oldest cylinders are of the thick wall design and none of these cylinders have been found to have lost wall thickness to less than the minimum required for use. The PEIS considers the toxicity of both fluorine and uranium compounds when evaluating potential accidental releases from cylinders; see Section 4.3.2 for further discussion of how accidental releases of UF_6 were evaluated. It should also be noted that the three storage sites have a great deal of experience in moving and handling these cylinders. For example, over 30,000 cylinder relocations have been conducted since 1992 without causing damage to a cylinder sufficient to cause a breach.

Comment 3

As you may know East Tennessee Technology Park (ETTP, formerly K-25) has an active reindustrialization program underway. The continued presence of the UF_6 cylinders might negatively impact the site reuse activities from an aesthetic viewpoint or as a perceived risk to co-located workers, as well as by the loss of the storage yard land to new uses.

Response 3

The Citizen Advisory Panel's concerns regarding continued presence of the depleted UF_6 cylinders at the ETTP (formerly K-25) are noted. The depleted UF_6 Management Program is committed to working with the Reindustrialization Program at the East Tennessee Technology Park to resolve any issues that may come up with respect to cylinder storage at the site.

Comment 4

DOE has a responsibility to begin reducing its stockpile of UF_6. The CAP urges that an expedited conversion program be started immediately. We have reviewed the voluminous amount of information associated with this subject and the variety of suggestions on how to properly handle this situation.

Response 4

The commentor's preference for starting an expedited conversion program immediately is noted. In response to comments received on the Draft PEIS, DOE has revised its preferred alternative, which now calls for prompt conversion of DOE's depleted UF_6 inventory into depleted uranium oxide (see Section 2.5.1 of the PEIS).

Comment 5

Our recommendations follow:

1. Increase and expedite the current maintenance program to clean and paint all cylinders starting with the most needy.
2. Improve the storage conditions so that all cylinders are accessible and safe.

Response 5

The commentor's recommendations for expedited maintenance and improved storage are noted. These recommendations are already being implemented through the UF_6 cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS). This plan was developed to eliminate substandard conditions and to eliminate the effects of corrosion through a recoating program. The management plan addresses all phases of the current UF_6 cylinder management project and is based on risk analysis and technical evaluations which determine the activities to be performed. Under this management plan, all cylinders must be stored out of ground-contact. Any cylinders discovered through periodic inspections to be in ground contact are relocated. Additionally, there are relocation plans to eventually restack all cylinders which will allow cylinder inspectors accessibility between cylinder rows. These plans are being implemented in a graded approach by relocating cylinders in the poorest storage conditions first. This plan is being implemented concurrently with extensive construction and recoating projects which will provide well drained storage yards for the cylinders and also provide protection for the exterior of the cylinders by recoating.

The sites have also implemented an extensive cylinder inspection program to allow identification of any damaged or breached cylinders. This inspection program also identifies those cylinders requiring maintenance activities such as valve replacement and nameplate replacement. Annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of pitting or heavy corrosion. All other cylinders must be inspected once every four years. Most of this work has already been completed at the three sites.

Comment 6

3. Convert the UF_6 to the more stable oxide (triuranium octaoxide) or metal form. There do not appear to be any technical barriers to beginning conversion. Begin the conversion process as soon as feasible.

4. Start conversion with the oldest cylinders and those in the worst physical condition.

5. Place the conversion products in interim storage until a decision is made for permanent storage, use, or disposal.

Response 6

The commentor's preference for converting UF_6 to uranium oxide or uranium metal as soon as feasible, starting with the oldest cylinders and those in the worst condition, and storing the conversion products on an interim basis, is noted. In response to comments received on the Draft PEIS, DOE has revised its preferred alternative (see Section 2.5.1 of the PEIS). DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metals and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and/or metal products for use.

Comment 7

The Energy Policy Act of 1992 provides for payment of the costs of remedial actions at gaseous diffusion facilities from the Uranium Enrichment & Decommissioning Fund. Appropriations received to date have lagged behind the available funds by an approximate factor of two. We urge that this money be made available in a timely manner for the UF_6 processing that is needed.

Response 7

Issues of DOE program funding are beyond the scope of this PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Commentor No. 57: Lamb, Ronald

Comment 1

The cylinders should continue to be stored. The older or compromised cylinders should be placed in over Paks like those used to protect drummed waste. All cylinders should be stored in an earthquake secure facility.

Response 1

The commentor's preference for continued storage of depleted UF_6 in cylinders is noted. The cylinder management program is designed to ensure that cylinders are continued to be stored safely in outdoor yards without the use of overcontainers ("overpacks"). Cylinders are inspected, monitored, and maintained to ensure that they meet safe storage requirements.

The safety of current storage of depleted UF_6 cylinders was addressed in the safety analysis reports (SARs) recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs did not find risks from earthquakes to be great enough to require cylinder storage in an earthquake secure facility. The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including earthquakes. The accidents considered in the PEIS for continued cylinder storage (Appendix D) were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point.

If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 2

No conversion to U_3O_8 should take place at the Paducah site due to the proximity of the New Madrid Earthquake Fault and the close proximity of the plant neighbors.

Response 2

The commentor's preference that conversion not take place at the Paducah site is noted by DOE. However, if a conversion facility were to be constructed at Paducah or any other site, seismic information would be considered in the design of the facility.

Comment 3

Conversion to U_3O_8 will add to the waste inventory because of the large volume of cylinders. If conversion had been considered at an earlier time the waste streams could have been handled easier.

Response 3

Comment noted.

Comment 4

If cylinders should bump into each other during a seismic episode and break off numerous fill valves, are there procedures in place to handle a large number of valve replacements?

Response 4

This scenario is highly unlikely due to the presence of a valve guard physically welded onto the cylinder body in particular cylinder designs while other designs include a cylinder skirt that acts as a valve guard. The procedure to change a valve would be the same whether it was to change one valve or one hundred valves.

In the event of such an emergency, the sites would first activate emergency preparedness and response procedures to assess the scene. Under normal conditions, the cylinders are stored with a vacuum on the contents. Should a valve be sheared, air would be pulled into the cylinder first until the pressure equalized with the outside pressure. At that time the chemical reaction would begin to take place which would eventually seal the hole left by the valve. Valve changes can still be made to damaged valves and other emergency measures can be taken to seal and contain the contents.

Comment 5

How many broken fill valves in the 30,000 plus cylinders would constitute a emergency?

Response 5

If one or more valves were broken, the storage sites would activate the Emergency Preparedness Teams.

Comment 6

Would stacking the cylinders two high in close rows add to the damage of more fill valves being broken during a seismic episode?

Response 6

The stacking configuration was evaluated in the seismic hazard evaluation of the Safety Analysis Reports for the storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). One of the conclusions was that rocking or rolling-out of saddles will not occur for single or multiple-stacked cylinders; in fact, the stacking of cylinders was found to preclude the "sliding" of an unsticked cylinder in its saddle during a performance category 3 (PC-3) seismic event. A PC-3 seismic event, for this case, is defined with a hazard accedence per year probability of 5×10^{-4}, a return period of 2000 years, a horizontal rock acceleration of 0.12 g's, and a horizontal top-of-soil acceleration of 0.30 g's. (Reference: DOE Standard 1021-93, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components.)

Commentor No. 58: Makhijani, Annie / Makhijani, Arjun
Institute for Energy and Environmental Research

Comment 1

The DOE's effort to address the long-term management of the country's depleted uranium hexafluoride, specifically the realization of the importance to convert this material into a stable form is long overdue. The Draft PEIS is seriously deficient because it does not address the most environmentally appropriate option — specifically, the DOE did not include the alternative of disposing of depleted uranium according to the rules of 40 CFR 191 which govern the disposal of transuranic (TRU) wastes. The Institute for Energy and Environmental Research (IEER), in its comments (Mar 22, 1996) on DOE's Notice of Intent (Jan 25, 1996), had already noted that the proposed list of alternatives was incomplete since it did not include the option of disposal under 40 CFR 191. The DOE has rejected our comments without providing any technical or environmental explanation. Our comments of March 22, 1996 are attached. DOE should include this option in the Final PEIS.

IEER recommends that depleted uranium be classified as a waste equivalent to TRU waste for management purposes.

Response 1

Depleted UF_6 is a source material. For purposes of evaluating disposal options in the PEIS, it has been assumed that depleted UF_6 would be converted into an oxide. This oxide form would be considered to be a LLW. By definition, only waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, is classified as TRU waste. Waste containing depleted uranium with no or little TRU radionuclides does not fall within this definition. Therefore, disposal of depleted uranium oxides resulting from the conversion of DOE's depleted UF_6 inventory would not be subject to the regulations specified in 40 CFR 191. The material would be classified as LLW and the disposal alternative evaluated in the PEIS considered it to be LLW.

Comment 2

IEER agrees with DOE that the no action alternative is inappropriate and should be rejected because of the dangers of UF_6 storage. For the same reason, long-term UF_6 storage in new containers should also be rejected. Overall, conversion to oxide would reduce risks. While conversion poses risks to workers and the off-site population, continued storage also poses serious risks.

IEER recommends that UF_6 be converted to an oxide form and declared a waste to be handled on a par with repository-designated TRU waste, with the possible exception of a relatively small quantity to be used for the blending down of highly enriched uranium. This should be the preferred option in the Final PEIS.

Response 2

The purpose of the PEIS is to present and compare the potential environmental impacts from alternative strategies for the long-term management of depleted UF_6, including evaluation of the no action alternative. Although some differences exist, the results of the PEIS indicate that the potential impacts to human health and the environment are generally similar among the alternatives considered. In addition, the results of the PEIS indicate that continued storage under the no action alternative is safe and is not "inappropriate" as stated in the comment.

The commentor's preference for conversion to an oxide form followed by disposal in a manner similar to TRU waste is noted. Please see the response to Commentor 58, Comment 1.

Comment 3

However, the various alternatives the DOE has considered have not been properly assessed in this PEIS.

Conversion of uranium hexafluoride: Most of the alternatives considered involve the conversion of uranium hexafluoride. Three alternatives would convert uranium hexafluoride to an oxide and one alternative would convert uranium hexafluoride to a metal. This conversion would have the positive result of putting the depleted uranium in a more stable chemical form therefore eliminating the chances of an hazardous releases of UF_6 and hydrofluoric acid from aging corroding cylinders. DOE's analysis is incomplete or deficient in regard to the:

- fate of the empty cylinders,
- commercial use of contaminated anhydrous hydrogen fluoride (produced during the conversion process),
- the radiological effects on workers.

Response 3

With respect to the management of empty cylinders, please see the detailed response to Commentor 58, Comment 4 below. Briefly, the management of empty cylinders was addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses. The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

With respect to the commercial use of anhydrous hydrogen fluoride, DOE plans to continue its support for the development of government applications for depleted uranium products. The use of depleted UF_6 as a fluorinating agent will depend on the conversion process selected, the residual uranium concentrations in the hydrogen fluoride produced, market demand, and both public

acceptance and regulatory considerations. Any commercial use of hydrogen fluoride produced from conversion of depleted UF_6 would take place after review by the U.S. Nuclear Regulatory Commission (NRC). Potential impacts from such use would be analyzed before a license or waiver could be obtained. The impact analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions.

The PEIS examined potential radiological doses to workers under normal operations that would be associated with continued storage of the cylinders (Sections D.2.1.1 and D.4.1.1), preparation of the cylinders for transport (E.3.1.1), the conversion of depleted UF_6 to either U_3O_8, UO_2, or metal (Section F.3.1.1), long-term storage of the cylinders (G.3.1.1), manufacture and use options (H.3.1.1) and disposal (I.3.1.1). Each of these appendices also addresses potential doses to workers under accident conditions (Sections D.2.2.1, E.3.2.1, F.3.2.1, G.3.2.1, H.3.2.1, and I.3.2.1).

Comment 4

1. Fate of the empty cylinders: DOE admits that ". . . ultimate disposition of the empty cylinders was not analyzed in detail as part as the alternative management strategies." The empty cylinders would become part of the DOE scrap metal inventory. The options for disposition are: recycling ". . . into LLW disposal containers, reuse as LLW containers, free release for re-melting, and disposal as LLW." However DOE has not analyzed the environmental and health impacts of these proposals. This lack of analysis is a serious problem since the volume of contaminated metal involved is large and doses to the public and to workers may be significant.

IEER recommends that the fate of the empty UF_6 cylinders and their proper disposition should be studied.

Response 4

The management of empty cylinders was addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). In the PEIS, for each alternative requiring conversion, the impacts of constructing and operating a cylinder treatment facility were included in the impact analysis. This analysis assumed an initial storage period of 3 months after UF_6 removal from the cylinders to allow the level of radioactivity associated with the decay products of uranium to decrease to acceptable levels. The cylinders would then be washed with water to remove the heels; finally the cylinders would become part of the DOE scrap metal inventory. As a part of the waste management analyses in the PEIS, the impact of disposal (i.e., burial) of the empty cylinders as low-level waste was also examined (Section F.3.7.4). It was found that the empty cylinders would represent only approximately 3% of the projected DOE complex-wide volume of LLW expected to be generated during the time period examined (i.e., through about 2030).

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The above-cited report by Nieves et al. analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 5

2. Commercial use of contaminated HF and CaF_2: The DOE has not properly assessed the management of both HF, a by-product of the conversion process, and calcium fluoride (CaF_2), a product of the neutralization of HF. Both these products will be slightly contaminated and in the Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride concerns are expressed as to the public acceptance of the uranium contaminants. Regardless of this concern, the DOE, in its Draft PEIS, assumed that these products could be commercially sold for unrestricted use. It is unacceptable to release a non-labeled contaminated product which has not received public acceptance. The Cost Analysis Report also states that the demand for HF is "still very uncertain." Another option is to use the HF for the production of UF_6. For this option as well as the commercial use option, DOE has not addressed the fact that part of the UF_6 inventory is recycled UF_6 which is contaminated by radionuclides other than uranium-238, such as Tc-99 and U-236 which both have a long half life.

IEER recommends that the fate of the anhydrous hydrogen fluoride and calcium fluoride should be properly studied; that radioactive materials such as HF from UF_6 processing and steel from empty UF_6 cylinders not be circulated in the civilian economy.

Response 5

The PEIS evaluated conversion options under which HF was produced for sale and under which HF was neutralized to CaF_2 which would either be sold, disposed as nonhazardous solid waste, or disposed as LLW. The assumption that HF containing only trace amounts of uranium (less than 1 ppm) could be generated was based on historical industrial experience, as detailed in the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of

Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The PEIS acknowledges that hydrogen fluoride (HF) produced during conversion could potentially be sold for use. Alternatively, the HF product could be neutralized by the addition of lime to form calcium fluoride. The solid calcium fluoride potentially could be sold for use or disposed of in either a landfill or a low-level radioactive waste disposal facility, depending on the uranium concentration and applicable disposal regulations at the time of disposal. The ultimate decision concerning HF or calcium fluoride production will depend on the conversion process selected, the residual uranium concentrations, market demand, and both public acceptance and regulatory considerations. In response to this uncertainty, the potential environmental impacts of both options (production of HF and neutralization and disposal as calcium fluoride) are considered throughout the PEIS.

In the PEIS the dose from Tc-99 was not evaluated, primarily because this isotope is much lighter than U-238, and is almost completely removed from the depleted uranium during the enrichment process. Radiological doses from Tc-99 would therefore be extremely small in comparison to the doses received from U-238 and decay products. In addition, because only a small fraction of the inventory is derived from recycled uranium, the fact that U-236 will preferentially end up in "product" cylinders compared to depleted "tails" cylinders, and the effective doses per unit activity are very similar between U-238 and U-236, doses from U-236 would also be small in comparison to U-238 and decay products.

Finally, the PEIS assumes that empty cylinders would be treated in a cylinder treatment facility and then become part of the DOE scrap metal inventory. Any commercial use of such scrap metal would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained. The impact analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions.

Comment 6

Radiological effects on workers: In their calculation of radioactive dose assessment, DOE does not take into account internal radiation doses that would be received by involved workers during the conversion process. This is a serious deficiency since involved workers are the most at risk. DOE claims that measures taken to prevent inhalation and ingestion of radioactive material would effectively protect the involved workers. The emphasis on prevention measures is not enough without a monitoring program installed for health purposes. DOE also claims use of respirators will reduce workers doses. But routine reliance on respirators is unacceptable as a radiological control practice. Moreover, some of the depleted uranium comes from the enrichment of UF_6 from recycled uranium from spent fuel. This UF_6 contains some radionuclides of concern such as technetium-99,

a long lived beta emitter and uranium-236, a long lived alpha emitter. DOE does not seem to have analyzed the radiological impacts.

For the manufacturing casks as with the conversion process, the contribution to the dose from internal radiation to involved workers has not been assessed.

IEER recommends that the issue of internal radiation for involved workers during conversion and cask fabrication be addressed carefully along with an assessment of the effects of uranium-236 and technetium-99.

Response 6

Radiological impacts were evaluated in the PEIS for both involved workers (those involved in hands-on activities) and non-involved workers (workers at the site not directly involved in hands-on activities) during conversion and manufacturing operations. The assessment of the radiation dose to non-involved workers considered internal radiation from the inhalation of radioactive material released through exhaust stacks. The evaluation of the dose to involved workers was limited to external radiation exposure. Internal radiation doses would be expected to be much smaller than external doses because (1) processes would be enclosed, (2) ventilation controls would be in place to inhibit airborne emissions within facilities, (3) indoor air would be monitored to ensure concentrations were below applicable standards, and (4) workers would be provided with appropriate personal protective equipment (e.g., respirators) if internal exposures were possible. Respirators are not used as the primary means of protection from internal exposures but are used only when necessary.

The commentor assumes that no monitoring programs would be in place at the facilities; however, dose monitoring is required for all radiation workers. Radiation workers are routinely monitored for external exposures and, in cases where workers are potentially exposed to free contamination, for internal exposures by the use of bioassay or whole-body counting. The worker doses are kept below approved administrative and regulatory limits. They are also kept as low as reasonably achievable (ALARA). Furthermore, the conceptual nature of the conversion, storage, manufacturing, and disposal facility designs does not allow for an accurate estimate of potential indoor air concentrations at this time.

In the PEIS the dose from Tc-99 was not evaluated, primarily because this isotope is much lighter than U-238, and is almost completely removed from the depleted uranium during the enrichment process. Radiological doses from Tc-99 would therefore be extremely small in comparison to the doses received from U-238 and decay products.

In addition, because only a small fraction of the inventory is derived from recycled uranium, the fact that U-236 will preferentially end up in "product" cylinders compared to depleted

"tails" cylinders, and the effective doses per unit activity are very similar between U-238 and U-236, doses from U-236 would also be small in comparison to U-238 and decay products.

Comment 7

Uses of depleted uranium: 1. Uses analyzed: DOE's preferred alternative is to use the entire inventory of depleted uranium after its conversion to a metal or an oxide form for radiation shielding in storage casks for spent fuel. However since these casks would have to be licensed by the NRC (6.11-9-1 Engineering analysis report,) this choice is premature. Even if the licensing is approved cask fabrication creates more problems than solutions. The problems are that:

- it is not a final solution since the casks envisioned do not meet the criteria for deep repository disposal. Hence this is not a solution but a stop-gap storage method that would create more contamination and radioactive waste in the form of used casks. The DOE has not done the preliminary work ascertaining the license ability of the casks. DOE's choice of preferred option is premature and inappropriate;

- DOE doesn't say what will happen to the DU in the casks. It only states that: "No assumptions were made regarding the fate of the oxide- and metal-shielded casks after use. The empty casks could be recycled, stored, or disposed of as LLW." (p. H-32).

Response 7

DOE's revised preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. The discussion of the preferred alternative in the Final PEIS was modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use.

The preferred alternative does not specify the nature of the end-use, rather, it specifies that products would be produced as uses became available. Although the PEIS evaluates two use options, use as uranium oxide and use as uranium metal as radiation shielding for spent nuclear fuel or high-level waste, these options were intended to be representative only, as stated in Section 2.2 and Appendix H of the PEIS. The representative use options were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses, such as the ability to obtain an NRC license for a storage cask, is considered beyond the scope of the PEIS. Such issues would be considered and evaluated in more detail in future planning and environmental analyses.

The PEIS did not address in detail the ultimate disposition of uranium after use because actions to be taken beyond the 40 year period considered in the PEIS (with the exception of long-term disposal impacts) are considered highly uncertain and speculative at this time. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Comment 8

2. Other uses not analyzed in depth: With the long-term storage options DOE preserves the possibility to pursue the use of depleted uranium in light water reactor fuel cycle, advanced reactor fuel cycles and, dense material applications. The light water reactor option has two sub-options: the reenrichment of DU and the use of DU for MOX. Among these options, the fact that the use of depleted uranium in advanced reactors (that is fast neutron reactors, also known as breeder reactors) is at all considered is particularly disturbing. Depleted uranium being the raw material for plutonium production, by converting it into a material not only much more radioactive but also weapons usable would not only defeat the stated purpose of the PEIS which is to "achieve the safe and effective long-term management of depleted UF_6." It would also have serious proliferation consequences.

Response 8

As described in Section 2.2 and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks. Regarding the use of depleted uranium in advanced reactors, the United States has no active breeder reactor program at this time. Implementation of an advanced reactor fuel cycle would require a change in national policy.

Comment 9

3. Uses not analyzed: The feasibility of using depleted uranium hexafluoride for the blending down of surplus highly enriched uranium was not considered in this PEIS. Although it would utilize only a small portion of the stock, this use would have several advantages, among them: the contribution to non-proliferation, a minimum of handling, and incorporation of depleted uranium into spent fuel. This use option could be made part of any of the alternatives except UF_6 storage.

Response 9

As stated in Section 2.2.4, Section 2.2.5, and Appendix H, the two use alternatives evaluated in detail in the PEIS, use as uranium oxide and uranium metal as radiation shielding, were selected as representative options for the purposes of comparing the potential environmental impacts of broad alternative management strategies. These options were intended to be representative only, and were not intended to preclude other potential uses in the future. This point has been clarified in Section 1.5.3 of the PEIS by adding text stressing the representative nature of the facilities, processes, and uses evaluated for the purpose of estimating environmental impacts.

Specific uses, such as use for blending down highly enriched uranium, would be considered and evaluated in future planning and environmental analyses, as appropriate. Several alternatives for managing highly enriched uranium were evaluated in the Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement, issued in June 1996, as summarized in Section 1.6 of the PEIS. It is expected that such uses would require only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy.

***Note on comment documents No. 58 and No. 59**: Commentor No. 58 (Annie and Arjun Makhijani, Institute for Energy and Environmental Research) resubmitted their comments on the Notice of Intent for this PEIS as an attachment to their comments on the draft PEIS, which is designated as comment document No. 59. All comments made during the scoping period of this PEIS, including the comments made by the Institute for Energy and Environmental Research were considered in the preparation of the draft PEIS. In addition, the responses to those comments were provided in Appendix L of the draft PEIS, which is still included in the final PEIS. The main theme of the IEER's scoping comments was waste classification and disposal of uranium oxides under the provisions of 40 CFR 191 as TRU waste versus disposal as low level waste. This theme was repeated in their comments on the draft PEIS and is addressed in the response to comment No. 1 from commentor No. 58.*

Commentor No. 59: Makhijani, Annie / Makhijani, Arjun
Institute for Energy and Environmental Research

See note at end of responses for Commentor 58

Commentor No. 60: Edmonds, Robert F.
Duke Engineering and Services, Inc.

Comment 1

Volume I, Page S-3: We agree that conversion of the UF_6 to U_3O_8 is the safest next step. This step can and should be initiated soon. The PEIS provides no compelling reason not to proceed

with this step. There are abundant safety and environmental reasons, as documented in the PEIS, why continued storage as DUF_6 is not the best alternative. Further, conversion to U_3O_8 does not preclude reuse of the depleted Uranium in the event national defense needs dictate or reuse options are ultimately proven cost effective.

Response 1

The commentor's preference for conversion of depleted UF_6 to uranium oxide is noted. It is not clear what the comment is referring to when it states that "There are abundant safety and environmental reasons, as documented in the PEIS, why continued storage as depleted UF_6 is not the best alternative." The PEIS shows that continued storage under the no action alternative is safe. DOE is committed to continue to safely manage the cylinders until they are emptied.

In response to comments received on the Draft PEIS, DOE has revised its preferred alternative (see Section 2.5.1 of the PEIS). The preferred alternative now includes prompt conversion of DOE's depleted UF_6 inventory to depleted uranium oxide.

Comment 2

Cost Analysis Report, Paragraph 4.1.2 Treatment of Emptied Cylinders: The PEIS Cost Report assumes that empty DUF_6 cylinders are crushed and sent to DOE facilities for disposal. There is no cost associated with disposal. This appears to be a completely unsupported assumption. There will be a cost, possibly a substantial cost, associated with disposal of the empty cylinders. They could be contaminated and require special handling.

Response 2

The PEIS assumes that the cylinders that have been emptied and washed in the cylinder treatment facility would be turned over to the DOE scrap metal program. It is highly unlikely that they would be disposed. They are more likely to be recycled as scrap metal. A PEIS support document by Nieves et al. (1997) entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC

(listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the EIS.

Comment 3

3. Cost Analysis Report, Paragraph 2.4.2 Use as Uranium Dioxide in DUCRETE for Shielding Applications: Report discusses the conversion of DUF_6 to UO_2 which in turn would be used to make DUCRETE. It should be pointed out that conversion of DUF_6 to U_3O_8 and then to DUCRETE is an equally acceptable option.

Response 3

DUCRETE is a depleted uranium-concrete material considered in the PEIS for shielding applications. DUCRETE can in general be formed from U_3O_8 or UO_2. The PEIS however considers DUCRETE formed from UO_2, because UO_2 is more dense than U_3O_8, and this would result in better shielding characteristics. Further information is provided in Section 1.2.1 (Depleted Uranium in Concrete [DUCRETE]) of Chapter 6.11 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 4

Cost Analysis Report, Paragraph 4.2.2 Revenue from Sale of Byproduct AHF and CaF_2: This paragraph, as well as the PEIS Volume I, speak about sale of AHF byproduct. It should be noted that there is also a market for Aqueous HF. It is an equally acceptable option to make and market Aqueous HF.

Response 4

The PEIS discusses the production and sale of anhydrous hydrogen fluoride (AHF) because there is a considerable market for AHF in North America, while the market for aqueous HF is limited. Nothing in the PEIS would preclude the production and sale of aqueous HF if the market for aqueous HF would improve. However, it should be noted that the sale of aqueous HF would be subject to the same types of restrictions as AHF in terms of licenseability or authorization limits for restricted or unrestricted use.

Commentor No. 61: Barclay, Mike / Janaskie, Mark
DPRA, Inc.

Comment 1

QUESTION: The preferred UF_6 management scenario presented in the PEIS carries with it a huge price tag. As such, would funding availability create performance uncertainties for DOE

that need to be acknowledged? Specifically, will the funds to begin conversion be available in the amounts needed to initiate large-scale conversion efforts by the year 2009? Will annual funding be available in sufficient amounts to support conversion of the entire inventory within the expected year conversion period? Both questions point to temporal uncertainties that have a bearing on DOE's strategy for interim storage and maintenance of UF_6 cylinders. Lesser amounts of funding would require longer — potentially much longer — storage, and a much greater emphasis on the corrosion protection and reconditioning of UF_6 cylinders. As best we can discern from the PEIS and from discussions at the public hearings, DOE's strategy for UF_6 cylinder corrosion control is to paint the cylinders with the worst corrosion. Perhaps inherent in this strategy is the idea that conversion efforts will start soon enough (e.g. 2009) and will conclude quickly enough (e.g. 2029) that a larger number of cylinders do not need reconditioning to prevent additional corrosion. Is this generally accurate as to DOE's underlying strategy?

Response 1

Issues of DOE program funding are beyond the scope of this PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

The objective of the cylinder painting program is to maintain sufficient cylinder wall thickness to allow cylinder transportation and heating in autoclaves. If the management strategy announced in the Record of Decision for the PEIS requires conversion, emptying corroded cylinders early in the conversion program will minimize cylinder painting requirements over the life of the program.

Comment 2

How many cylinders does DOE anticipate painting at the three sites? It is our understanding that corrosion coatings from paint will last about ten years. Other corrosion protection options, although slightly more costly initially, offer much longer corrosion protection. Specifically, thermal spray coatings provide 30+ years of corrosion control, and offer other significant advantage including dramatic cost savings potential when life cycle costing is factored into total cost considerations. Has DOE factored life cycle costing into its decision making regarding the choice of paint over other coating options? Why did DOE choose paint as a preferred coating choice?

Response 2

DOE plans to paint about 6,800 cylinders at Paducah and 2,950 at ETTP over the next five years. This number represents the sum of the cylinders from former G- and F-yards at Paducah and K-yard at ETTP which have been determined to be at risk of corroding to the point that they would have a minimum wall thickness less than the ASME Code allowable for unfired pressure vessels. If this schedule can be met, DOE will, on a statistical basis, save the most mils of wall lost due to corrosion and maintain those cylinders as a code-approved population. Based on the corrosion modeling, the other populations of cylinders do not need painting for some time or possibly not at

all to maintain ASME minimum wall thickness. If DOE accelerates disposition of the depleted UF_6, then more painting or "better," i.e. longer lasting coating, may not be necessary.

DOE elected to perform an evaluated procurement (with a scoring system for price and technical performance factors) for a paint system that was technically judged to provide at least twelve years of low maintenance service life. This scoring system was also designed to consider coatings that perform for longer periods but at higher initial costs. In each case, the initial investment was prohibitively high compared to the money available in any given year. Going to a longer time period, i.e. paint fewer cylinders per year at higher dollars per cylinder, to compensate for a fixed budget is not possible due to the time frame that the cylinders must be recoated to maintain the code compliance.

Comment 3

QUESTION: As stated in the PEIS, DOE's preference is to convert the entire inventory of UF_6 material into usable products. Given the large volume of UF_6, it is unclear whether a correspondingly large market demand exists for products arising from the conversion effort. Has DOE conducted a thorough market analysis (applications, demand) for UF_6 conversion products? If so, please describe the results of this analysis, and an estimate of the percentage of the inventory for which definable, cost-effective usages exist?

Response 3

The DOE has performed a market study on the potential uses of depleted uranium. The second paragraph in Appendix H indicates that the PEIS examined using depleted uranium as radiation shielding material because the largest potential market appears to be shielding applications. The reference for this statement is Kaplan, S.A., 1995, "Depleted Uranium Market Study."

Comment 4

QUESTION: Given that there appears to be a limited market for the converted uranium oxide (at least based on current information), what will happen to the remainder of the UF_6 stockpile? In terms of program management, it seems certain that the remainder of unconverted UF_6 will become a waste (per U.S. EPA regulations), and therefore will likely be transferred to DOE's EM program. Given this scenario, is there an integration of efforts currently taking place between DOE programs to address this kind of future scenario? In addition, have there been any discussions between DOE programs as to how the waste would be formally transitioned into the EM program? Also, given the transition of UF_6 as waste into the EM program, is there an existing remediation/cleanup fund established to manage UF_6 as waste material?

Response 4

DOE has managed its depleted UF_6 inventory as a resource for future use, rather than as a waste. DOE expects that uses will be available in the future for some portion of the depleted UF_6

inventory, and it will continue to support the development of government applications for depleted uranium products. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS. If a disposal strategy would be selected, the specifics of that strategy such as timing, conversion and disposal site selection, specific technologies to be used, interface and coordination arrangements with EM, etc., would be evaluated in future project and environmental reviews to be conducted following the Record of Decision.

Comment 5

QUESTION: The PEIS states that there is a very substantial cost associated with transferring the non-conforming cylinders to a central location for conversion. The actual reference case stated in the PEIS estimates this cost at more than $800 million. Of that $800 million, approx. $161 million is for what DOE terms "overcontainers." Given that reference case in the PEIS, we would appreciate responses to the following questions:

1.) Has DOE looked at other options to "re-engineer" the non-conforming cylinders for transport/shipping, so as to eliminate the need to employ overcontainers?

2.) Is there an actual U.S. Dept. of Transportation regulation/requirement to use overcontainers for the UF_6 cylinders? If so, what is it?

3.) Has the DOE held discussions with the U.S. DOT to discuss the requirements for shipping non-conforming cylinders? If so, is this what DOE based its $161 million overcontainer estimate on in the PEIS?

4.) Using the DOE reference case of $161 million for overcontainers, what is the true unit cost per cylinder for transporting the non-conforming cylinders to a central location for conversion?

5.) Does the term "overcontainers" mean the same as "overpacking," as in waste operations?

Response 5

The preparers of the PEIS were unable to locate the source of the cost numbers presented in the comment. Cost information is not provided in the PEIS, but is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS) (available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), or by contacting the DOE program manager identified on the cover sheet of the PEIS.). Responses to the specific comments listed are provided below:

(1) The PEIS considered two representative options for preparing cylinders that do not conform to Department of Transportation requirements, the use of "overcontainers," and the transfer of the contents from non-conforming cylinders to new cylinders. These two options are described in Appendix E of the PEIS, with additional detailed information provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS).

DOE has funded some preliminary studies into wall thickness requirements to maintain a code vessel status for "unfired pressure vessels" in storage and in use (heating). The Department

of Transportation is bound by 49 CFR 173.420 for regulating UF_6 cylinders in transit. The DOE would be required to demonstrate "equivalent levels of safety" for any cylinders not meeting those specific requirements. No work has been performed to "re-engineer" the cylinders with their contents, except for the addition of paint to arrest corrosion and maintain wall thicknesses.

(2) Depleted UF_6 cylinders were originally designed, built, tested, and certified to meet Department of Transportation requirements for shipment. Shipping requirements are specified in Title 49 of the Code of Federal Regulations (Part 173.420) and ANSI N14.1 (American National Standard for Nuclear Material — Uranium Hexafluoride — Packaging for Transport requirements). These requirements include pressure vessel code design, fill limits, wall thickness minimums, pressure limitations, cylinder body damage limitations and repair requirements. DOE has evaluated the inventory of cylinders based on these requirements and has made estimates of the numbers of cylinders that no longer will meet these requirements. Cylinders that conform to the DOT shipping requirements can be prepared for shipment without a protective overcontainer. However, after several decades in storage, some cylinders may no longer conform to the DOT requirements and would require some type of preparation prior to shipment. As described in Appendix E of the PEIS, two options were considered for preparing non-conforming cylinders for shipment; placement of non-conforming cylinders in protective overcontainers that provide equivalent safety or transfer of the contents from non-conforming cylinders to new cylinders.

(3) Representatives from the current cylinder management program have met with DOT regulators on several occasions and have participated in very open and candid discussions regarding the condition of some cylinders. In order to ship cylinders that do not meet current regulations, even under a DOT exemption, DOE must demonstrate that the cylinders meet the "equivalent safety" of a conforming cylinder. There are no 49 CFR requirements to use overcontainers for depleted and normal assay UF_6 cylinders, however, there are overcontainer requirements for shipping enriched UF_6.

(4) Unit costs for transportation are a function of the number of shipments and the distance that those shipments have to be transported. Thus, there is no "true unit cost" on a per cylinder basis due to the dependency on shipping distance.

(5) In the context of the PEIS, the term "overcontainer" refers to a container into which a cylinder could be placed for shipment. The overcontainer would be designed to provide equivalent safety of a UF_6 cylinder which today qualifies as a DOT Type A package. It does not mean overpacking as in waste operations.

Comment 6

We understand at the Nevada Test Site (NTS) has recently changed its Waste Acceptance Criteria in the last year or so, so that it can receive more DOE waste for disposal. Given the scenario that DOE determines that UF_6 conversion is not economically feasible or prudent, would anything

prevent the DOE from sending the UF_6 waste to the NTS for disposal, or even interim storage (retrievable storage) prior to DOE developing a better, more economically efficient method to convert the UF_6?

Response 6

DOE considers the depleted UF_6 to be a source material, and not waste. However, even if DOE decided to dispose of the depleted uranium in its depleted UF_6 inventory, disposal in the form of UF_6 would not be acceptable because of the chemical characteristics of UF_6. Prior to disposal the UF_6 would have to be converted into a more stable form, such as uranium oxide. Long-term storage as UF_6 is one of the alternatives analyzed in the PEIS. This type of storage was assumed to take place at a representative site, which could in reality be anywhere in the United States. For this reason, the transportation of UF_6 cylinders over a range of distances was included in the PEIS. If the strategy selected in the Record of Decision for this PEIS is the long-term storage as UF_6, then the site selection would be accomplished as part of the future planning and analysis process.

Commentor No. 62: Ross, Wayne A. / Haass, Mathew, P.E.

Comment 1

We have previously provided information on the Molten Glass Reactor (MGR) Process for the single step immobilization of the uranium hexafluoride. Attached is a copy of the material previous provided in 1995 and 1996 on this process. This process has a factor of at least two lower cost than those included in the EIS. It should also have less environmental impacts. This option was not identified or considered in the EIS and is not within the bounds of the EIS for cost or for impacts. Therefore the EIS failed to consider a reasonable, technically feasible, cost-effective and environmentally favorable alternative for the disposition of the deleted UF_6.

Response 1

The Molten Glass Reactor process is based on in-situ vitrification technology. It was not analyzed within the PEIS because it does not appear to be sufficiently developed to offer hope of significant cost reduction compared to established processes. A recent report by the National Academy of Sciences (National Research Council 1996; the full citation is provided in Chapter 8 of the PEIS) indicated that a 5-year research and development program would be required to determine feasibility and costs of the MGR process. In addition, the technologies considered in the PEIS were intended to be representative and were not intended to preclude other technologies that may become available in the future. Technology selection, if conversion was required by the management strategy selected in the Record of Decision for the PEIS, would be addressed in future analyses.

Comment 2

We recognize that additional work will be needed to verify the process, but as was stated in the Summary of the Cost Analysis Report Section 3.0 Most technologies would require significant engineering development. Thus the MGR process with the previous developments for high-level and mixed waste vitrification and the development of the In-situ-Vitrification Process (ISV) would make the state of development superior to many of the other proposed alternatives. Thus, the lower state of development of the MGR process is not a sufficient reason for omitting it from consideration.

Response 2

The Molten Glass Reactor process could be considered to be a less mature technology compared to those considered in the PEIS, which are based upon either processes that have been used commercially (such as metallothermic reduction) or are extensions of industrial practices (e.g., revision of the COGEMA process to produce anhydrous hydrogen fluoride). The National Academy of Sciences considered that the MGR process required a 5-year research and development program to determine its feasibility and estimate costs. In addition, the conversion technologies considered in the PEIS were intended to be representative and were not intended to preclude other technologies that may become available in the future. Technology selection, if conversion was required by the management strategy selected in the Record of Decision for the PEIS, would be addressed in future analyses.

Comment 3

The MGR process would be generally consistent with the intent of the preferred alternatives "use of the material." The MGR process would place the uranium in a high concentration in a vitreous state near the earth's surface, thus providing the opportunity to retrieve and reprocess the material as a very high grade ore, if in the future there is a need for depleted uranium. At the same time, the uranium has very low availability to the environment, as the vitreous waste form provides very good containment of the uranium.

Response 3

The Molten Glass Reactor (MGR) process proposed in the comment would convert the depleted UF_6 into a vitreous state, presumably for long-term storage purposes. Vitrification was considered in the PEIS, but was not analyzed in detail for reasons discussed in Section 2.3.4 of the PEIS.

Comment 4

The "disposition of other alternatives" in the engineering analysis documents (Section 4.5) stated "Another possible sub-option is vitrification, in which depleted uranium oxide would be enclosed in glass. The basic technology is developed (for disposal of high-level radioactive waste), but other types of waste preparation are generally preferred for depleted uranium. Vitrified waste would require more space for disposal. In addition, a vitrification facility would be more

complicated and costly to build and operate than a cementing facility." These statements to dismiss the alternative, while possibly applicable to a stand alone vitrification processing facility that would incorporate the waste into glass in canisters for disposal, are not applicable to the MGR Process and therefore the MGR process does not qualify for exclusion based on it. The MGR would have lower disposal area requirements and lower capital and operating costs than any of the proposed facilities.

Response 4

Currently available literature does not appear to substantiate the claim made in this comment that the process would incur lower costs than other conversion processes. The proposed technology is still in the developmental stage and has not been fully demonstrated. It was considered when the representative technologies were selected for the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), but was not analyzed in detail for reasons given above. The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 5

There does not appear to be a strong basis for the preferred option. All alternatives have similar impacts and costs.

Response 5

The preferred alternative as described in Section 2.5 of the PEIS is the alternative that DOE judges will best fulfill its statutory obligations and defined mission. The management alternatives evaluated in the PEIS have similar environmental impacts and costs because they generally involve similar activities such as continued cylinder storage, transportation, and conversion. The Record of Decision will explain how the selected management strategy was chosen from among the alternatives.

Comment 6

The PEIS Summary document should contain a discussion of the various life cycle cost of the alternatives.

Response 6

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives is generally not considered an environmental impact; consequently, cost information is not provided in the summary or main body of the PEIS. However, cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available to the public at the DOE public reading rooms near the three current

storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS. Cost information will be considered along with the results of the PEIS and other information in the Record of Decision for the PEIS.

Comment 7

The use of discounted cash flow, while technically justifiable, obscures the actual costs for the various processes. I have not seen many DOE projects where the costs have decreased with time. They nearly always increased. Discounting at a rate of 7% makes major operating costs in the out years very small and meaningless. A constant dollar basis is more meaningful, but probably still optimistic.

Response 7

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives is generally not considered an environmental impact; consequently, cost information is not provided in the PEIS. However, cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Discounted cash flow, or present-worth, analysis is typically applied in comparison of the costs of various alternatives. This approach takes into account the time-value of money, in that costs which are incurred in the future, are discounted into present year dollars. As an example, a single dollar placed in an account with a 7% compound interest rate would be equivalent to approximately $870 in 100 years. A shortcoming of stating all costs in constant dollars is that it does not consider this time value of money.

Comment 8

The projection that all of the materials will be used seems highly speculative. I did not identify in the draft how all the uranium would be used. An accounting of the use of the materials should be included in the final EIS. The accounting could identify future uses currently unidentified. Some order of magnitude calculations give the following results. Page H-10 indicates that 933 casks would be produced for 20 years for a total of 18,660 casks. I don't think there is sufficient uranium to produce that many casks based on other information. The current forecast (DOE/RW-0006 Rev 12, page 23) indicates that there will be less than 90,000 MTU of commercial spent fuel. If one uses the Multiple Purpose Cask (MPC) as the model cask, then each cask will hold 11 MTU. Thus, if all the spent fuel was to be shipped in MPC, about 8200 shipments is all that would be needed. It seems unrealistic, however, that all of the fuel would be shipped to the repository in single use casks. It

would be far more economical for reactor operators to use reusable casks that can be use for 100's of shipments. Thus the use of most of the inventory for casks seems unrealistic and the preferred alternatives basis that all materials can be used is high speculative. Your position would be greatly strengthen if you had some statements from DOE-RW that they were planning on using the uranium for this purpose. With respect to the Hanford SNF in K-Basins there has been serious concerns expressed about the present of uranium metal in the repository. Further, we anticipate that the use of uranium as counter weights would not be highly regarded by industry, when they found the needs for radiation monitoring and inventory control were necessary. This leads us to the conclusion that a significant fraction of the materials will need to be processed and disposed. The MGR being a modular process could accomplish this very effectively and could be implemented in a relatively short period of time.

Response 8

The engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) contains further information concerning the number of required depleted uranium casks. Section 1.1 of the EAR on page 6.11-1-2 indicates that a total of 10,000 to 12,000 depleted uranium casks would be required for radiation shielding of high-level waste and spent nuclear fuel. At over 40 tons of uranium per cask, essentially the entire DOE inventory of depleted uranium would be consumed. Since the depleted uranium casks are intended for storage purposes, it would be necessary to have a number of depleted uranium casks sufficient in number to safely store the entire inventory of commercial spent nuclear fuel. The EAR is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Insufficient information is available concerning the large scale application of the Molten Glass Reactor (MGR) concept using depleted UF_6, and thus it is not possible to establish the required operating duration for this process, for comparison with the processing duration of 20 years applied in the PEIS analyses.

Comment 9

It was interesting to note that one of the major hazards identified was the shipment of HF. The MGR process converts the fluoride to calcium fluoride and dissolves it in the glass structure thus eliminating the HF hazard. It also means that there is only one transportation operation in the MGR process further reducing transportation impacts.

Response 9

The PEIS did consider options in which HF was neutralized to calcium fluoride (see Appendix F). The PEIS considered technologies that had a sufficient technical basis to carry out reasonably precise, preconceptual designs. The Molten Glass Reactor (MGR) process was not evaluated in the PEIS because it is in the early stages of conceptualization and development.

Further information concerning options not analyzed in depth is provided in the engineering analysis report (LLNL 1997; the full citation is provided in Appendix F of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 10

The concentrated form of the final waste form requires less land space than other options since all of the uranium could be disposed in an area about 1200 ft by 1200 ft (33 acres). Note this is less than the disturbed area for one cask manufacturing facility (36 acres).

Response 10

Comment noted. The Molten Glass Reactor process identified in this comment is similar to in-situ vitrification, and was not retained for analysis in the PEIS for the reasons stated in Section 2.3.4.

Commentor No. 63: Cronin, Bill / Harmon, Melinda
See responses to Commentor No. 51

Commentor No. 64: Murray, Alexander P.
Private Consultant

Comment 1

Disposal and waste management are significant issues not well addressed in the PEIS. It is highly probable that a significant fraction of the DU — perhaps all of it — will end up as a radioactive waste, either as itself or in a reuse "product." It is not until well into the PEIS (Chapter 5) that the reader is informed that near surface disposal will significantly exceed 10 CFR Part 61 limits (for NRC/commercial facilities) and DOE limits for public doses. In other words, codified regulations will be broken. Also, mined cavity disposal, which may be a solution for DU, does not currently exist for LLW, and there are no current plans for mined cavity disposal of LLW in the U.S.

Response 1

Although the results of the disposal alternative indicate that radiation doses to individuals could potentially exceed regulatory limits for disposal in a "wet" environment at some point in the distant future, the analysis also indicates that impacts would remain within regulatory limits for a disposal facility in a "dry" environment. The PEIS also stresses (see Appendix I) that the post-closure disposal analysis is based on generic information and is subject to a great deal of uncertainty. Actual impacts from disposal would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to

groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. If disposal were implemented in the future, all disposal activities would take place in accordance with applicable NRC rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option).

Comment 2

Market demand does not and is not likely to exist for the reuse of DU, and the PEIS does not identify routes to build such a market. Currently, cost and liability are almost insurmountable hurdles for the "reuse" of DU, as its competitor for the (most likely) reuse scenarios (spent fuel shielding) is concrete. The use of DU shielding requires an integrated approach to minimize consumer, utility, and DOE costs, and DOE acceptance of DU liability (basically disposal). This implies that even for reuse scenarios, the DU form must be compatible with disposal. Myself and other authors have written on this extensively.

Response 2

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products. As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses is considered beyond the scope of the PEIS. Such issues would be considered and evaluated in more detail in future planning and environmental analyses. The PEIS acknowledges that at the end of their useful lives products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4, 2.2.5, and 5.9 of the PEIS).

Comment 3

No significant uses of DU currently exist in shielding applications. No licensed spent fuel casks use DU shielding, and there are no current plans or pending applications for spent fuel casks using DU. DOE-RW has identified DU as a cost and machining disadvantage for spent fuel casks. The PEIS needs to openly state these points and identify means to resolve them. Again, myself and others have written on this extensively.

Response 3

The PEIS evaluates two representative options for use of depleted uranium for radiation shielding. The selection of these use options for analysis in the PEIS was not intended to imply that

the PEIS will be used to select a specific end-use or preclude other potential uses. While it is true that depleted uranium is not used in currently licensed spent fuel storage or transportation casks, this does not preclude development of such a use in the future. In fact, depleted uranium is included as shielding in a transportation cask design currently undergoing licensing by the NRC. If further proposals to use depleted uranium as shielding in storage or transportation casks are put forth in the future, issues related to the efficacy, costs, engineering considerations and environmental considerations would be discussed and evaluated. Your comments on your expertise in this area are noted.

Comment 4

The analyses and alternatives are uneven and neither analyzed at comparable levels nor taken to equivalent endpoints. For example, all of the uranium dioxides will perform differently. The gelation-produced uranium dioxide is equivalent to nuclear fuel in terms of high density and low porosity, and will have improved leach resistance, heat transfer, and sizing as compared to the other oxides (including the lower density uranium dioxide) — in short, it's a better material. Significant items have been left out of the analyses (e.g., disposition of shielding, roll up of disposal impacts, and protective action distance impacts on site sizes). There is no reconciliation between known technologies/impacts and those in the report — for example, the proposed uranium dioxide pellet furnaces used for analysis in the PEIS correspond to 100-200 teU/yr capacity, not the 7,000 teU/yr capacity claimed by the analysis. The same pellet technology also currently requires about 1 FTE/te/yr, not the 0.014 FTE/te/yr used in the PEIS. The conversion reactors (low number and large size) appear to be very optimistic. The gelation facility includes two plants (one to U_3O_8 and one to UO_2) which is not consistent with the technology and explains why its impacts are slightly higher. The PEIS should recognize these shortcomings, limitations, and differences, and be more equivalent in its analyses.

Response 4

This comment deals with a number of specific issues, which are addressed below. In general, the technical bases for the impacts process designs in the PEIS are provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Issue 1: "The analyses and alternatives are uneven and neither analyzed at comparable levels nor taken to equivalent endpoints. For example, all of the uranium dioxides will perform differently. The gelation-produced uranium dioxide is equivalent to nuclear fuel in terms of high density and low porosity, and will have improved leach resistance, heat transfer, and sizing as compared to the other oxides (including the lower density uranium dioxide) — in short, it's a better material."

Response: The PEIS does take into account the differences between the two uranium oxide forms: U_3O_8 and UO_2. The conversion routes necessary to produce the various uranium oxide forms are examined in the PEIS. The chemical characteristics of the various uranium oxide forms (e.g., density which affects storage area, leaching rate for disposal) are considered in management options such as long-term storage (Section 2.2.3 in the PEIS) and disposal (Section 2.2.6 in the PEIS).

Issue 2: "Significant items have been left out of the analyses (e.g., disposition of shielding, roll up of disposal impacts, and protective action distance impacts on site sizes)."

Response: The disposal of shielding containing depleted uranium was not analyzed in detail at this time because actions to be taken beyond the 40 year period considered in the analysis are considered highly uncertain and speculative. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Disposal impacts have been estimated over a period of at least 1,000 years, and are provided in Appendix I of the PEIS. Disposal impacts were estimated for two phases: the operation phase and the post-closure phase. Post-closure impacts were estimated at 1,000 years after the disposal facilities were assumed to fail.

The conversion facility land areas in the PEIS do not include protective action distances (buffer zones). The need for buffer zones surrounding a facility would be determined by site-specific environmental impact studies, which will follow this PEIS.

Issue 3: "There is no reconciliation between known technologies/impacts and those in the report — for example, the proposed uranium dioxide pellet furnaces used for analysis in the PEIS correspond to 100-200 teU/yr capacity, not the 7,000 teU/yr capacity claimed by the analysis. The same pellet technology also currently requires about 1 FTE/te/yr, not the 0.014 FTE/te/yr used in the PEIS. The conversion reactors (low number and large size) appear to be very optimistic. The gelation facility includes two plants (one to U_3O_8 and one to UO_2) which is not consistent with the technology and explains why its impacts are slightly higher. The PEIS should recognize these shortcomings, limitations, and differences, and be more equivalent in its analyses."

Response: A typical UO_2 fuel fabrication plant processes enriched uranium in numerous production lines with low capacity equipment (100-200 teU/yr). Low capacity equipment is used for criticality control and ensure strict quality control.

The depleted UO_2 conversion plants assumed continuous process operation using two or three lines of high-capacity equipment (2,000-3,500 teU/yr). Equipment development for the sintering furnaces is needed. But the throughput needed for sintering and pressing is not unusual for the ceramic industry.

Plant staffing for the depleted UO_2 conversion plants was assumed to be similar to a chemical plant using proven processes and equipment. The process was automated and controlled from a central control room, which would reduce the number of required staff. Each process system was assigned 1 to 2 operators, and a supervisor was provided for every 6 operators.

The number of conversion reactors assumed in the PEIS can be assumed to be conservative. Two separate reactors in series was assumed for conversion of UF_6 to U_3O_8, while COGEMA in France use a single reactor for conversion.

The conversion of UF_6 to UO_2 by gelation in the PEIS includes U_3O_8 production and dissolution but it is not two plants. The basis for the gelation process in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) is the Oak Ridge Report ORNL/TM-6850, "Chemical Flowsheet Conditions for Preparing Urania Spheres by Internal Gelation" (July 1979). The two-step gelation process in the PEIS bounds the impacts and is expected to be satisfactory for PEIS purposes.

Comment 5

The limitations of the technologies should be recognized in the PEIS, and means identified to address them. Only the French conversion to U_3O_8 technology has been used on a scale approaching that needed for the PEIS, and it needed compactors to increase the density to circa 3 g/cc. To state that current pelletization technology is established for the throughputs and equipment used in the PEIS is incorrect-the gelation route with VTF's has actually achieved higher equipment rates per unit floor area.

Response 5

The limitations of the technologies considered in the PEIS are considered in the technology assessment report (LLNL 1995; the full citation is provided in Chapter 8 of the PEIS) and in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report also contains information concerning the uncertainties associated with the facility designs, with current throughput scale as one factor that was considered.

Section 6.8 (UO_2: Gelation / Ceramic UO_2 Facility) in LLNL (1997a) contains information concerning the throughput scale of the gelation process, which has been demonstrated at the Oak Ridge National Laboratory at a small laboratory scale.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 6

Recent NRC positions in this area are not stated in the EIS, but are alluded to in the supporting documentation. The NRC (in a response to the FR notice and in a separate EIS) has clearly stated concerns about the lack of a use for the DU, the likely probability that a significant amount (if not all) of the DU will become waste, and the high probability that DU will require "deep disposal" because of the unacceptably high MEI dose rates from near surface disposal. Such significant conclusions by a regulator should be included and discussed in the PEIS.

Response 6

The NRC recommendations, as stated in the agency's response to the Federal Register Notice (59 FR 56324), are reflected in the PEIS by the consideration of the disposal of uranium oxide (U_3O_8) in a mined cavity as one of the alternatives considered. In addition, a new section has been added to the PEIS (Section 1.7) that summarizes studies and reports related to depleted UF_6 management, including the EIS prepared by the NRC, "Final Environmental Impact Statement for the Construction and Operation of the Claiborne Enrichment Center, Homer, Louisiana" (NRC 1994). The findings of this NRC EIS, which support disposal of uranium oxide in a mined cavity, are summarized in the PEIS.

Comment 7

DU metal seems to receive a favorable treatment in the PEIS with impacts significantly below historical experience. This appears because some of the release fractions and impacts are underestimated significantly (beyond technological optimism). This should be corrected in the PEIS.

Response 7

It is assumed in this response that the comment concerns the conversion of UF_6 into uranium metal via batch reduction, which is a mature industrial process with many years of historical experience.

Information concerning the batch reduction of UF_6 into uranium metal can be found in Section 6.9 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The release fractions used in the accident analysis were based upon the document "Recommended Values and Technical Bases for Airborne Release Fractions, Airborne Release Rates and Respirable Fractions at DOE Non-Reactor Nuclear Facilities" (DOE-HDBK-0013-93, July 1993). This handbook is the recommended resource for airborne release fractions for postulated accident scenarios involving radioactive materials.

The document "Disposition of Surplus Highly Enriched Uranium Environmental Impact Statement" (DOE/EIS-0240, 1996) considered batch reduction of enriched UF_6 into uranium metal, for potential blending with low-enriched uranium. The impacts of postulated accidents in this document are similar to those considered in the PEIS.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 8

Gelation technology appears to receive a less than favorable treatment in the PEIS, using TCE as a solvent instead of oil, tray instead of tube furnaces, and including a U_3O_8 production step, followed by nitric acid dissolution and UO_2 production (the aforementioned two plants in one misrepresentation). While in the final analysis the difference is small, it is incorrect, and the PEIS should correct the misrepresentation. There are recent published articles (which you have copies of) that give a detailed description of gelation technology as applied to DU, and these should be used as references in the PEIS.

Response 8

The PEIS does not misrepresent or unfavorably treat the gelation process. Based on the data and references available, a reasonable (but not optimal) design was prepared. The major uncertainties associated with the gelation design considered in the PEIS are associated with the disposition of the wash effluent and the capacity of the gelation columns.

To answer the specific issues raised in this comment:

1. Using silicone oil as the gelation medium would require adding a gel washing step. The report "Internal Gelation to Prepare (U, Pu)Ox or UO_3 Spheres Using Perchloroethylene Media" (ORNL/TM-9330, 1984) states residual oil adhering to the gel spheres must be washed off using a solvent. The spent solvent would then be distilled to separate the oil and solvent for recycle. The same report suggest using perchloroethylene as the gelation medium. Each gelation medium has its advantages (and disadvantages). Page 6.8-1-2 of the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) states "Using a different gelation medium such as silicone oil is not expected to significantly affect the environmental impacts of the gelation facility."

2. Vertical tubes furnaces are simpler than tray tunnel furnaces because there are no trays handling/conveying mechanisms. It should however be noted that the tube furnace diameter (and capacity) may be limited by the requirements to maintain uniform temperature between the tube wall and centerline.

3. The gelation process considered in the PEIS includes U_3O_8 production and dissolution, but it is not two plants. The basis for the gelation process in the EAR is the report "Chemical Flowsheet Conditions for Preparing Urania Spheres by Internal Gelation" (ORNL/TM-6850, 1979). In the ORNL flowsheet, gelation column feed (acid deficient uranyl nitrate, or ADUN) was prepared by dissolving U_3O_8 in a sub-stoichiometric quantity of nitric acid.

4. Only articles on UO_2 fuel fabrication were used in preparing the gelation process. No articles appear to be publicly available that specifically dealt with depleted UO_2.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 9

Costs are not brought forward in the PEIS. Costs from the CAR and from published articles should be discussed and reconciled in the PEIS, as cost is likely to be a significant determinant in the DU disposition option selected.

Response 9

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives (as contained in the cost analysis report [CAR]) is generally not considered an environmental impact; consequently, cost information is not provided in the PEIS. The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy.

Comment 10

DUSCOBS and PYRUC shielding materials are not discussed in the PEIS. DOE appears to have an interest in these materials, and they are likely to have better properties for disposal than either DU metal or uranium oxide in concrete. As such, they should be mentioned and discussed.

Response 10

As stated in Section 2.2.4, Section 2.2.5, and Appendix H, the two use alternatives evaluated in detail in the PEIS, use as uranium oxide and uranium metal as radiation shielding, were selected as representative options for the purposes of comparing the potential environmental impacts of broad alternative management strategies. These options were intended to be representative only, and were not intended to preclude other potential uses in the future. This point has been clarified in Section 1.5.3 of the PEIS by adding text stressing the representative nature of the facilities, processes, and uses evaluated for the purpose of estimating environmental impacts. Specific uses, such as those mentioned by the commentor would be considered and evaluated in future planning

and environmental analyses, as appropriate. One of the uses mentioned in the comment, DUSCOBS, was evaluated by the independent technical reviewers in the technology assessment report (LLNL 1995; the full citation is provided in Chapter 8 of the PEIS) and was found to be not feasible due its lack of maturity and not enough information being available at the time. However, if a use strategy is selected in the Record of Decision, all specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks.

Comment 11

Waste: In Section S.4.8 on page S-40, waste management impacts are discussed. DOE should consider briefly highlighting the potential uranium content of the secondary streams, along with a brief assessment of acceptability for either reuse/nonradioactive disposal or disposal as radioactive waste. DOE should expand the discussion in the last paragraph about uranium disposal as LLW. The DOE may wish to cite regulatory agency positions on the wastes, including the NRC position letter (from Benero) sent to DOE as part of this EIS process and the NRC LES EIS analysis. For example, the NRC documents provide analyses supporting DU disposal as a LLW, but note that its disposal could require a mine or another means of "deep" ("Non near-surface") disposal. Currently, no "deep" disposal sites exist, and all current LLW disposal sites (existing and planned) use near-surface facilities. Thus, it would seem that disposal of DU may have significant impacts and regulatory requirements beyond those listed in the PEIS. DOE should consider adding the cumulative impacts from DU oxide disposal to Section S.4.13 "Cumulative Impacts."

Response 11

Although there are uncertainties in the predicted uranium content of secondary waste streams, estimates of the potential uranium content of CaF_2 are given in Sections S.4.8, 2.4.8, 5.3.7, F.3.7.1, and F.3.7.2 (i.e., less than 1 ppm). An estimate of the potential uranium content of MgF_2 is given in Section F.3.7.3 of the PEIS (i.e., 90 ppm). This estimate has been added to Sections S.4.8, 2.4.8, and 5.5.7, as requested by the commentor.

With respect to the fate of the CaF_2, the PEIS does state in Sections S.4.8 and 2.4.8 that "the low level of uranium contamination expected (i.e.,less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste is most likely." If disposal of CaF_2 is required, the PEIS acknowledges that it may be considered LLW, and assesses the impacts for both disposal as nonhazardous solid waste and disposal as LLW. Currently there are no known uses for the MgF_2 that would be produced if the use as metal alternative were to be selected; it is therefore assumed that this MgF_2 would require disposal either as nonhazardous solid waste or as LLW. Brief discussions of the market for anhydrous HF and historical industrial experience showing that if produced, it could be purified to contain less than 1 ppm uranium, are provided in Sections 2.3.3 and F.2.1 of the PEIS. Text has been added to Sections S.4.8 and 2.4.8 to clarify the assumption made in the PEIS that if HF were produced, it would be sold for use subject to appropriate review and approval by the U.S. NRC or DOE.

The PEIS assumes that any depleted uranium oxide disposed of would be classified as LLW. The evaluation of disposal options in the PEIS considered disposal in representative facilities which could be used for the disposal of LLW, including shallow-earthen structures, vaults, and mines. Because the PEIS is not intended to identify sites for future management activities, the potential impacts of the disposal options were evaluated using generic environmental settings, and considered both "wet" and "dry" sites. The characteristics of these settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the alternatives. After the Record of Decision for the PEIS, potential facility locations would be evaluated and appropriate site-specific analyses for any required facilities would be conducted.

The detailed analysis presented for disposal in the PEIS does indicate that the dose to a hypothetical receptor from contaminated groundwater would exceed regulatory limits for a disposal facility in a "wet" environment for all three disposal options considered, including disposal in a mine. However, the analysis also indicates that groundwater impacts would be less than regulatory limits for a disposal facility located in a "dry" environment, including shallow-earthen structures and vaults. (These results are summarized in Section 2.4.5 and presented in detail in Section I.4 of Appendix I). It must be stressed, as noted in Appendix I, that the disposal calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. Rather than cite regulatory agency positions that may not be applicable to the disposal of depleted uranium oxide in the summary of potential waste impacts, text has been added to Sections S.4.5 and 2.4.5 (Water and Soil Impacts) detailing some of the uncertainties of the non-site-specific analysis for disposal, and stating that if disposal were implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option).

Cumulative impacts were evaluated in the PEIS only for components of the alternatives for which the locations of the actions were already known (i.e., continued cylinder storage and cylinder preparation for shipment). The cumulative impacts of these components are described in Section 5.8, and summarized in Section S.4.13. Text has been added to Section S.4.13 to clarify the scope of the cumulative impacts analysis.

Comment 12

Leach Rates — Page 2-22 briefly mentions leach rates and waste forms, and states that grouted wastes are representative of immobilized waste forms with low leach rates, with the implication that grouting is also representative of vitrification. DOE should clarify this text, as grouting may be representative for some parameters (e.g., facility size) but not representative in others (e.g., energy usage, emissions). Also, while grouting should provide for somewhat lower

leach rates as compared to the ungrouted material, vitrification would be expected to provide for much lower leach rates than grouting (typically, 5-6 orders of magnitude less), and this may be an issue for some disposal options. Consequently, these items should be discussed.

Response 12

Vitrification of depleted uranium oxides for the purposes of disposal is discussed on Section 2.3.4 of the PEIS and in the technical backup report "Technology Impact Review — Vitrification of Uranium Oxides Resulting from Conversion of Depleted Uranium Hexafluoride," by Swanstrom et al. (1997). The backup report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS. As discussed in the PEIS and in the backup report, technologies for vitrification of depleted uranium oxides are in the early stages of development, and since the PEIS is intended to provide an analysis of broad, programmatic alternatives, a mature and common technology, grouting, was used as the representative technology to evaluate and compare the impacts of stabilization for disposal. If vitrification proves to be a better technology in the future, nothing in the PEIS would preclude its use.

Comment 13

Empty Cylinders — The impacts from disposition of the empty cylinders are not included, although potential options are listed (page 2-23). It would seem reasonable to provide a brief discussion on these options and include impacts from cylinder disposition in the EIS.

Response 13

A PEIS support document by Nieves et al. (1997) entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 14

Water Impacts — The summary table of impacts (Table 2-2) and the supporting text for the water and soil section (page 2-50) note that the groundwater uranium concentrations will exceed drinking water guidelines. It is recommended that the expected concentrations are also expressed in terms of individual radiation doses.

Response 14

The potential radiation doses to members of the general public from the use of groundwater at the three current storage sites was calculated for the no action alternative and the action alternatives; the doses are given in Sections 5.1.1.1.2 and 5.2.1.1.2. The doses during the post-closure phase for the disposal as oxide alternative are discussed in Section 5.6.1.1.2.

In Table 2-2 it is stated that uranium groundwater concentrations could exceed guidelines under the Disposal as Oxide Alternative, wet environmental setting. The doses and chemical health risks from this exposure have been added to Table 2.2 under Human Health and Safety — Normal Facility Operations. Supporting text has also been added to Section 2.4.1.

Comment 15

Waste — Pages 2-52 et seq present a summary of the waste management impacts from the impacts. Comparisons are primarily with the DOE waste management system, although these facilities could also be commercially operated under NRC or State regulations. Consequently, DOE should consider adding a comparison to commercial LLW generation rates and categorization per 10 CFR Part 61. The section should also include estimated uranium levels for the magnesium fluoride waste (from DU metal production) and discuss the aspects of DU disposal, including the potential need for either a dedicated or a deep disposal facility.

Response 15

Because of the many uncertainties present at this time, the comparison of waste management impacts from depleted UF_6 waste was limited primarily to the DOE waste management system. Currently three commercial facilities (i.e., Barnwell, SC, Richland, WA, and Envirocare in UT) are accepting about 37,000 m^3/yr of commercial LLW, and DOE is disposing of approximately 65,000 m^3/yr LLW at DOE facilities. DOE LLW generation is expected to increase to about 100,000 to 200,000 m^3/yr once environmental restoration operations begin. Commercial facilities which manage LLW have the capability to expand rapidly and may accept DOE LLW in the future if it can be managed profitably. A summary of this information on commercial LLW generation rates has been added to Section C.10 as background information.

An estimate of the potential uranium content of MgF_2 is given in Section F.3.7.3 of the PEIS (i.e., 90 ppm). This estimate has been added to Section 2.4.8 as requested by the commentor, as well as to Sections S.4.8 and 5.5.7.

The detailed analysis presented for disposal in the PEIS does indicate that the dose to a hypothetical receptor from contaminated groundwater would exceed regulatory limits for a disposal facility in a "wet" environment for all three disposal options considered (i.e., disposal in shallow-earthen structures, vaults, or mines). However, the analysis also indicates that groundwater impacts would be less than regulatory limits for a disposal facility located in a "dry" environment for all three disposal options (these results are summarized in Section 2.4.5 and presented in detail in Section I.4 of Appendix I). It must be stressed, as noted in Appendix I, that the disposal calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. Text has been added to Sections S.4.5 and 2.4.5 (Water and Soil Impacts) detailing some of the uncertainties of the non-site-specific analysis for disposal, and stating that if disposal were implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option).

Comment 16

Dilution of Effluents — On page 5-51, the text indicates effluent levels exceeding EPA guidelines for uranium, but notes that the concentration would be much lower and below the guideline after dilution in nearby surface water. This should be clarified, and potential dose consequences of these effluents presented.

Response 16

The EPA guideline of 20 µg/L referred to is the proposed maximum contaminant level for drinking water, and thus is strictly applicable only to water samples taken at a tap and not to facility effluents. The applicability of this guideline is discussed in Footnote "f" of Tables S.2 and 2.2. In the context of page 5-51, the guideline was used only for purposes of comparison with estimated levels in surface waters. In order to clarify the applicability of the 20 µg/L levels as a guideline rather than a standard, a sentence has been added to Section 4.3.5 of the PEIS.

Details on dilution calculations for surface water discharges for all of the alternatives are discussed in Sections C.2, D.2.4.1, E.3.4.1, F.3.4.1, G.3.4.1, H.3.4, and I.3.4 of the PEIS, and in the supporting PEIS document titled "Water and Soil Impact Analyses in Support of the Depleted Uranium Hexafluoride PEIS" (Tomasko 1997b; the full citation is provided in Appendix C of the PEIS). The supporting reports are available for review at the DOE public reading rooms near the

three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The dose to the Maximally Exposed Individual from the General Public from all potential exposure pathways is presented in the following tables and figures: Table D.2, Table D.22, Figure E.9, Table F.4, Table G.3, Table H.2, and Table I.6. These doses included ingestion of surface water calculated on the basis of water concentration estimates given in the above-referenced Appendix Sections.

Comment 17

Metal Waste — Page 5-76 of the PEIS presents waste management for the metal cask manufacturing route. Waste management appears to have overlooked secondary wastes related to manufacturing, which are unique to uranium metal. For example, induction furnaces for uranium metal are usually lined with graphite, which requires periodic removal and replacement (sometimes as frequently as every ten charges or so). Also, while the proposed approach appears to use primarily direct casting, some uranium metal machining operations may be required, and, historically, these generate significant wastes containing partially oxidized uranium metal. The PEIS should include these potential impacts that primarily affect only the metal route.

Response 17

The graphite liner wastes from induction furnaces used in casting of uranium metal (mentioned in the comment) are included in the operations waste of the metal manufacturing facility (see page 5-17 of the PEIS). Table H.15 of Appendix H lists the operations waste (LLW) for both the uranium oxide and uranium metal facilities. The difference in the quantities (650 m^3/yr and 126 m^3/yr) is due primarily to the graphite liner wastes mentioned in the comment.

While some machining operations may be required during the uranium metal fabrication process, almost all of this machining will be on uncontaminated stainless steel parts. Very little LLW is expected from the machining of uranium metal.

Comment 18

Doses from DU Disposal: Section 5.6 (pages 5-78 et seq) and Appendix I present the impacts from disposal of the DU, for both the operational phase and the post-closure period. The radiological impacts from the accidents seem unexpectedly high; for example, the analysis shows public doses of up to 1.1 rem and noninvolved worker doses as high as 140 rem, apparently due to earthquake initiated events, without explanation. The routine impacts also seem high for the postclosure phase and appear to follow the radiological order: mine impacts > vault impacts > trench impacts.

Calculations appear to use an infiltration area effect and do not account for chemical form, solubility, and kinetic effects. Table 1.31 contains zero values for the dry site doses for all three

disposal approaches, and no collective dose estimates are included. These points are non-obvious and it is recommended that they are explained in more detail.

Response 18

With respect to radiological impacts from accidents associated with disposal options, the earthquake involving release of U_3O_8 was associated with high radiological doses, as noted by the commentor (see Appendix I, Table I.10). The high doses for U_3O_8 are due to the material form and the release height. U_3O_8 is a fibril material which is almost powder-like. This characteristic results in a higher release amount (400 pounds) compared to a similar accident with UO_2 pellets (0.7 pound) (see Appendix I, Table I.9). Additionally, an earthquake is assumed to cause structural failure of the building, during which the uranium oxide containers collapse and release the material at ground level. This is much different than the tornado event assumptions where the wind speeds are larger and there is some upward movement to the released material. The lower wind speed and ground release result in larger releases near the building and the surrounding areas for the earthquake event, and thus result in high worker and public doses. This type of specific accident scenario information is provided in the engineering analysis report (LLNL 1997; the full citation is provided in Appendix I of the PEIS) associated with the PEIS.

The routine impacts for the post-closure phase address the potential impacts from groundwater use. The groundwater could become contaminated as a result of container failures that release U_3O_8 or UO_2 to the environment. Although U_3O_8 and UO_2 are essentially insoluble in water, a conservative estimate of dissolution was obtained by assuming that Schoepite ($UO_3 \cdot H_2O$) would form under the aerobic conditions present in the soil phase. Estimates of groundwater concentrations were then obtained by assuming the leachate concentration in the waste area was equivalent to the solubility of Schoepite. As radionuclides travel downward to the groundwater table, distribution of radionuclides in soil solid and soil liquid phases were assumed in equilibrium. This assumption was acceptable because it would take a very long time (at least several hundred years in the calculation cases) for radionuclides to reach the groundwater table and to reach the maximum concentration level. Potential impacts were calculated with the estimated maximum groundwater concentrations within 1,000 year after failure of the disposal facility.

On the basis of the above assumptions, the relative potential impacts would depend only on the dimensions of the disposal area and the infiltration rate. Factors such as solubility, chemical form, and kinetic effects would be the same for a mine, vault, or shallow earthen structure. Impacts for disposal in a mine would be greater because of the larger disposal area required. As noted in Section I.4.1.1.1, impacts for dry sites would be zero, because it would take more than 1000 years for uranium and its decay products to reach the groundwater table [due to a combination of the depth to the watertable (500 ft — Section 3.4.4.1) and the low rate of infiltration (0.1 in./yr — Section 3.4.4.1)]. Additional details on these calculations can be found in Tomasko (1997; the full citation is provided in Appendix I of the PEIS), as indicated in Section I.4.2.

Collective impacts were not estimated because it would require detailed information on the groundwater flow direction and distribution as well as knowledge of the off-site population that would use the groundwater. Since siting of a disposal facility is not addressed in this PEIS, estimation of collective impacts would involve a large degree of uncertainty, and was therefore not conducted.

The engineering analysis report, Tomasko (1997), and other supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 19

Unspecified Applications: On page S-11 and later in the summary (pages S-42 et seq), DOE identifies the preferred alternative strategy as use of 100% of the DU hexafluoride inventory, as either uranium oxide, uranium metal, or a combination of both, without specifying the use of the material and the potential impacts (positive and negative) from such DU use. The PEIS also does not provide information indicating a market demand capable of consuming 100% of the DU inventory, but the conversion of the DU hexafluoride would occur as ". . . uses for these [uranium oxide and metal] products become available" (page S-43). Without applications for significant quantities of DU oxides and metals, these DU materials may ultimately become a waste material. The discussion does not discuss regulatory and licensing requirements for these DU applications, It is recommended that (1) DOE identifies the likely market consumption of DU oxides and metals over the time frame of the EIS, (2) DOE estimates the impacts from these potential DU uses, (3) DOE considers the potential of the converted DU materials becoming a waste, thus, requiring conversion into forms compatible with disposal, and (4) DOE evaluates the likely regulatory and licensing aspects.

Response 19

The commentor's recommendations are addressed below in the order that they are listed in the comment:

1. The PEIS evaluates two representative use options, use as uranium oxide and use as uranium metal as radiation shielding. As stated in Appendix H of the PEIS, these options were intended to be representative only, and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses is considered beyond the scope of the PEIS. Such issues would be considered and evaluated in more detail in future planning and environmental analyses.

In addition, the PEIS is not intended to provide a detailed analysis of potential market demand. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as necessary, to continue the safe management of its depleted UF_6 cylinder inventory.

2. The impacts associated with a specific use will depend on what use or uses are ultimately identified, which is beyond the scope of the PEIS. As mentioned above, the PEIS is not intended to select a specific end-use or preclude other potential uses in the future. Any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained. The impact analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions. As with the use of any radioactive material, careful consideration would be given to whether the benefits of the proposed use outweigh the potential risks.

3. The PEIS acknowledges that at the end of their useful lives products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4, 2.2.5 and 5.9). Potential need for converting metal into an oxide if disposal is required is acknowledged.

4. The purpose of the PEIS is to provide an evaluation and comparison of potential environmental impacts associated with the alternatives considered. Regulatory and licensing aspects are outside the scope of the PEIS, but would be addressed, as appropriate, when specific uses are identified. A listing of environmental, occupational safety, and health permits and compliance requirements is presented in Chapter 6 of the PEIS.

Comment 20

DU as Cask Shielding- DOE appears to be relying upon the potential future use of DU as SNF cask shielding for a large consumption of its DU inventory (see page S-43 and 1-8, and Volume 2 of the EAR, which analyzes a DU cask manufacturing facility as the only use of DU). If this is indeed the case, DOE may wish to describe and discuss it in a little more detail in the PEIS summary and in Section 2.5 (pages 2-54 et seq), and it should be noted that no currently licensed or planned SNF cask uses DU.

Response 20

Appendix H of the PEIS provides information concerning the current and potential uses of depleted uranium. It also provides detailed information on the design and potential future use of depleted uranium as spent nuclear fuel (SNF) cask shielding.

Historically, uranium has been used for shielding applications on a small scale. No existing, licensed, or proposed spent nuclear fuel shielding designs use depleted uranium in quantities exceeding 10 percent of the DOE inventory. The two conceptual shielding designs considered in the PEIS would however consume the entire DOE inventory.

Further information concerning the potential use of depleted uranium in spent nuclear fuel shielding is provided in Section 6.11 (Potential Shielding Applications in Metal & Oxide Forms) of the engineering analysis report (LLNL 1997; the full citation is provided in Appendix H of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 21

Fate of DU Shielding. As currently written, the PEIS does not include a discussion of the eventual fate and potential impacts of the DU SNF cask after its use (e.g., see pages 2-14 and 2-15). Pages 5-55 and 5-65 also mention that DU cask disposition after use is excluded, and page 5-65 notes that disposal would amount to an additional 180,000 cubic meters (6.4 million cubic feet) of waste requiring disposal, with a (calculated) average specific gravity of 2.2. This does not seem inconsequential, particularly if a dedicated disposal facility is required and the impacts are estimated to be similar to disposal (e.g., page 5-83 et seq; exceeding 10 CFR Part 61.41 dose limits). Also, there are statements in the document that question if significant quantities of DU metal are suitable for disposal (e.g., last paragraph on page 2-21). Inclusion of a discussion about the disposition of the DU cask after use, and potential impacts, is recommended.

Response 21

The PEIS acknowledges that at the end of their useful lives, products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4, 2.2.5 and 5.9). At this time, any analysis of disposal after use would be too speculative as it is not known when and at what rate the material would be declared surplus and would be disposed of. Although large quantities of DU metal may not be acceptable for disposal, small quantities of the metal on an annual basis have been disposed of in the past and could again be accepted at some future disposal facilities.

Comment 22

"Uranium Oxides:" The PEIS generally combines all uranium oxide compounds under the title "uranium oxides" for consideration in the alternatives and strategies (see page S-6 et seq). This seems too all inclusive, as uranium oxides have significantly different chemical and physical properties that produce a wide range of ES&H impacts. For example, uranium octaoxide is a high porosity powder, with a low density and a significant respirable fraction. Uranium dioxide powder is also porous, and can spontaneously ignite in air. On the other hand, sintered uranium dioxide has the highest density of the uranium oxides and is essentially pore free. The presence (or absence) of

pores also has significant implications for the potential disposal of the material, either as a management option or as an end-use item; a denser, essentially pore free material would appear to be advantageous. Thus, a uranium dioxide material sintered to a lower density (say, 4-5 g/cc) would not be expected to perform as well in a disposal environment as a uranium dioxide sintered to a high density (say, 9-10 g/cc). It is recommended that more qualifiers are given to the term "uranium oxides," perhaps including low and high density as the principal discriminators.

Response 22

The PEIS recognizes the differences noted in the comment among different chemical forms of uranium oxides. In fact, the analyses were done separately for conversion to and storage and disposal of U_3O_8 and UO_2. The results are also reported separately for these two chemical forms (see Section 5 and Appendices D through K). The impacts of long-term storage as oxide and disposal as oxide alternatives are reported in Section 2 and in the Summary as ranges covering both forms of uranium oxide as well as differences in assumptions concerning environmental settings (see section 4.2.3 of the PEIS). The reason for this was to clearly define the differences among the alternatives and at the same time, allow the reader to explore the chemical specific aspects of the management options considered in the PEIS. Although the headings of sections and the names of management options and alternatives refer only to oxides, the results in Section 5 and Appendices are reported as chemical specific.

Comment 23

Equivalent Bases and Life-Cycle Effects: The text does not seem to incorporate a life-cycle approach to the different management alternatives and compare them on an equivalent basis (see pages S-7 et seq). For example, recycle (if a market exists) and disposal would seem to be the logical endpoints for all of the alternative branches shown in Figure S.2, and may influence the impacts and potential alternative(s) selected. However, disposal is only shown for the disposal as oxide alternative. It would seem that the "manufacture and use" alternatives will ultimately result in impacts from the DU component; for example, the material (perhaps as itself or in a product) could be shipped to a disposal facility. Such potential impacts do not appear to be included in the analysis, and may even preclude some options or require additional conversion and conditioning; for example, without supporting analyses, it is unlikely that significant quantities of DU metal can meet the regulatory requirements of disposal sites. Thus, pursuit of use as a metal option may require another conversion facility (with its impacts) to convert the DU metal into a form compatible with disposal. Other examples of the need for equivalent bases include the oxide conversion routes, due to fundamental differences in the uranium oxide forms. One of the specific oxide conversion routes (gelation) appears to be manufacturing uranium dioxide with properties comparable to high density nuclear fuel which would be anticipated to have improved stability and related properties as compared to the other oxides. The gelation route also appears to include two plants — one for uranium octaoxide production and one for dissolution/uranium dioxide production — which appears inconsistent with literature reports on the process (i.e., only one plant; no production of uranium octaoxide) and the other oxide conversion routes. Long-term storage also appears to lack the

realization of ultimate disposal in the future. The PEIS should consider and analyze the alternatives on an equivalent basis with the same/comparable endpoints and include life-cycle effects.

Response 23

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for a 40 year assessment period for all alternatives. In addition to this analysis, an evaluation of the long-term impacts from disposal was included in the PEIS because such impacts can be reasonably predicted. A life-cycle analysis for the alternatives other than disposal was not performed at this time because actions to be taken beyond the 40 year period considered in the analysis are considered highly uncertain and speculative. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

The gelation route in the PEIS includes U_3O_8 production and dissolution, but it is not two plants. The basis for the gelation process in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) is the Oak Ridge Report ORNL/TM-6850, "Chemical Flowsheet Conditions for Preparing Urania Spheres by Internal Gelation" (July 1979). This report provided a complete design to convert UF_6 to U_3O_8, and supplied the process information needed to prepare a material balance and flowsheet to convert U_3O_8 to UO_2 microspheres by gelation. The gelation process in the PEIS has not been optimized, but it is considered to be reasonable and suitable for impact analysis.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 24

Results: Pages S-15 et seq summarize and compare the results of the impacts for the alternative management strategies. Some of these results seem inconsistent and are not intuitively obvious. For example, it is not clear why the use as uranium oxide results in higher impacts than the use as uranium metal (see pages S-20 and S-49) — the opposite would be anticipated. Land use impacts seem uneven; conversion and metal use plants would be anticipated to have larger land use because of facility size and require potentially larger setbacks for potential accident mitigation from uranium releases (see the NRC LES EIS). It is not clear if the disposal analyses include all of the potential long-term impacts and doses from uranium leaching from the disposal area. It is recommended that DOE consider greater consistency in the results and clarify the summary.

Response 24

With respect to differences in impacts from accidents between the use as oxide and use as metal alternatives, many categories of accidents are summarized in Tables S.2 and 2.2 of the PEIS. In general, the impacts of accidents from use as oxide and use as metal are the same (see the Categories Likely Cylinder Accidents, Low Frequency-High Consequence Cylinder Accidents, Low Frequency-High Consequence Accidents at All Facilities-Chemical Accident). The category of accident referred to by the commentor, namely Low Frequency-High Consequence Accidents at All Facilities-Radiological Accident, does have higher consequences for the use as oxide alternatives than the use as metal alternative. This is due to the specific accident scenarios appropriate to the technologies being evaluated; additional information on the accident scenario assumptions for manufacture and use is given in Section H.3.2 of Appendix H, and in the engineering analysis report (LLNL 1997; the full citation is provided in Appendix H of the PEIS). However, in general the results of accident impact analyses for the use as oxide and use as metal alternatives were considered to be approximately the same. (The engineering analysis report is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC [listed in the Notice of Availability], and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.)

The land use requirements for long-term storage and disposal alternatives are greater than those for conversion and use alternatives because of the large land area required to store or dispose of the entire inventory. Conversion facility land areas presented in the PEIS do not include buffer zones. NUREG-1140 p. 30 suggests a 1 mile protective action distance (PAD), which is based on a UF_6 cylinder rupture that releases uranium and HF. The PAD is the recommended distance for which emergency planning would be appropriate to mitigate off-site exposure to accidental releases. A conversion facility is not required to have ownership of the area encompassing the PAD. The PAD for a metal or oxide shielding facility would be much less because UF_6 would not be handled at these facilities. Wherever land use for conversion facilities is discussed in the PEIS, text has been added acknowledging the need for a protective action distance. The engineering analysis report provides more details on land-use assumptions.

The disposal analyses do include long-term impacts and doses from leaching from the disposal area; these impacts are discussed in detail in Section I.4 of Appendix I and presented in Tables S.2 and 2.2 under "Water and Soil." Text has been added to Tables S.2 and 2.2 under "Human Health and Safety-Normal Operations" to indicate long-term post-closure impacts from disposal.

Comment 25

Ranking: The summary of the results (page S-15 et seq) does not include a ranking of alternatives, and implies that all of the alternatives are acceptable. DOE may wish to rank or identify those alternative(s) that appear more favorable than others based upon the analysis. DOE may also want to consider if any of the proposed alternatives are precluded by the analysis; for example, page

5-84 mentions individual (groundwater ingestion) doses of 100 mrem/yr from disposal, thus exceeding 10 CFR Part 61 standards of 25 mrem/yr. Page 5-84 also mentions a scenario for a hypothetical future resident living on the disposal site and receiving radiation doses as high as 10 rem/yr. The PEIS summary also mentions an NOV on storage at the Portsmouth facility, which might imply that a no-action alternative is not a viable option for this site.

Response 25

The purpose of the PEIS is to provide a meaningful evaluation and comparison of the potential environmental impacts of broad alternative management strategies. Thus, the summary and main body of the PEIS provide a discussion and comparison of potential impacts among the alternatives. In general, alternatives cannot be easily or meaningfully "ranked" in an overall sense because potential impacts occur in several different environmental areas, such as impacts to human health and safety, groundwater, air quality, and ecology. No one alternative offers advantages in all environmental areas, making any "ranking" of alternatives very subjective. Consequently, the PEIS discusses and compares the potential impacts of the alternatives in each area separately. The results of the PEIS indicate that all alternatives have generally similar environmental impacts, although differences do exist in the types and magnitude of impacts for some areas assessed, as discussed.

In addition, the PEIS indicates that no alternatives are precluded on purely environmental grounds. Although the results of the disposal alternative indicate that radiation doses to individuals could potentially exceed regulatory limits for disposal in a "wet" environment at some point in the distant future, the analysis also indicates that impacts would remain within regulatory limits for a disposal facility in a "dry" environment. The PEIS also stresses (see Appendix I) that the post-closure disposal analysis is based on generic information and is subject to a great deal of uncertainty. Actual impacts from disposal would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required.

Comment 26

Technology and Equipment Development: The PEIS encompasses numerous technologies that are at different stages of development, in terms of process, understanding, equipment, (potential) impacts, and uncertainties. For example, of the conversion, application, and disposal impacts discussed within the summary, none are practiced on any scale domestically, and only conversion to the octaoxide is practiced on a large scale internationally, producing a low density product. Thus, there is only one direct analogy. DOE should consider including a technology discussion, with status and assessment, perhaps with either a time schedule or probability of success, for some of these technologies. For example, it seems like a significant extension of existing uranium dioxide sintering technology to take pellets from 100 te(U)/yr/line to 7,000 te(U)/yr/line. From the uranium

dioxide technology perspective, microspheres (e.g., from gelation) may be the more mature technology because of the (potential) use of tube furnaces and pilot plant tests with equipment processing rates an order of magnitude larger. Similarly, a uranium dioxide/concrete cask approach appears to be a significantly easier technology to understand and scale than casting a 40 te(U) metal shield.

Response 26

Subsection 1.2.6 (Uncertainties) in Section 6.0 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) discusses the process and equipment uncertainties associated with each option. In general, the conversion to oxide and the batch conversion to metal processes are well known with extensive operating experience. The continuous reduction to metal process requires development and extensive scale up. Oxide shielding manufacture is a simple process but needs to be demonstrated. Metal shield manufacture requires large-scale melting, casting, and machining that needs development.

Conversion of UF_6 to U_3O_8, recovery of 70% HF, oxide compaction, packaging in bins, and storage inside buildings is performed on a large scale (15,000 tonnes per year) by COGEMA in France to stabilize depleted UF_6. Recovery and upgrade of the 70% HF to anhydrous HF (AHF) has not been demonstrated. The EAR assumed production of AHF using a process patented by J. Mestepey of Sequoyah Fuels. The AHF process needs verification and demonstration.

Conversion of UF_6 to UO_2 ceramic pellets is performed in nuclear fuel fabrication plants (500 tonnes per year). The pusher-type furnaces used for fuel pellet sintering would not be suitable for large throughputs. Equipment development is needed for the sintering furnaces. But the throughput needed for pressing and sintering is not unusual for the ceramics industry.

Production of UO_2 nuclear fuel microspheres by gelation has been successfully tested in pilot-scale units. For large throughputs, the gelation liquid effluent must be recycled to avoid high reagent costs and waste disposal costs. A recycle process must be developed for gelation to be viable.

Batch reduction to uranium metal is a mature industrial process used to produce uranium metal for nuclear fuel, penetrators, and armor. Higher production rates can be achieved by adding more batch furnaces. A system to decontaminate the MgF_2 byproduct was installed at Aerojet (Jonesborough, TN).

Continuous reduction to metal research was conducted at Oak Ridge Y-12. Extensive development and scale-up would be needed.

Oxide shielding applications (DUCRETE cask) was researched at the INEEL. Development work is continuing at Nuclear Metals Inc. The process is similar to concrete mixing.

Batch melting and casting to produce uranium metal fuel and other products is a standard industrial process. Metal shielding applications (metal cask) will require large-scale melting and casting of uranium metal. The single pour concept to cast the annular shield requires extensive development.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 27

Existing Facilities and Experience: There are obvious analogies with existing, commercial fuel cycle facilities, which process uranium hexafluoride into uranium dioxide (for nuclear fuel) and (to a lesser extent) uranium metal. These facilities are already licensed by the appropriate regulatory agencies. The PEIS does not mention these facilities, either as a source of experience or as a source of processing capacity, particularly during the development of uses for the DU materials and as a means for surge capacity. The PEIS also does not appear to draw upon the operating experience of these facilities, including waste generation and uranium content of byproducts. DOE may wish to include the experience of operating commercial facilities and comment upon their potential use (or non-use) during the development of applications and uses for the DU.

Response 27

The PEIS considered the historic operations of similar existing processes and facilities during the development of process design and estimation of waste generation, atmospheric emissions, etc. for each option. This information is provided in Section 3.0 (Summary of Options Analyzed in Depth) of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). All new facilities were assumed to be constructed and operated at a generic green field site, as future planning and analysis documentation would determine the exact locations for any new facilities constructed in support of depleted uranium management.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 28

Regulatory Basis for Future Facilities: The PEIS indicates several facilities may be involved for the management alternatives, and may involve DOE, commercial, and/or both types of facilities. DOE should briefly discuss the regulatory basis for these facilities, potential differences (if any), and any impacts, and any effects from facilities transitioning from DOE to the NRC regulatory environment.

Response 28

Major laws, regulations, executive orders, and compliance instruments that would apply to activities of the Depleted Uranium Hexafluoride Management Program under the no action and other alternatives are identified in Section 6 of the PEIS. The PEIS evaluates the environmental impacts of broad programmatic strategies for the long-term management of the depleted UF_6 inventory. It does not propose any site-specific facilities or technologies for conversion, long-term storage, manufacturing, and disposal, nor address whether facilities would be owned or operated by DOE or the commercial sector. Before implementation of the strategy selected in the ROD, site-specific evaluations would be performed and the proposed facilities would have to comply with all applicable regulations and standards.

Comment 29

Economics: The PEIS mentions a separate Cost Analysis Report (CAR) as providing input to the PEIS (e.g., page 1-7). However, program costs do not appear to be included in the analyses. DOE should consider including the costs and other economic impacts in the PEIS, perhaps as part of the summary (e.g., in Table S-2).

Response 29

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives is generally not considered an environmental impact; consequently, cost information is not provided in the PEIS. However, cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

In addition, the cost information is used as input to the socioeconomic analysis presented in both the summary and main body of the PEIS. The PEIS addresses socioeconomic impacts on human communities, including changes in employment, local housing demand, public finances, and population in-migration.

The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, including the cost analysis and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 30

DU Quantities: The insert on page S-2 identifies some 46,422 DU cylinders distributed between the three sites. While the total quantity is listed in the main text of the report, it would be helpful to have the approximate masses (as either MTU or $MTUF_6$) for the three sites listed in the summary as well. The insert on page S-2 also notes that an additional 8,000 cylinders have been produced by USEC. It is suggested that this number is also divided between the sites and expressed in mass quantities. It is also recommended that a brief discussion about the USEC DU is included, perhaps as part of the first paragraph on page S-4. While the EIS excludes the USEC DU from its analysis, it also implies that there is a reasonable probability of it becoming DOE's responsibility. Consequently, DOE may want to consider that possibility in its impact analysis.

Response 30

The text of the insert in Section S.1.1 and the text in Chapter 1 of the PEIS have been revised to include the quantity of depleted UF_6 in metric tons.

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citation is provided in Chapter 8 of the PEIS). In order to accommodate these new cylinders, the PEIS has been revised. Rather than increasing the amount of cylinders assumed to be processed annually, the revised PEIS assumes that the work-off period (the period over which the processes assumed in the PEIS, for example, cylinder preparation, transportation, conversion, manufacturing, would take place) has increased by approximately 6 years (i.e., from 20 to 26 years).

Comment 31

Other DU Uses: Page 2-21 mentions non-shield use of DU. No mention is made of quantities or relative percentages of the DU inventory. Also, it is not self-explanatory that DU cask manufacturing and uses bound all of the potential uses; for example, metal uses would appear to require a significant amount of alloying and/or machining, and involve handling and disposal concerns. DOE may wish to include a longer discussion and a better explanation.

Response 31

As described in Section 2.2 and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses

as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks.

Comment 32

Other Sites: Pages 3-58 et seq present information on the generic sites for wet and dry locations, and mention that the site data for each are derived from actual wet and dry sites. It is suggested that the actual sites which provide the basis for the generic locations are listed.

Response 32

Data taken directly from actual sites (i.e. cities within the U.S.) were the meteorological data used in the impact calculations for disposal options. However, the selection of the meteorological data was performance based and not related to potential locations, other than a dry or wet setting, for a disposal facility. Thus, the identification of these sites in the PEIS has no value. The meteorological data used in the characterization of the "dry" and "wet" settings for the location of a disposal facility were taken from archives of the National Weather Service. Meteorological data from cities that met the dry or wet annual rainfall criteria (approximately 10" and less or 40" and more, respectively) were screened to obtain a set of 5 locations in each case that resulted in the largest range of impacts that is consistent with either a dry or wet setting.

Comment 33

Time frame: Page 4-2 lists a 41 year time period for the EIS (through the year 2039), and indicates activities beyond 2039 would be subject to appropriate NEPA reviews and decisions in the future. This appears to truncate the analyses for some of the alternatives which might influence the selection of the preferred option; for example, impacts from wastes in a disposal cell are unlikely to occur by 2039, major cylinder/container replacements may be required for the storage option in the 10-20 years after 2039, significant applications may not have developed etc. DOE may wish to consider a time period consistent with the logical conclusion of the options or their "life-cycle," which may require a time frame beyond 2039.

Response 33

At the beginning of the PEIS preparation, the 40-year timetable appeared to be the most reasonable, based on consistency among alternatives. It was chosen as a reasonable period over which to estimate and compare the environmental impacts of the alternative management strategies considered in the Draft PEIS (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. For the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. Initial facility operations were based on a 20-year period for processing all of the inventory, which has been extended in the Final PEIS to approximately 26 years to account for processing up to an additional 15,000 cylinders that were previously the responsibility of USEC. Although the 40-yr time frame has been used for

the evaluation of operations, potential long-term impacts have been included for both disposal options (Section I.4 of Appendix I) and continued storage options (Appendix D, Table D.1 and throughout). Because of the extensive maintenance assumed for cylinders/containers under long-term storage options, also assuming that large numbers of containers would have to be replaced in the 10 to 20 years after 2039 was not considered reasonable.

In response to comments on the Draft PEIS, DOE has determined that, if an alternative requiring conversion is selected, that it is in the best interest of the public and the government to begin conversion as soon as possible. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory.

Comment 34

Failure Rates: Pages 5-3 and 5-19 discuss the estimated cylinder failure rates for the No Action and UF_6 Storage alternative. These appear to use the opposite ends of the failure rate range — No Action uses the lowest failure rate, while Storage uses the highest failure rate-without explanation. Also, the existing cylinders may not have adequate wall thickness under either alternative due to corrosion over the years (see Appendix E), and the DU may have to be transferred to new cylinders within the time frame covered by the EIS. DOE should consider presenting a discussion on these items in the text. Also, on page 5-40, Table 5.4 lists tank rupture accident as "incredible" events. Usually, these are assigned a value corresponding to the "extremely unlikely" frequency bin. A brief discussion is recommended

Response 34

As explained in the Introduction to Section 5.1, two analyses were actually conducted for the No Action alternative; one assuming that the cylinder maintenance and painting program would be effective in controlling further corrosion of the cylinders, and a second analysis which assumed that external corrosion was not halted by improved storage conditions and painting so that cylinder corrosion continued at historical rates. The number of breaches assumed under the action alternatives, including long-term storage as UF_6, fell between the numbers assumed for the two No Action Alternative analyses. This was considered to be a reasonable assumption, because it is less certain that ongoing cylinder yard improvements and cylinder painting would be strictly maintained for the decreasing cylinder inventory under the Action Alternatives. The outcome of the increased number of assumed cylinder breaches for the action alternatives was a slightly higher estimate of impacts on groundwater, air quality, and human health and safety for the action alternatives, although the estimated impacts are still within applicable standards or guidelines. Further details on the assumed cylinder breaches under the action alternatives, and the impact of these assumptions on the analyses, are given in the Introduction to Section D.4 of Appendix D. Text has been added to the Introduction to Section 5.2 (Long-Term Storage as UF_6) to clarify the rationale for breach rate assumptions.

Methods for dealing with cylinders which do not meet DOT transportation requirements (e.g., do not meet minimum wall thickness requirements) are detailed in Appendix E, Cylinder Preparation. Appendix E evaluates the options of using overpacks or transferring the cylinder contents to new cylinders for up to the entire cylinder inventory.

Table 5.4 of the PEIS indicates the frequency of the HF tank rupture and Ammonia tank rupture accident scenarios to be within the incredible range, i.e., a frequency estimated to occur less than one time in 1 million years of facility operations. This frequency takes into account the initiating frequency of a large seismic or equivalent beyond design basis event (within the extremely unlikely range, i.e., between once in 10,000 years and once in 1 million years of facility operations) and the probability of failure of all active and passive safety features (such as water sprays at the HF storage building, loss of containment features such as building filtration, etc.). The consideration of the frequency of the initiating event with the probability that all mitigation measures would fail simultaneously results in an accident frequency of less than one time in 1 million years of facility operations.

Comment 35

Site Sizes: Page 5-55 identifies land use requirements for the facilities. These seem small, particularly when compared to other proposed facilities performing similar operations (e.g., the LES EIS analyzes a generic conversion facility with a site area of 1,000 acres). The text also does not indicate if any major setbacks, protective action distances (PAD's), or planning zones are likely to be needed around the facility because of the handling of large quantities of DU, the hexafluoride, and/or the metal (including melting operations). DOE should consider a discussion in the text on these subject matters.

Response 35

Conversion facility land areas presented in the PEIS do not included buffer zones. A nominal facility occupies about 30 acres, or 900 × 1500 ft. NUREG-1140 p. 30 suggests a 1 mile protective action distance (PAD), which is based on a UF_6 cylinder rupture that releases uranium and HF. The PAD is the recommended distance for which emergency planning would be appropriate to mitigate off-site exposure to accidental releases. A conversion facility is not required to have ownership of the area encompassing the PAD. The PAD for a metal or oxide shielding facility would be much less because UF_6 would not be handled at these facilities. Wherever land use for conversion facilities is discussed in the PEIS, text has been added acknowledging the need for a protective action distance.

Comment 36

Accident Consequences: Pages 5-55 et seq discuss the use and impacts of uranium dioxide as shielding, and pages 5-66 et seq discuss the use and impacts of uranium metal as shielding. Some of the values imply non-intuitively obvious lower impacts from a metal route as compared to the oxide route; it is recommended that these are discussed and explained in more detail. For example, the text on page 5-71 estimates the highest consequences from an accident with the metal route as

15 mrem (from a fire involving three cylinders, an energetic accident with reactive materials), as compared to 270 mrem (from an earthquake during uranium dioxide storage, a low energy event with non-reactive materials) — there is no explanation for the difference. Also, the supporting information in Appendix H shows similar inconsistencies; the unlikely accidents for the oxide (Table H-5, page H-16) are significantly higher than the corresponding accidents for the metal (page H-17). Page H-17 also contains apparent inconsistencies and incongruences; the mishandling/ dropping of solid DU metal accident releases a greater quantity of uranium than the molten uranium accidents. Upon further review, the source of these apparent anomalies goes back to Section 6.11 of the EAR, where different material at risk and release fractions were used. All of the metal cases examined used the least bounding values, and values inappropriately low for the phenomena being modeled per the DOE accident handbook. These errors should be corrected.

Response 36

The text in Section 5.5.1.2.2 of the PEIS (including page 5-71 of the Draft PEIS) is comparing aggregate results of the highest consequence accidents within 4 frequency categories between the oxide conversion options and the metal conversion options. For the low-probability accidents associated with metal conversion, the highest consequence accident (fire involving three cylinders) still has a relatively low radiation dose of 15 mrem for the maximally-exposed individual (MEI) in the general public, because the accident is associated with a fire, which has a buoyant plume that moves upward and disperses in the atmosphere prior to sinking back to ground level at some distance from the release point. In comparison, the dose of 270 mrem is associated with an earthquake at a U_3O_8 (not UO_2) conversion facility (see Table F.9 for details on each highest consequence accident in each frequency category). Much of the difference in predicted consequences for accidents involving U_3O_8, UO_2, and uranium metal are associated with the form of the material. U_3O_8 is an easily-dispersed powder, whereas only the oxide coating on uranium metal billets can be readily dispersed. Releases from drops of UO_2 pellets are somewhat more similar to releases from drops of metal billets. Text has been added to Section 5.5.1.2.2 (page 5-71 of the Draft PEIS) to clarify the reasons that the consequences of some of the accidents associated with the use as metal alternative are lower than those associated with the use as oxide alternative.

The size of releases from UO_2 shielding- and metal shielding-manufacturing facility accidents would depend on the exact accident scenarios; in some cases releases from accidents involving UO_2 pellets will be smaller than those associated with uranium metal billets. The mishandling/dropping of solid DU metal accident questioned in the comment did have a higher assumed release than the mishandling/dropping of a UO_2 drum; this was mainly because the metal billet contained more uranium than the drum, so there was more material at risk (see Section 6.11.7 of the engineering analysis report for further details).

The DOE accident handbook (DOE-HDBK-3010-94) was used in deriving release fractions for the accidents modeled; in instances where the conditions of the modeled accident supported it, the median values were used instead of the bounding values. See the response to Commentor No. 89, Comment 35 for further details.

Commentor No. 65: Squibb, Katherine S., Ph.D.
University of Maryland

Comment 1

The Department of Energy's (DOE) Draft Programmatic Environmental Impact Statement (D-PEIS) for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride (DU-HF) is lacking with respect to it's assessment of the long-term impacts of converting and using DU-HF. A review of the summary clearly depicts DOE's strong interest in utilizing this stockpile, but the supporting evidence does not adequately address the legitimate environmental concerns associated with DU use — concerns which are based on a growing body of scientific data. While the summary presents a clear picture of DOE's commitment to provide "support for the development of applications for depleted uranium products," it does not, and with our current knowledge probably cannot, adequately assess the current extent of environmental impacts at the three DU-HF sites. In turn, it cannot assess what impacts to the nearby communities and the local environment will result from future releases of the evaluated alternatives. Without better scientific knowledge of the toxicity of DU, it is impossible to provide even a guess of the potential impacts, which makes the risk projections provided within this summary of little value. As a result, we support the long-term storage of this material, with improved containment and monitoring, until we are better equipped to assess the toxicity and safe uses of the DU stockpile.

Up front, it should be noted that our limited resources only allowed us to review the summary and not the entire PEIS. Thus, we acknowledge that some discussion within the body of the PEIS itself may address a few of the concerns raised in the comments that follow. We believe that it is acceptable for us to comment based solely on the summary, as this is the main document likely to be reviewed by the commenting public. We hope that these comments are still useful for DOE and we request that these comments be considered with the utmost diligence.

Response 1

The commentor's preference for long-term storage of the depleted UF_6 inventory is noted by DOE. Additionally, each of the comments received has been carefully considered by DOE. In order to adequately address some of the comments, the detailed analyses and supporting text provided in the body of the PEIS need to be referenced; the specific sections are cited in the responses to specific comments as appropriate. The current extent of environmental impacts at the three current storage sites was thoroughly addressed in Section 3 of the PEIS, titled "Affected Environment." The impacts from potential future releases of depleted uranium compounds were addressed in Appendix D of the PEIS, titled "Continued Cylinder Storage." A great deal is known about the toxicity of depleted uranium compounds; more detail on the toxicity is given in the responses to Commentor No. 65, Comments 8 and 9. The data used to assess the toxicity of depleted uranium compounds in the PEIS are summarized in Sections C.4.1.2, C.4.2.2, C.5.1.2, and C.5.2.1 of Appendix C.

Comment 2

Current Storage: Significant concerns exist with current storage conditions based on the fact that cylinders now show evidence of corrosion and that at least seven cylinders have developed breaches. While the management plan in place is to "continue safe storage," it seems to be in question whether safe storage is currently taking place. This is supported by community concerns that have been expressed from around the sites, and the Notice of Violation that has been issued by the Ohio Environmental Protection Agency. We assume that the Defense Nuclear Facilities Safety Board has suggested improving both inspection time tables and storage approaches.

Response 2

In May of 1995, the DNFSB issued to DOE a recommendation (Recommendation 95-1) regarding the storage of the depleted UF_6 cylinders. This recommendation was as follows:

1. Start an early program to review the protective coating of cylinders containing the tails from the historical production of enriched uranium.
2. Explore the possibility of additional measures to protect these cylinders from the damaging effects of exposure to the elements, as well as any additional handling that may be called for.
3. Institute a study to determine whether a more suitable chemical form should be selected for long-term storage of the depleted uranium.

In June of 1995, DOE accepted Recommendation 95-1 and emphasized five focus areas for DOE response:
1. Removing cylinders from ground contact and keeping cylinders from further ground contact;
2. Relocating all cylinders into an adequate inspection configuration;
3. Repainting cylinders as needed to avoid excessive corrosion;
4. Updating handling and inspection procedures and site-specific Safety Analysis Reports; and
5. Completing an ongoing study that will include an analysis of alternative chemical forms for the material.

In October of 1995, DOE submitted an Implementation Plan that incorporated completed and near-term actions in accordance with these five focus areas. This plan also committed to managing the cylinders using a systems engineering approach. Through this approach and open dialogue among the DNFSB staff, the following objectives segment the safe storage mission of the program in response to the current condition of the system and the projected life cycle schedule for completing the last phase of the system (Decontamination and Decommissioning):
1. Achieve and maintain acceptable risks
2. Achieve and maintain cylinder integrity
3. Improve conduct of operations
4. Evaluate and monitor containment integrity, and
5. Administer the system

The DNFSB reviews DOE's progress on these items regularly.

Comment 3

While the summary explains that a dense plug is formed by the reaction of moist air with the exposed DU-HF, the summary does not address if any studies have been made to assess the adequacy of such a plug. Certainly, this plug may not be air tight, allowing additional moisture to enter the container thereby acting as a continued source of HF gas. It would seem prudent for DOE to develop a better storage system regardless of the decision to use or store these cylinders. Either way, many of these containers will still house DU-HF for years or decades to come, and will require improved storage capabilities.

Response 3

The statement that a dense plug is formed at the location of the hole in a breached cylinder was not intended to imply that this plug was considered to be a permanent means of patching the cylinder; rather, it was intended to indicate the reason that uranium compounds and HF are not released from breached cylinders at a faster rate. The text in the Section S.1.1 and Section 1.1 has been revised to make this clear.

Since the initial discovery of two breached cylinders at the Portsmouth site in 1990, the cylinders at all three sites have been inspected, 5 additional breached cylinders were identified before 1998, and an extensive cylinder program management plan has been established.

An additional breached cylinder was identified at the K-25 site in 1998; see Appendix B, Section B.2 of the PEIS for further details on this cylinder breach. Breached cylinders are either patched or have the contents transferred to new cylinders to prevent further material loss. The conditions which allowed some breached cylinders to go unidentified for long periods of time have been eliminated. All cylinders are now inspected at least every four years (those with more extensive corrosion or pitting are inspected annually). There is also a radiological program to detect leakage from valves. An intensive effort is ongoing to improve yard storage conditions at all three cylinder storage sites. New storage yards with stabilized concrete bases have been constructed at the Paducah and Portsmouth sites. Cylinders are being relocated to allow space for adequate visual inspections; relocated cylinders are being placed on concrete saddles to keep them out of ground contact. Due to improved storage conditions and frequent inspections, any breached cylinders identified in the future are expected to be recently breached with little material loss (as was the case for the cylinder identified in 1998). The introduction to Appendix D of the PEIS contains additional details about the current cylinder management program.

Comment 4

While the summary lists various technical assessments that have been or are being conducted, none of these studies nor this PEIS really assess the potential environmental impacts from the current production and storage operations or the proposed alternatives. This flaw has been seen in PEISs produced for other purposes by DoD, where the PEIS selects a direction to focus development dollars, but does not consider the specific technologies that may be employed and does not consider the site-specific characteristics. In the end, such factors will strongly influence the

extent of contamination and impacts from the general approach (i.e. use as oxide) selected. Once the process reaches the point where these specific factors are assessed, there will be serious pressures to make the approach work given the time and financial investments made. This limits the adequacy of the site specific assessments when they are made. In turn, we strongly suggest that DOE take a serious look at the potential risks from converting DU-HF and its use an oxide or metal before one selects a programmatic alternative. Factors that should be considered in this evaluation are the migrating potential of DU that will be released, the cumulative impacts of such releases in conjunction with preexisting contamination, and the potential impacts on costs of the selected approach when the toxicity of such compounds are elucidated.

Response 4

In the analyses conducted for the PEIS, considerable effort was put into characterizing the potential environmental impacts from the continued storage operations, and from the other components of the alternatives. For example, continued cylinder storage is a component of all the alternatives. Extensive studies on cylinder corrosion rate, as well as historical rates of handling-induced cylinder breaches, were used to estimate the extent of possible material releases from cylinders during the period of cylinder management addressed in the PEIS (that is, through 2039), for both the No Action alternative and the Action alternatives. These estimates were subsequently used to estimate impacts from the released material with respect to air and water quality, worker and general public exposure and risk, and ecological risk. Also, detailed plans for continued cylinder storage activities (such as painting schedules, inspection schedules, cylinder yard reconstruction, and cylinder relocations) were used to estimate potential impacts with respect to worker health and safety, land use, socioeconomics, waste management, and resource requirements. These analyses are site-specific and were conducted separately for each of the three current storage sites. The results are presented in detail in Appendix D of the PEIS, and summarized in Sections 5.1-5.7, and in Section 2.4. The cumulative impacts of continued cylinder storage at the three sites in conjunction with existing operations at those sites are discussed in Section 5.8.

The technologies and options assessed for the other components of the alternatives, such as conversion, long-term storage, manufacture, and disposal, were defined by technical experts on the basis of suggestions from the general public, as summarized in the technology assessment report (see Section 1.4 of the PEIS for further details). Subsequently, an engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) was developed which provided a more detailed, in-depth technical analysis of the representative management options identified in the technology assessment report. The engineering report provides design and operational data for these options, and was used as the basis for characterizing the potential environmental impacts from these management options. For example, the engineering analysis report provided estimates of contaminant levels in stack and water effluents from representative conversion, storage, manufacturing, and disposal facilities. These data were used in the PEIS to estimate impacts to air and water quality and worker and general public health and risk. The engineering analysis report is available for review at the DOE public reading rooms near the three current storage sites and in

Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information (see Section 4.2.3 of the PEIS). The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities is included in the PEIS. Upon implementation of the strategy selected and announced in the Record of Decision for the PEIS, site-specific evaluations will be performed, including the effects of site-specific projects and the range of alternative actions, including a "no action" alternative. NEPA and its implementing regulations do not require site-specific evaluations when specific projects are not being proposed (for further details on the applicability of the analytical approach used in the PEIS, see the response to Commentor No. 15, Comment 1.)

The cost of the various alternative strategies is beyond the scope of the PEIS, but cost estimates are provided in the cost analysis report (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report and other PEIS supporting reports are available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 5

Affected Environment: The summary sorely lacks a description of the environmental sampling that has been conducted at each site. In the case of Paducah, Kentucky, it is mentioned that the effluent discharges are regulated under Kentucky Pollutant Discharge Elimination System, but there is no discussion of whether radiological parameters and/or uranium metal are monitored in this system. While the specifics of such a monitoring program may be beyond the scope of this summary, whether or not environmental sampling from Big Bayou and Little Bayou Creeks has been considered in selecting the proposed alternative is relevant and critical. The extent of contamination in surface water and sediments is a significant issue, since future activity will add to the levels already present even if future emissions do not exceed the governing release limits of the time. There is no discussion of such sampling, and there clearly needs to be in order to determine the current baseline risk level at the site, both for human health and ecological receptors, The potential exposure pathways (see below) and current ambient levels are important for projecting future exposure scenarios.

Response 5

The summary is by necessity a very abbreviated version of the information given in the body of the PEIS; because there are no known environmental or health problems associated with current contaminant levels in sediments or surface water near the Paducah site, it was deemed sufficient to limit the information given in the summary to the statement that the effluent discharges are regulated under the Kentucky Pollutant Discharge Elimination System.

Sections 3.1.5.1 and 3.1.7 give greater detail on the extent of current contamination of surface water and sediments near the Paducah site, and the potential for associated health impacts. In 1993, measured uranium and PCB concentrations in sediments at a downstream monitoring location in Little Bayou Creek were significantly higher than background levels (i.e., 200 mg/kg for uranium and 2 mg/kg for PCBs). However, the results from monitoring at the same location in both 1994 and 1995 showed significantly lower levels (13-22 mg/kg for uranium; <0.1-1.4 mg/kg PCBs). In Section 3.1.7 the potential health impacts of exposure to Little Bayou Creek sediments are evaluated; the results indicate that radiological doses would be well below the maximum radiation dose limit set for the general public, and that adverse health impacts from chemical toxicity would also not be expected.

It should also be noted that at this time the DOE is not entertaining proposals for siting future depleted UF_6 management facilities at the Paducah site or any other site. The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects.

Comment 6

As with the Paducah site, there is no mention of the current extent of contamination in local media at the Portsmouth site in Ohio. Assuming significant contamination is already present as suggested by the groundwater data that are referenced, would it affect the feasibility of the selected alternative if it were deemed necessary to conduct such operations at other sites? This question requires serious consideration, particularly since the conversion technology to be used to produce the oxide or metal is not assessed in the D-PEIS. If contamination is approaching environmental limits, then even the expected discharges may not be acceptable. As with any Brownfields site, the investor (DOE in this case) certainly should want to know whether they will be able to conduct operations at the site or nearby (as suggested on S-14), requiring adequate site characterization. From the description of environmental settings, it is unclear whether the environmental data on the natural environment are limited to climatic conditions or if the site specific environmental data includes current contamination levels.

Response 6

The summary is by necessity a very abbreviated version of the information given in the body of the PEIS. Therefore, the summary affected environment section for Portsmouth only stated briefly

that contamination has been detected in on-site monitoring wells. The details on existing environment, including contamination levels at Portsmouth, are provided in Section 3.2 of the PEIS; information on existing groundwater contamination is provided in Section 3.2.5.2.

As summarized in Section 3.2.5.2, significant groundwater contamination is present at the Portsmouth site; three areas of contamination have been identified. The groundwater contamination is being addressed through ongoing environmental programs regulated by state and federal entities, and is not associated with releases from the current cylinder storage sites.

The PEIS did evaluate the potential environmental impacts from conversion to either U_3O_8, UO_2, or metal, using representative facility design data and representative site characteristics (see Section 4.2.3 of the PEIS). Based on these representative data, construction and operation of conversion facilities is not expected to cause significant new groundwater contamination (see Section F.3.4.2 of Appendix F).

DOE does not at this time propose to site any of the facilities associated with any of the alternative management strategies. Proposals for selection of technologies and sites for facilities will not be developed until after a strategy is selected as announced in the Record of Decision for this PEIS. The Record of Decision for this PEIS will not by itself support any decision to select technologies, or site, construct, or operate conversion, long-term storage, manufacturing, or disposal facilities. If or when proposals for these future actions are developed after the PEIS ROD, appropriate additional environmental reviews will be conducted. These reviews would be required to address potential cumulative impacts of the proposed alternative together with past, present, and reasonably foreseeable future actions at the specific site for which the new facility is proposed.

Comment 7

Exposure Pathway Assessment: In Table S-2, the chemical exposure of concern for both the non-involved worker and the general public is listed as falling below a hazard index of 1. Did the calculation of such risks include all the pertinent exposure pathways which may apply, including fish/game consumption, drinking water, inhalation, etc? It would be inappropriate to consider just the workplace exposure for the noninvolved worker, if that person lived nearby and fished in the local stream. In predicting future impacts or risks, one must consider the individual's total exposure. This has been a serious flaw within risk assessments at Superfund sites, and improving this approach is not unreasonable to request given that 1) this is a "looking forward" assessment which allows us to be more protective since the contamination has not yet been produced, and 2) we are still unable to adequately assess other parameters, such as synergistic effects, which do reduce the conservativeness of the risk projections being made.

Response 7

Exposure analysis for the various alternatives evaluated in the PEIS was a complex process, and involved considering different exposure pathways for different management options because of the nature of the releases assumed (see Section C.4.1.3 and C.5.1.3 of Appendix C for

details). Calculation of human health risks included all pertinent exposure pathways that may apply. Human exposure via the fish/game consumption pathway was not evaluated in the PEIS because available data indicate that uranium, the primary contaminant of concern, does not biomagnify in the food chain, indicating that significant exposures via consumption of contaminated fish or game are unlikely. In addition, the environmental releases from site-specific operations considered in this PEIS (continued storage and cylinder preparation) at the current storage sites are generally small and consideration of this pathway would not make a noticeable difference in the calculated risks.

Risks to the maximally exposed individual (MEI) member of the public and among workers were calculated separately because different exposure pathways and durations apply to each individual. If a person lived near the site and worked at the site, that person's exposure and risk could be estimated conservatively by adding the MEI public dose to the MEI worker dose.

Comment 8

Toxicity of Uranium: Based on the limited research that has been completed on the toxicity of uranium metal, it seems quite premature to be selecting an alternative in this PEIS for the next 40 years. In light of the ignorance with which the Department of Defense exposed Gulf War soldiers to DU, DOE should strongly consider whether it wants to make the same short-sighted mistake. We have been intensively studying lead for decades and we are still learning more everyday about its toxicological effects and the low levels at which such effects are exerted. We are still trying to recover from the use of this metal in paint and gasoline, which is a direct result of our inability or disinterest in predicting environmental accumulation and the resulting impacts if the compound turned out to be toxic. As a society, we must not make the same mistake again by blindly pursuing commercial use of the DU-HF stock.

Response 8

Since the start of use of uranium in weapons in the 1940s and 1950s, a large amount of toxicity testing has been conducted with uranium compounds, and knowledge about toxicity has also been gained from the evaluation of occupational exposures that have occurred. It is well established that the main toxic effect of concern for uranium exposures is damage to the kidneys. A discussion of the evaluation of uranium compound toxicity in the PEIS is provided in Section C.5.1.2 of Appendix C. As stated in the text, the U.S. EPA has deemed the data sufficient for the derivation of a chronic oral reference dose, which is defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The uranium oral reference dose of 0.003 mg/kg-d was used for the evaluation of the chemical toxicity of oral exposures in the PEIS. The U.S. EPA has not at this time derived an inhalation reference dose for uranium compounds. When an inhalation reference dose is not available, the oral reference dose is sometimes substituted as the inhalation reference dose. However, in the PEIS, the occupational permissible exposure limit for soluble uranium of 0.05 mg/m^3 was modified to make it protective for sensitive subpopulations — the resulting value was 0.0003 mg/kg-d, which is 10 times lower (or more protective) for evaluating

inhalation exposures than using the oral reference dose would have been. All potential exposures from normal operations evaluated in the PEIS were compared to these benchmark levels. With the exception of possible post-closure exposures due to drinking contaminated groundwater near a disposal facility in a wet environmental setting, all the exposure levels evaluated were much less than the associated reference dose levels. In addition to the evaluation of the chemical toxicity of uranium, the PEIS thoroughly evaluated increased cancer risk associated with the radioactivity of uranium (see Section C.4.2.2 for information on how the increased cancer risks from radiological exposures were evaluated in the PEIS).

Handling of uranium in the workplace has shown that levels of exposure to uranium compounds that are below the occupational exposure limits do not cause injury to the kidney, or any other observable toxic effect. Although it is possible that some sub-clinical effect does occur in humans at lower exposure levels, such an effect is unlikely to be significant. The issue with the exposures that occurred during the Gulf War seems to be more a lack of knowledge about the extent of exposure than one of data lacking on the toxicity of uranium. The mechanisms of toxicity of lead and uranium are completely different; the toxicity of lead does not bear on the depleted UF_6 PEIS. Data on uranium toxicity are sufficient at this time to evaluate the impacts of potential exposures from the alternative management strategies included in the PEIS.

Comment 9

Given the extensive research currently underway regarding DU, it does not seem appropriate to be completing this PEIS at the present time. Research at the Armed Forces Radiobiology Research Institute suggests that DU may be more mutagenic than lead, and that this metal can reach the brain and fetuses of exposed animals. Additionally, work is currently being conducted on exposed Gulf War veterans at the VA Hospital in Baltimore, Maryland, which may provide valuable information on the distribution of DU within the body and possible impacts on specific organ systems in humans. It would seem logical to learn from our mistakes and select long-term storage until we are better able to assess potential human health impacts from its toxicity as well as its radiological emissions in localized lung tissue.

Until the results of these various investigations are published and reviewed by the scientific community, we cannot know if the projections of adverse effects are accurate. The chemical toxicity of low level DU exposure does not seem to have been adequately considered. The monitoring of effects in soldiers is still in progress, so we question statements describing how "a few workers have been exposed to estimated amounts of uranium approximately three times the guideline levels used for assessing irreversible adverse effects, but none of these workers actually experienced such effects." The effects used to establish the guideline values do not include low level, chronic effects of DU just now being recognized.

Response 9

The commentor's preference for long-term storage is noted by DOE. It should be noted that the data on the toxicity of depleted uranium and its compounds are sufficient for the evaluations

conducted in the PEIS. The reference dose used to evaluate oral exposures incorporates an uncertainty factor of 1,000 (that is, it is 1,000 times lower than the lowest level observed to cause adverse effects in animals). The reference level used to evaluate inhalation exposures is similarly protective (see also the response to Commentor No. 65, Comment 8). Although it is possible that some sub-clinical effect does occur in humans at lower uranium exposure levels, such an effect is unlikely to be significant for the purpose of comparison of alternatives in the PEIS.

Comment 10

Release and Environmental Fate: Predicting the extent of release and long-term fate of the DU released during its conversion and subsequent use should be meticulously evaluated. On page S-42, the authors state the "potential uses that are capable of consuming a substantial fraction or all of the depleted uranium inventory are not yet fully developed, and it is entirely possible that the 100% use scenario may involve some of the material being converted to an oxide and used, with the remaining portion being converted to uranium metal and used." Without reviewing the specific industrial processes to be implemented in the conversion and use alternative, it is impossible to accurately assess how much DU would be released. This is a serious issue since other industrial sites have been closed down due to the excessive release and migration of DU. This quote also reveals that little is known about what commercial applications will exist for the converted material. Despite these unknowns, the PEIS clearly reflects an entrepreneurial eagerness by DOE to utilize the stock in this fashion. This assessment of the summary is further supported by a statement on the following page in which the authors indicate that "this preferred alternative allows flexibility in responding to changing market conditions and to the continued development of new uses for conversion products." We question whether this is appropriate, as the conversion process may be pushed forward without a clear plan and understanding of its eventual use. This, in turn, will evoke significant pressures to find a use for the oxide or metal and likely reduce the quality of the decision process used to determine acceptable use.

Response 10

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2). However, as a programmatic EIS (PEIS), it evaluates a range of representative technologies for each alternative. Consequently, the impacts of some management activities, such as conversion and manufacture and use, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities are included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site- and technology-specific evaluations will be performed for the necessary components of the selected strategy. All facilities eventually constructed and operated for the management of the

depleted UF_6 inventory will be licensed by the appropriate agencies and will comply with applicable regulations.

Proceeding with conversion of the depleted UF_6 inventory might provide other advantages besides the ability to use the material. Conversion to oxide would produce a more stable form for storage of the inventory, and conversion would also address the problem of the slow but continuing deterioration of the cylinders.

Comment 11

Ecological Impacts: The consideration of ecological impacts in the summary is limited. A full paragraph discusses the loss of habitat resulting from carrying out particular alternatives. However, no concrete information is provided regarding the chemical effects of elevated uranium concentrations on ecological receptors, although the potential for such effects is mentioned. While few data exist for specific ecological impacts, a study by Los Alamos on the long-term fate of DU found significant concentrations in various aquatic plant species as well as aquatic organisms such as tadpoles. Detritus, benthic diatoms and phytoplankton were predicted to contain the highest levels of DU in the environment, and the impacts of the conversion and use alternative on these important parameters of the food chain should be considered. In short, an adequate assessment of the data that do exist should be made, and critical data gaps should be pinpointed before we decide whether use of this stockpile is prudent.

Response 11

Although the summary section (S.4.7) does not include details of ecological impacts of uranium or other contaminants in environmental media, such potential impacts were considered in the analyses of the alternatives. A more detailed discussion of the methodology used in the analyses is provided in Section 4.3.7 and additional details have been added to Appendix C, Section C.3. A bioconcentration factor was included in the calculations of radiological dose estimates to aquatic vertebrates and invertebrates (e. g., fish and shellfish) exposed to undiluted effluent. The results indicated dose levels considerably below harmful levels. Dilution of the effluent in a receiving stream by a factor of 8,000 to 111,000, would reduce uranium concentrations further.

Comment 12

Given the lack of discussion regarding the environmental assessments at the sites, a few observations are worth noting. For instance, radioactivity and/or uranium appear to have been found in groundwater at the Portsmouth and K-25 sites, but not at the Paducah site. As for the estimated maximum radiation dose to a member of the general public, the value presented for the Paducah site is 3 mrem, but only 0.07 mrem/yr for the Portsmouth site. This is quite a difference for two similar sites which raises questions with regard to the adequacy of the assessment, or indicates that significant differences exist between the site estimations and/or quality of operations. Such observations within the summary suggest that DOE should take a closer look at the quality of the assessments conducted or the manner in which the assessment was presented in the summary. Even if it is the latter, this is a significant issue as many from the public who provide comments will only

have the time or ability to review the summary. It is important for DOE to be as clear as possible and provide the public with the opportunity to constructively assess the PEIS without undue burden.

Response 12

The radiation doses for the maximally exposed individual (MEI) of the general public presented in Sections S.3.1, S.3.2, and S.3.3 and in Tables 3.3, 3.8, and 3.13 were estimated using (1) environmental monitoring data for each of the sites obtained from annual environmental reports and (2) assumptions on potential exposure pathways for the off-site public. Difference in the monitoring data, assumed exposure pathways, and the distance of emission sources to the nearest fence line would result in differences in the estimated MEI doses. For example, the MEI dose for the Paducah site includes a contribution from ingestion of wildlife. However, this pathway was not considered for the Portsmouth site because the monitoring data showed the contamination in wildlife was below the detection limits. It should be noted that neither a dose of 3 mrem/yr nor one of 0.07 mrem/yr would be considered a high dose; the radiation dose limit set for individuals in the general public is 100 mrem/yr, and the average dose from background radiation is about 360 mrem/yr. The summary sections do give the annual dose limits and background radiation rates to aid in interpretation of the doses attributable to the site operations. For practical reasons, further discussion of radiation exposures and effects was provided in the main body of the text. Please see Section 4.3.1.1.1 of the PEIS for a general discussion of radiation exposures and effects, and Sections 3.1.7.1, 3.2.7.1, and 3.3.7.1 for more details on the estimated annual doses to the MEI.

With respect to the summary of groundwater contamination given in the summary, a statement has been added to Section S.3.1 to clarify that a radioactive isotope (technetium-99) has been detected in groundwater at the Paducah site.

Commentor No. 66: **Graber, Jean and Dick**
See responses to Commentor No. 51

Commentor No. 67: **Connolly, Dennis**
See responses to Commentor No. 51

Commentor No. 68: **Short, Duane**
See responses to Commentor No. 51

Commentor No. 69: **Ganyard, Patricia E.**
See responses to Commentor No. 51

Commentor No. 70: Knopp, Lisa
See responses to Commentor No. 51

Commentor No. 71: Elliott, Guy R. B.
Santa Fe Alloys & Los Alamos Consultants

Comment 1

Comments on the Draft PEIS-This Writer's Opinions: Overall High Quality. Your wise recommendation, as based on the material presented, is to convert the DUF_6 to metal or oxide and to use the DU for shielding of HLW. It was very much needed. That way the DU will be recoverable later while being protected for now.

To emphasize the need to save DU, the reader should recognize that many of the better uranium sources worldwide have already been destroyed to collect and use U-235, but leaving >99.5% of the natural U unused. Saving the remainder (mostly U-238) as breeder fuel would allow its use substantially fully as reactor fuel (as Pu-239) by future generations. Yet some people seriously recommend burying this fuel as waste! Wasting the DU would be an environmental atrocity. (See "Management and Disposition of Excess Weapons Plutonium," National Academy Press, 1994, p.28, and DOE/NN-0007, Jan. 1997, p.39, showing that Pu fuel is now used in other countries.)

Response 1

The commentor's preference for the conversion and use of depleted uranium to conserve it as a valuable resource is noted.

Comment 2

Avoidance of Too Strict Definitions of Processes to Be Used: From a chemical and engineering view, this PEIS should be looked on as sketches of what sort of approach could be used to convert the DUF_6, to metal or oxide. As such these sketches allow realistic broad decisions such as saving the DU for future use, as just discussed.

However, the current overregulation from within and outside of DOE tends to turn such sketches into rigid models before experiment has shown what would be realistic. Consider, for example, the recent failures of numerous radwaste vitrification units-inadequately tested proposals rigidly specified what turned out to inadequate approaches.

Here the decision to use continuous metallothermic reductions for production of uranium for cask shielding is sound. However, as discussed below, the writer recommends versions of reductions that differ significantly from the version described, e.g., UCRL-AR-124080 Vols 1 and 2, Rev 2, Sec 6, 10-4.

However, there is need to examine cost features.

Response 2

The PEIS considers two representative options for converting UF_6 to uranium metal, a batch metallothermic reduction process and a continuous metallothermic reduction process. The two representative metal conversion options were used to provide a basis for comparing the environmental impacts of broad, programmatic alternatives. The PEIS does not recommend a specific conversion process nor will the PEIS be used to select a specific conversion process. The Record of Decision for the PEIS will consider the results of the PEIS along with other information, such as cost and engineering data, to select a management strategy.

Comment 3

Locations and Types of Facilities Needed for UF_6 Conversions to Metal or Alloy: Alternative to Hydrogen reduction of UF_6 to UF_4: Historically this reduction has been used before the continuous metallothermic reductions of UF_4 by Mg in molten salt as done by Sante Fe Alloys (SFA) prior to its work for AVLIS with ORNL (Lockheed Martin) and LLNL.

However, an alternative continuous metallothermic approach (description proprietary by LAC) by SFA would convert UF_6 to UF_4 in molten salt prior to continuous Mg reductions to metal or alloy.

Incorporating this LAC metallothermic reduction to UF_4 as a precursor to the U-metal production would (a) avoid the cost of separate hydrogen reduction facility and operations, (b) integrate well with the molten salt operations of the Mg-UF_4 reductions, and © avoid some shipping and handling.

Response 3

Comment noted.

Comment 4

Alternative to Aqueous Separation of MgF_2 By-product from NaCl Molten Salt Additive: Because of experimental flaws in ORNL pilot tests, which seemed to invalidate containers used by SFA for continuous metallothermic reductions, the separation of MgF_2 by-product continuously from molten salt was abandoned in the system of the PEIS-instead batch aqueous separations were incorporated into the DOE plans.

However, SFA is eager to correct the ORNL flaws and demonstrate that continuous circulation of molten salt carrier with removal of solid, clean MgF_2 by-product can be maintained.

Response 4

Comment noted.

Comment 5

Alternative to Formation of U-3%Fe Alloy in UF_4-Mg Reductions: As described, the continuous metallothermic reductions lead to U-Fe alloy, which has the advantage of a lower melting point than pure U. However, the U-Fe alloy is brittle in castings and unwanted in breeding. Therefore, the production and casting of pure U should be evaluated also.

Response 5

Comment noted. Production and casting of pure U are evaluated in the engineering analysis report (Sections 6.9 and 6.10) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) and in the PEIS (Appendix F, Section F.3). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 6

Location of U-Metal Production Facilities: To avoid the expenses and hassles of shipping radioactive materials by people's houses, it seems best to move the DUF_6 cylinders on-site at Paducah, ORNL, and Portsmouth to already HEPA-filtered buildings. Then, movable, also HEPA-filtered, UF_6-UF_4 units for continuous metallothermic reductions can be operated to produce U castings already suitable for use in casks. Then, with one radioactive shipment, the unshielded casks and the shielding castings could be assembled at the HLW site.

It seems reasonable, and in accord with many environmentalists' wishes, that the casks could be stored long-term in underground mausoleums, where they were available for remote monitoring and eventually for HLW recycle and DU reactor use.

Response 6

Because DOE is not proposing or selecting sites for conducting management activities at this time, it was assumed for the PEIS analysis that conversion and manufacturing facilities would be located at separate, independent sites, requiring transportation of materials between them. If conversion were required by the alternative ultimately selected by DOE, locating a conversion facility at one or more of the existing storage sites or using mobile treatment facilities could indeed reduce the transportation and cylinder preparation requirements. However, the location, number, and type(s) of conversion facilities that may be required is beyond the scope of the PEIS and will be addressed in future planning and environmental analyses. Following use, products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste.

Comment 7

Reduction of Costs for Operations and Maintenance on the Manufacture of Metallic Shielding: With some $800 million as the cost of Operations and Maintenance (Cost Analysis,

UCRL-AR-127650, May 1997, p.57) for manufacturing metallic shielding, it becomes very important to move the material rapidly through the processing, e.g.,in ten years.

If an SFA continuous metallothermic reduction unit produced 1 cu ft of DU/hr full time for a year, the unit would produce 8760 cu ft of U. With 620,000 cu ft of U in cylinders, it would take 70.8 unit years to dispose of the DUF_6. With those assumptions, 10 SFA units could dispose of the DUF_6 within ten years.

Response 7

Comment noted.

Commentor No. 72: Patton, Paul E. / Voinovich, George V. / Sundquist, Don
Governors of Kentucky, Ohio and Tennessee

Comment 1

More than forty years ago the U.S. Department of Energy began the uranium enrichment initiative that created a common link between Ohio, Kentucky, and Tennessee. This commonality includes the U.S. Department of Energy's legacy of waste, a significant portion of which is made up of depleted uranium hexafluoride. Today, our three states are working together in order to recommend the selection of an appropriate and lawful alternative for the long-term management and use of depleted uranium hexafluoride. We believe that such an alternative must minimize impacts on human health and the environment, as well as benefit the overall mission of our states and the U.S. Department of Energy ("DOE").

Response 1

The DOE is committed to working with the States of Ohio, Kentucky, and Tennessee to ensure that the management of depleted UF_6 is conducted in a manner protective of human health and the environment and consistent with the mission of both the State and Federal governments.

Comment 2

DOE should consider the immediate conversion of all depleted uranium hexafluoride (DUF_6) to the less hazardous uranium oxide (U_3O_8) and provide above ground storage of the U_3O_8. We do not believe that waiting for possible market demands for the DUF_6 is justification for delaying this project. It is incumbent upon DOE to immediately begin seeking funds from Congress for this conversion. We urge DOE to complete conversion by the year 2018 or earlier and reduce the mortgage of maintaining the cylinders.

Response 2

The commentor's preference for immediate conversion to U_3O_8 followed by above-ground storage is noted.

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products. (See Section 2.5.1 of the PEIS.)

DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Comment 3

A long-term strategy for DUF_6 must include DOE's entire cylinder inventory, including heel and small cylinders. The 10,000+ cylinders of DUF_6 generated by the United States Enrichment Corporation (USEC), which will revert to DOE ownership upon privatization of USEC, must also be considered in any plans.

Response 3

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citation is provided in Chapter 8 of the PEIS). In addition, the management of heel and small cylinders has been clarified in the Final PEIS. (See Sections 1.5.2 and F.3 of the PEIS).

Comment 4

An estimated $480 million has been accrued by USEC since 1993 in order to offset the cost of the future conversion of DUF_6 generated by USEC. DOE should work with Congress now to ensure this fund is not diverted into the federal treasury for an unrelated use. In addition, DOE might consider partnering with the future owner of USEC in a long-term strategy for managing and converting DUF_6, in order to avoid redundancy of efforts. Any partnering effort, however, must not slow progress toward conversion.

Response 4

Legislation ensuring that amounts accrued by USEC for the disposition of depleted UF_6 are used for that purpose has been passed by Congress and signed by the President. Any future partnering with USEC regarding the management of depleted UF_6 would be described in appropriate documents that could include contracts, memoranda of agreement, or legislation.

Comment 5

Natural phenomena events or accidents may not have been adequately considered in the PEIS. DOE must identify the "worse-case" cylinder conditions and explicitly use this information in the hazard modeling descriptions.

Response 5

Natural phenomena events such as earthquakes or tornadoes were considered in the impact analysis for all options and alternatives in the PEIS. The condition of the cylinders was considered in the hazard modeling through the analysis of accident events in which corroded cylinders would be breached during handling (see Section D.2.2 of Appendix D).

The PEIS Appendices D through J list the accidents analyzed and provide the results of analyses. The results are summarized in Sections 5 and 2, and in the Summary. The accidents selected in the PEIS for representing the impacts of accidents were those that had the highest consequences of all accidents considered in each frequency range. Further details are provided in the safety analysis reports prepared by DOE for the three current storage sites (LMES 1997a-c), and in the engineering analysis report (LLNL 1997). See the reference list for Appendix C for the full citations for these references.

Comment 6

In order for states to effectively evaluate the potential impacts of the preferred alternative, DOE must provide information on the location of the site where conversion would occur and how wastes generated from this process will be managed. In order to avoid the undue risk of transporting deteriorating cylinders, we recommend that DOE evaluate the feasibility of on-site conversion plants.

Response 6

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2 of the PEIS). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. (NEPA and its implementing regulations do not require site-specific evaluations when specific projects are not being proposed.) Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities, including impacts from wastes which would be generated, is included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, additional NEPA reviews for any site-specific proposals would be prepared identifying the environmental impacts of site-specific projects and a range of alternative actions, including a "no action" alternative.

The commentor's preference for on-site conversion is noted by DOE. If conversion is part of the management strategy selected, a range of possible conversion sites, including the current storage sites, would be considered and evaluated in detail in future planning and environmental analyses.

Comment 7

DOE must ensure that funding for safe storage and maintenance of DUF_6 cylinders and storage yards is at an adequate level to protect human health and the environment.

Response 7

Issues of DOE program funding are beyond the scope of the PEIS. Budget submissions are consistent with implementing required safety practices to protect workers, the public, and the environment.

Commentor No. 73: Hartzog, Georgeann
See responses to Commentor No. 51

Commentor No. 74: Stanhnke, Linda
See responses to Commentor No. 51

Commentor No. 75: Daniell, Robert H.
Kentucky Department for Environmental Protection

Comment 1

DOE's Preferred Alternative: DOE's preferred alternative, as repeatedly mentioned in PEIS is to use the entire inventory of DUF_6 as metal or oxide. However, no evidence has been documented in the PEIS, which suggests that the market demand exists or will be found for all or even a significant part of DUF_6 inventory in the near future. Moreover, two independent studies ("Integrity of Uranium Hexafluoride Cylinders" DNFSB TECH-4, May 5, 1995, and "Affordable Cleanup?.- Opportunities for Cost Reduction in the Decontaminating and Decommissioning of the Nation's Uranium Enrichment Facilities," Board on Energy and Environmental Systems, Commission on Engineering and Technical Systems, National Research Council of the National Academy of sciences, February 9, 1996) also report that the market demand doesn't currently exist for the DUF_6 or its conversion products, nor is the demand anticipated in the near future. In light of the present uncertainties in the market demand, the Division therefore recommends that the DOE should consider converting the entire inventory immediately to the more stable form U_3O_8. The long-term storage of this material is much safer than the current storage of DUF_6, and it can also be retrieved if future demand is obtained.

Response 1

The commentor's preference for conversion of depleted UF_6 to depleted uranium oxide for storage is noted.

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products. (See Section 2.5.1 of the PEIS)

Comment 2

Time Frame: The PEIS doesn't justify the 40-year time frame considered. Justification is warranted for the same. The PEIS recommends storing the cylinders until 2010, after which 20 years would be required to convert the entire inventory of DUF_6 using DOE's preferred alternative. During these years, there is continued storage of DUF_6 required, which will also necessitate the continued monitoring activities. The Division therefore recommends that the process of conversion should be expedited in order to minimize the risk to the human health and the environment from continued storage of deteriorating cylinders. This would also help in cutting down the cost on the annual maintenance and surveillance activities.

Response 2

The timetable presented in the PEIS was developed to provide a basis for the calculation of potential impacts (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. The PEIS does not recommend storing the cylinders until 2010, rather, for the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable. In response to comments received, DOE has revised its preferred alternative. As indicated in the response to comment 1 above, it now includes prompt conversion of DOE's depleted UF_6 inventory into uranium oxide and HF or CaF_2.

Comment 3

Management of USEC cylinders: The PEIS doesn't take into account the cylinders (~8000) produced by United States Enrichment Corporation (USEC) since its privatization. The ownership of these cylinders has yet to be determined. It is the Division's understanding that under the current agreement between DOE and USEC, the USEC will be able to return to DOE, any waste not easily disposed of commercially. In this scenario, if these cylinders are considered waste, there is a possibility that they could be returned to the DOE. This represents a significant increase in the inventory. Hence the Division recommends that a contingency plan should be incorporated in the PEIS to address the USEC cylinders.

Response 3

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). (See Sections 1, 2, 6, and the Summary of the PEIS.)

Comment 4

Conversion Facilities/Site Selection: It is the Division's understanding that the DOE has not yet come to the conclusion of final selection of the site, as is evident from the PEIS. The PEIS describes the impact on the environment, considering various generic settings. However, the Division believes that site specific impact is also necessary after final selection of the site. For example, it is clear from the PEIS that the DOE has not given enough attention to the earthquake prone regions, and the seismic activities at the sites proposed for storage of the waste. The Division believes that it is critical and the site-specific information should be included in the PEIS. If PGDP is selected as one of the conversion facilities for example, then new facts gathered about this should be considered. The summary of some recently gathered seismic data at Paducah site is given in the specific comments.

Response 4

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities are included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site-specific evaluations will be conducted. Site selection activities would

evaluate site characteristics, such as potential response to seismic events, potential for flooding, and site geology to ensure that suitable locations were chosen. Following site selection, any new facilities would be designed and built to meet engineering and construction standards and requirements appropriate for the selected location and the mission of the facility.

Comment 5

Generation of Secondary Waste: Preliminary calculations performed by Division indicate that if DOE's preferred alternative were used, large amounts of secondary waste could be generated. More specifically, around 70% of the product stream will consist of Uranium (in the metal or oxide form) and 30% will be in the form of other products (anhydrous HF, CaF_2, or MgF_2). The Division believes that the potential exist that all the handling, transportation, and disposal for uranium left at the end of the treatment process will meet Low-Level Waste (LLW) requirements. Moreover, unless the specific technology is available to totally remove all the radioactive contamination from these secondary products (e.g. HF, CaF_2, MgF_2, etc.), all the disposal, handling, and treatment activities for this waste must follow the (LLW) management guidelines. Please provide a description of all potential anticipated wastes that may be derived from the preferred alternative.

Response 5

The waste management analyses in the PEIS assumed that if HF could not be sold for reuse, it would be converted to CaF_2, which would either be disposed as LLW or as nonhazardous solid waste. Similarly, it was assumed that MgF_2 produced in the conversion to metal process would either be disposed as LLW or as nonhazardous solid waste. The impacts of these waste management assumptions with respect to the Preferred Alternative are summarized in Tables S.3 and 2.4 under "Waste Management." Please see Sections 5.4.7, 5.5.7, 5.7.8, and 6.3.7.7 of the PEIS for more detailed discussion of potential waste management impacts under the preferred alternative.

Comment 6

One of the chemicals of potential concern (COPC) identified in the conversion (to oxide or metal) is ammonia. Provide a brief discussion regarding the generation of ammonia.

Response 6

Approximately 662,000 to 2,900,000 lb per year would be required as a process chemical for conversion of UF_6 to either uranium oxide or metal. The ammonia is assumed to be commercially available and to be transported to the conversion site in 11,000-gallon rail cars. The ammonia is used in the conversion process to generate hydrogen (and nitrogen). A description of the use of ammonia in the conversion processes is given in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), which is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 7

DOE has proposed a 40-year time frame for the proposed alternatives. Please provide a detailed justification for the proposed 40-year time frame.

Response 7

At the beginning of the PEIS preparation, the 40-year timetable appeared to be the most reasonable, based on consistency among alternatives. It was chosen as a reasonable period over which to estimate and compare the environmental impacts of the alternative management strategies considered in the PEIS (see Section 2.1). The schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives. For the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. Initial facility operations were based on a 20-year period for processing all of the inventory, which was extended in the Final PEIS to approximately 26 years to account for processing up to an additional 15,000 cylinders that were previously the responsibility of USEC. These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

In response to comments on the Draft PEIS, DOE has determined that, if an alternative requiring conversion is selected, that it is in the best interests of the public and the government to begin conversion to oxide as soon as possible (see Section 2.5.1 of the PEIS). The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory.

Comment 8

Consideration of "no-action"alternative should include at a minimum, implementation of Recommendation 95-1 of the Defense Nuclear Facilities Safety Board.

Response 8

Implementation of Recommendation 95-1 of the Defense Nuclear Facilities Safety Board regarding the storage of depleted UF_6 in cylinders is included in the analysis of the no action alternative as presented in Appendix D of the PEIS. In its acceptance of Recommendation 95-1, DOE committed to a systems engineering approach to UF_6 cylinder management that includes visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, cylinder coating maintenance, and cylinder yard maintenance. This approach has been implemented through a 3-Site Management Project to ensure technical consistency and equivalent safety at the three current storage sites.

Comment 9

It is clear from the PEIS that DOE has not given enough attention to the earthquake prone regions, and seismic activities at the sites proposed for storage of the waste. The Division believes it is critical that site specific information is included within the PEIS.

The following is a summary of new information discovered at the PGDP: Dr. Ronald Street of the University of Kentucky, Department of Geological Sciences commenced an investigation of earthquake related features in the vicinity of the PGDP ("Acquisition of Shear Wave Seismic Reflection and Refraction Data in the Area of the Northwestward Trending Contaminant Plume at the PGDP"). The purpose of this investigation is to map geologic contacts between the Mississippian limestone, the McNairy Formation, the lower Continental Deposits, and the upper Continental Deposits. It has been proposed that faulting has created horst and graben features in these units and that these features may affect groundwater flowpaths in the area on the Northwest and Northeast plumes. A pilot study conducted by Dr. Street located a small graben structure north of the PGDP. As part of the current project, Dr. Street has collected 17.3 km of six and twelve fold reflection and refraction data using a 24 bit floating point seismograph unit. Work on this project started in May of 1997 and a final report is due to AIP in May of 1998.

Preliminary interpretations of the data collected in this study were presented to the AIP in February 1998. These interpretations, which are subject to change, indicate that the PGDP is underlain by a series of northeast trending fault zones exhibiting substantial vertical offset on the surface of the Mississippian Limestone as well as the upper surface of the McNairy formation.

In other work conducted by Dr. John Nelson of the Illinois Geological Survey northeast trending faulting was found in sediments north of the PGDP in Southern Illinois. Dr. Nelson identified faulting in road cuts and railroad cuts. He also identified a graben in the surface of the McNairy formation with a vertical offset of 200+ feet.

Dr. Tom Hildenbrand (USGS, Menlo Park) compiled magnetic, seismic moment, and gravity maps for the Paducah region. An anomalous feature appeared approximately 5 miles northwest of the PGDP on all three maps, gravity high, a magnetic high, and a cluster of small earthquakes. This feature has been interpreted as a mafic intrusion located near the community of Needmore. Earthquakes in the vicinity of this possible intrusion are thought to be the result of the regional compressive stress field being deflected around the structure.

This evaluation indicates that the probability of significant seismic activities within this region is high and that further consideration is needed within the PEIS.

Response 9

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Earthquake initiated accidents are considered at the three sites for the continued cylinder storage and cylinder preparation activities, the only activities that were analyzed on a site-specific basis in the PEIS. The analysis of accident scenarios for continued

cylinder storage and cylinder preparation (Sections D.2.2 and E.3.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports recently prepared for each of the three storage sites (LMES 1997a-c). The SARs do recognize and discuss the potential for multiple cylinder failures in association with an earthquake. See the reference list for Appendix C for the full citations for the SARs.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. Each of the three SARs has several page presentations of seismic data and discussion of the earthquake hazard for the associated site. This material can be found in Section 1.5 of each SAR. For the Paducah site earthquake hazards associated with the New Madrid fault are discussed in detail.

The accidents considered in the PEIS for continued cylinder storage and cylinder preparation were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point.

The recent report by Dr. Ronald Street of the University of Kentucky, Department of Geological Science (as cited in the comment), was not yet available as of the preparation of Volume 3 of this document (November 1998). Work conducted by the USGS was utilized in preparing the SARs. DOE will review and evaluate new data that become available (e.g., the report by Dr. Ronald Street). Based on the results of the review, DOE will take appropriate action, which may include updating the SARs and instituting new safety features, to maintain the safety basis of its cylinder management program.

Comment 10

The PEIS should describe clearly the criteria for choosing the sites for treatment/disposal. The Division believes that such information is crucial. It is the Division's understanding that several options will be available for the conversion process of UF_6 to either oxide or metal and production of anhydrous HF. Because there are varying chemical products and potential waste products generated with different conversion methods; DOE must provide a general description of waste products and waste which are anticipated to be generated. If a method has been selected, please state the method.

Response 10

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2). However, as a

programmatic EIS (PEIS), it does not propose specific sites or specific technologies. Instead, the impacts of the management activities were estimated using representative facility designs and environmental settings. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site-specific evaluations will be conducted. Site selection activities would evaluate site characteristics, such as potential response to seismic events, potential for flooding, and site geology to ensure that suitable locations were chosen. Following site selection, any new facilities would be designed and built to meet engineering and construction standards and requirements appropriate for the selected location and the mission of the facility. The approach of preparing a broad, strategic evaluation of programmatic alternatives, followed by detailed site-specific analyses, is supported by case law. Please see the response to Commentor 75, Comment 4 for further details on requirements for preparing programmatic EISs.

The PEIS evaluated 2 representative options for conversion to U_3O_8, 2 representative options for conversion to metal, and 3 representative options for conversion to UO_2. The engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) provides the rationale for the selection of the representative technologies. The EAR is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The options selected for analysis were based on industrial experience with the technology and proven feasibility of implementation. Experimental technologies were not evaluated at this stage of the management strategy selection process. If conversion were to be required under the management strategy selected, the specific technology used may differ from those evaluated in the PEIS. For each of the representative conversion technologies evaluated, a summary of expected wastes generated was given in Section F. 3.7 of the PEIS.

Comment 11

Additionally, DOE must address the management and disposal of miscellaneous wastes that will be generated during the conversion process. This would include management and disposal of potentially large volumes of low-level wastes from the neutralization of HF; also various filters and filtered materials.

Response 11

The PEIS evaluated 2 representative options for conversion to U_3O_8, 2 representative options for conversion to metal, and 3 representative options for conversion to UO_2. For each of the representative conversion technologies evaluated, a summary of expected wastes generated was given in Section F.3.7 of the PEIS. This summary includes low-level wastes which would be generated if an option involving neutralization of HF were chosen. Filters and filtered materials are also included in the estimated waste amounts; specific assumptions about these types of wastes are given in the engineering analysis report (EAR) (LLNL 1997; the full citation is provided in Appendix F of the PEIS). The potential impacts from management and disposal of these wastes are

also discussed in Section F.3.7, as well as in Sections S.4.8, 2.4.8, 5.3.7, 5.5.7, 5.7.8, 6.3.3.7, 6.3.5.7, and 6.3.7.7 of the PEIS.

The EAR is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 12

Finally, discussion is needed for the management of "cylinder heels" from the bottom of the DUF_6 cylinder. This material contains a variety of radionuclides (i.e. daughter products and other contaminants) that are not suitable for conversion into uranium oxides or uranium metal.

Response 12

For alternatives that include conversion of the UF_6 to oxide or metal, removal of the cylinder contents would be required. After the bulk removal of depleted UF_6 from a cylinder, some depleted UF_6 (i.e., less than 50 lb) that contains a small amount of uranium decay products remains in the cylinder; this material is called the cylinder "heel." For conversion options, it was assumed in the PEIS that a cylinder treatment facility would be co-located with the conversion facility (see Appendix F). Prior to treatment at the cylinder treatment facility the cylinders containing heels would be stored for 3 months, during which time most of the activity from the short-lived daughter products of uranium-238 would decay away. The cylinders could then be handled safely. At the treatment facility the cylinders would be washed with an aqueous solution to remove the heels. The UF_6 from the heel would be converted to U_3O_8 which would be sent for either disposal or storage. Wastewater from the process would be treated to meet the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and discharged to nearby surface waters, or to an appropriate wastewater sewer, depending on the location of the treatment facility. More detailed information on the potential impacts from management of the cylinder heels in a cylinder treatment facility is provided in Sections F.3.1.1.4, F.3.1.2, F.3.2, F.3.3, F.3.4.1.4, F.3.4.2.4, F.3.4.3.4, F.3.5.4, F.3.6, F.3.7.4, F.3.8, and F.3.9.4.

A small number of cylinders (less than 500) each containing less than 50 lb of depleted UF_6 are also currently in storage at the sites. These cylinders have been in storage for more than 3 months and thus do not present a hazard due to the radiological activity of U-238 daughter products. The PEIS has been expanded to include the treatment of these heels cylinders. (See Sections 1.5.2 and 4.2.1 of the PEIS.)

Comment 13

While evaluating the alternative "conversion of UF_6 to oxide or metal form," different steps have been delineated as is the case with the other alternatives. In this particular case, the facilities for conversion process, storage of converted uranium form, and the manufacturing of the casks (which is the end use for this alternative, and this is DOE's preferred alternative) are all planned to be located at separate locations. There will be transportation required between these locations. The

PEIS should address the impacts of the transportation, including the potential impacts on the environment, human health. However, the transportation impacts could be minimized if DOE would integrate the conversion and manufacturing plants in one complex. This would reduce the amount of land required thereby decreasing possible habitat loss. It is not clear whether DOE has considered this alternative. If not, we recommend that this option be considered.

Response 13

The purpose of the PEIS is to provide an analysis of broad, programmatic alternatives, and not to select sites at this time. Consequently, for the PEIS analysis, facilities for conversion, storage, and manufacturing were assumed to be located at separate sites, requiring transportation of materials between them. The impacts of transportation are addressed in the PEIS for distances ranging from 155 to 3,100 miles (250 — 5,000 km), with detailed information provided in Appendix J and the supporting report by Biwer et al. (1997) entitled "Transportation Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement." Transportation impacts could be minimized by collocating facilities at one site; however, the location, number, and type(s) of facilities that may be required is beyond the scope of the PEIS and will be addressed in future planning and environmental analyses after an overall management strategy is selected in the ROD.

The Biwer et al. report and other PEIS supporting reports are available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 14

A correction is needed on page 3-7, Section 3.1.4. 1; the reference to the earthquake magnitude of 7.3 should have been referenced as the "Nuttly Scale" and not as the "Richter Scale." Although, the Nuttly Scale does converts to 8.0 on the Seismic Moment scale sometime referred to as the Richter scale.

Response 14

The discussion on earthquakes has been completely revised to be consistent with information presented in the Safety Analysis Reports (SAR) for the three sites under the continued-storage alternative. For Paducah, the earthquake is now referenced as magnitude 7.3.

Comment 15

Section 3.1 Paducah Site; U.S. EPA has authorized the Commonwealth of Kentucky for the Resource Conservation and Recovery Act (RCRA) Program. Therefore, when references are made to the U.S. EPA RCRA program, the Kentucky Hazardous Waste should also be referenced.

Response 15

The text of Section 3.1 has been revised to indicate that the Commonwealth of Kentucky, Division of Waste Management administers the RCRA program for the Paducah site.

Comment 16

Pages 2-60 and 2-61; 2-64 and 2-65; 2-68 and 2-69; 3-2 and 3-4; Figure 3.1 of Volume I of the Draft DUF_6 PEIS are missing. A comprehensive review could not be performed due to the lack of these pages. Provide the missing pages.

Response 16

DOE regrets the printing error which caused several pages to be missing from some copies of the Draft PEIS. The missing pages have been sent separately to parties who have informed DOE of their absence.

Comment 17

Page 5-108, Section 5.8.2.1 Paducah Site; the last paragraph states that 11 pollutants have been detected in the groundwater effecting quality. This statement is incorrect. Numerous pollutants have been detected at the PGDP. In fact, one of the most predominant contaminants at the site is omitted, Technetium 99. Other radionuclides and organic contaminants have been detected in groundwater throughout the PGDP.

Response 17

The pollutants specified in Section 5.8.2.1 were those that had exceeded standards or guidelines, as reported in the Annual Site Environmental Report for 1993 (MMES 1994b; the full citation is provided in Chapter 8 of the PEIS). Technetium-99 was not mentioned because it had not exceeded the derived concentration guideline of 4,000 pCi/L (see Section 3.1.5.2 of the PEIS). However, the commentor is correct that pollutants in addition to the 11 compounds stated in Section 5.8.2.1 have been detected in groundwater at the PGDP. The text in Section 5.8.2.1 has been modified to include discussion of groundwater contamination with technetium-99 and other pollutants.

Commentor No. 76: Schregardus, Donald R.
State of Ohio Environmental Protection Agency

Comment 1

There is no evidence to suggest that market demand exists or will be found for all or even a large part of DOE's DUF_6 inventory in the near term or the foreseeable future. Therefore, conversion should begin as soon as possible and be completed by 2018 or earlier. DOE should begin now to seek funds from Congress for conversion, and should consider the immediate conversion of all the DUF_6 to U_3O_8, and long-term above-ground storage of this material. According to the Draft PEIS, the preferred alternative for long-term use of DUF_6 is conversion of 100% of stockpiled DUF_6

to oxide (i.e., U_3O_8 and/or UO_2) and depleted uranium metals. Conversion would not begin until 2010, and would occur over a twenty year period on the basis of market demand. However, in the Draft PEIS, DOE states that "the actual percentage of depleted UF_6 inventory for which uses will be identified within the time frame assessed in the PEIS (i.e., up to the year 2040) will be determined as uses develop and conversion begins." In other words, this market demand is uncertain.

The National Research Council of the National Academy of Sciences (NSF) conducted a review in 1996 of possible uses for depleted uranium in shielding applications, as a fluorinating agent, and for re-enrichment by Atomic Vapor Laser Isotope Separation (AVLIS)("Affordable Cleanup?: Opportunities for Cost Reduction in the Decontaminating and Decommissioning of the Nation's Uranium Enrichment Facilities," Board on Energy and Environmental Systems, Commission on Engineering and Technical Systems, National Research Council of the National Academy of Sciences, February 9, 1996.). According to the NSF, market demand does not currently exist for DUF_6 or its conversion products, nor is demand anticipated in the near future. This is corroborated by the DNFSB who stated in a 1995 report ("Integrity of Uranium Hexafluoride Cylinders," Defense Nuclear Facility Safety Board Technical Report, May 5, 1995) that according to DOE, only a "small fraction" of depleted uranium has a use in the "foreseeable future."

We recognize that market demand is, at best, uncertain. DUF_6 can be stored more safely in a converted state. Therefore, rather than wait for market demand to drive conversion, DOE should begin now to seek funds from Congress for conversion, and should consider the immediate conversion of all the DUF_6 to U_3O_8, and long-term above-ground storage of this material, which can be retrieved if demand is established. If a market exists for a small percentage of DUF_6, only those cylinders in the best condition should remain unconverted for use by the market.

Response 1

The commentor's preference for conversion of depleted UF_6 to depleted uranium oxide as soon as possible followed by storage of the oxide is noted.

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products. (See Section 2.5.1 of the PEIS).

Issues of DOE program funding are beyond the scope of the PEIS. Budget submissions are consistent with implementing required safety practices to protect workers, the public, and the environment.

Comment 2

The Draft PEIS provides no assurance that DOE will fund and implement an adequate long-term program of inspecting and coating cylinders throughout the life of the DUF_6 cylinders, prior to conversion. Safe cylinder management requires an adequate inspection program combined with an aggressive cylinder coating program. Several times throughout the PEIS, it is indicated that funding for a cylinder coating program is "uncertain." However, DOE states in the PEIS that coating is expected to be successful and therefore, minimal releases of DUF_6 from cylinders to air and groundwater are expected. It is unclear how DOE can assume coating will be successful if funding is uncertain and the success rate of coating cylinders is unknown. Even if funded, there is no assurance that coating will be adequately applied and renewed frequently enough to prevent or slow corrosion. DOE must comply with all DNFSB recommendations for management of cylinders and yards, and with the DUF_6 management plan contained in Ohio orders.

Response 2

Although it is expected that the cylinder coating program will be effective in prohibiting further corrosion of the cylinders, DOE acknowledges in the PEIS uncertainties related to the coating effectiveness. In response to these uncertainties, the environmental impacts in the PEIS were evaluated for two cases, one in which the coating is assumed to be effective in preventing continued corrosion, and one in which coating is assumed to be ineffective (see Appendix D). The results of both cases are discussed in Chapter 5 and in detail in Appendix D. DOE is committed to continuing for as long as necessary the safe management of its depleted UF_6 cylinder inventory and to complying with the depleted UF_6 management plan contained in the Ohio orders. DOE has accepted and implemented the DNFSB recommendations for safe storage of depleted UF_6.

Comment 3

DOE should ensure that the PEIS addresses the management of DUF_6 in compliance with RCRA and state hazardous waste law. The February 28,1998 Director's Findings and Orders reiterated Ohio EPA's view that DUF_6 is a mixed waste regulated under RCRA and state hazardous waste law. These Findings and Orders provide an exemption from state hazardous waste requirements for a 10 year period to allow DOE to identify and implement an appropriate and lawful strategy for use, reuse, or conversion of this material. The Findings and Orders require compliance with a safe management plan for the DUF_6 during the 10-year period. Ohio has also reserved legal rights to reassert state hazardous waste requirements. Thus, it is imperative that the PEIS address the management of DUF_6 as a mixed waste under RCRA and state hazardous waste law.

Response 3

As stated by the Commentor, the February 28, 1998 Director's Findings and Orders provides an exemption from state hazardous waste requirements (including management of the depleted UF_6 as a mixed waste under RCRA and state hazardous waste law) for a 10 year period to allow DOE to identify and implement an appropriate and lawful strategy for use, reuse, or conversion. Although the Director's Finding and Orders state that the Ohio EPA has determined that the depleted UF_6 is a "waste" as defined by ORC Section 3734.01 and OAC rules 3745-50-10

and 3745-51-03, it is also stated that DOE disagrees with Ohio EPA's determination, notwithstanding DOE's agreement to the Orders. In all management strategies evaluated in the PEIS, DOE takes the position that depleted uranium, whether as UF_6, oxide, or metal, would be managed as source material as defined by the Atomic Energy Act of 1954 as amended. Source material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA) and authorized state hazardous waste programs.

In accordance with the Director's Finding and Orders, the current depleted UF_6 management practices at the Portsmouth facility are consistent with the safe management plan described in the Orders. Additionally, the PEIS assesses the potential environmental impacts of alternative plans for the long-term management of the depleted UF_6. Following the PEIS, the selection of a plan will partially satisfy the requirements of the Director's Findings and Orders — that the DOE reconsider its original plan to begin conversion in 2020, and that DOE make a good-faith effort to identify uses for the material.

Comment 4

A variety of independent and DOE estimates regarding breached cylinders are available but not considered in the Draft PEIS. The Draft PEIS estimates that 59 breaches and releases from cylinders could occur over the next forty years, assuming control of external corrosion by painting cylinders. Assuming no control of corrosion, the Draft PEIS estimates that 731 breaches and releases could occur. However, according to the Defense Nuclear Facility Safety Board (DNFSB) (Recommendation 95-1 to the Secretary of Energy pursuant to 42 USC 2286a(5) Atomic Energy Act of 1954, as amended) it has been stated by DOE and the former MMES that 200 cylinders are expected to breach if no corrosion control is undertaken, and more than 1000 cylinders have the potential to breach in storage within 22 years (by the year 2020).

Response 4

As correctly stated by the commentor and explained in the Introduction to Appendix D, two analyses were conducted for continued cylinder storage under the No Action alternative. The first analysis took credit for the improved cylinder management program, and specifically assumed that the painting program would eliminate breaches caused by corrosion. Under these assumptions, the assumed breaches would be the result of mechanical damage occurring during handling. The number of breaches assumed to occur from handling damage through 2039 were 36 for the Paducah site, 16 for the Portsmouth site, and 7 for the K-25 site (as stated in the text). For assessment purposes it was assumed that cylinders damaged during handling would be restacked without knowledge of the damage so that the breach and subsequent material loss would proceed slowly over a period of 4 years. In practice, these conditions are highly unlikely because any abnormal occurrences during handling are recorded and the involved cylinders carefully monitored thereafter. However, the breaches and material loss were assumed in order to assess potential impacts of releases of depleted UF_6 to soil, surface water, air and groundwater (and associated human health and ecological impacts).

Another reasonably foreseeable scenario for cylinder breaches would be the possibility that the painting program would not be effective in controlling further corrosion, or that the required painting schedule could not be maintained. In order to address this possible (but less likely) scenario, a second assessment based on the assumption that external corrosion was not halted by improved storage conditions and painting was also conducted. Based on these assumptions, the total numbers of breaches estimated through 2039 were 444 for the Paducah site, 74 for the Portsmouth site, and 213 for the K-25 site. The impacts based on these assumptions are presented in Section D.3 of Appendix D as a supplemental analysis.

The numbers stated in DNFSB Recommendation 95-1 were based on early estimates and did not account for improved cylinder storage yard conditions that have been implemented under the cylinder project management plan (LMES 1997d — see Introduction to Appendix D for details on this plan). The estimates used in the PEIS were based on ongoing corrosion studies as summarized in Appendix B. Project personnel continue to develop more information regarding the physical condition of cylinders and the corrosion rate of the steel. As cylinder monitoring continues and new corrosion data become available, DOE will use these data to guide the cylinder management program and continue the safe management of the inventory.

Comment 5

DOE's estimate of three to four cylinder spill accidents from breaches due to corrosion appears unrealistically low. The Draft PEIS estimates that as a result of all activities associated with the preferred alternative, three to four spill accidents will occur by 2038 as a result of cylinders that will breach due to corrosion. However, DOE records show that from 1990 to 1992, seven cylinders stored at the DOE three gaseous diffusion plants have breached due to corrosion. In light of DOE's own predictions mentioned in comment #2 above, as well as the current age of the cylinders, unknown cylinder corrosion rates, and the uncertainty of a long-term, ongoing cylinder coating program, a more realistic estimate of cylinder spill accidents due to corrosion must be made.

Response 5

The seven breached cylinders were identified in the period between 1990 and 1992 due to a newly-implemented intensive cylinder inspection program. Of the seven breaches, only two were the result of external corrosion. The remaining five breaches were the result of poor handling causing damage to the cylinder wall. The identification of a breached cylinder does not necessarily lead to a spill accident. When a breached cylinder is identified, stringent handling procedures are followed to patch the cylinder and remove the contents if necessary. These procedures greatly minimize further material loss from the breached cylinder. One additional breached cylinder was identified in 1998; see Appendix B, Section B.2 of the PEIS for further details on this cylinder breach.

The cylinder spill accidents referenced by the commentor were modeled in the PEIS to evaluate the possibility that a cylinder weakened by external corrosion would develop a hole during handling. The low frequency of such an occurrence was estimated on the basis of actual experience

in the cylinder yards. Over 30,000 cylinder relocations have been conducted at the three storage sites since 1992 without causing damage to a cylinder sufficient to cause a breach. Additionally, the UF_6 cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS) has been developed to eliminate substandard cylinder storage conditions and to eliminate the effects of corrosion through a recoating program. Under this management plan, annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of heavy pitting or corrosion. All other cylinders must be inspected once every four years. This inspection schedule is based upon detailed knowledge of the chemistry of UF_6 and the rate of reaction if the cylinder wall should be compromised through external wall thinning from corrosion or handling damage. Any cylinders suspected of being in weakened condition due to extensive corrosion or other reasons would require special handling precautions, thus minimizing the chances of cylinder spill accidents. Because of the ongoing extensive cylinder management project, the assumed low frequency of 3 to 4 cylinder spill accidents was considered justified.

Comment 6

If cylinder breaching rates have been underestimated, all other calculations made in the Draft PEIS that were based on this breach rate, such as the impact of a release of DUF_6 to soil, groundwater, human health, etc., have also been underestimated. These estimates should be revised accordingly.

Response 6

As explained in the Introduction to Appendix D, two analyses were conducted for continued cylinder storage under the No Action alternative. The first analysis took credit for the improved cylinder management program, and specifically assumed that the painting program would eliminate breaches caused by corrosion. Under these assumptions, the assumed breaches would be the result of mechanical damage occurring during handling. The number of breaches assumed to occur from handling damage through 2039 were 36 for the Paducah site, 16 for the Portsmouth site, and 7 for the K-25 site (as stated in the text). As explained in the response to Commentor 76, Comment 5 above, these breaches are different from the 3 to 4 corroded cylinder spills assessed for Accident Conditions in Section D.2.2 and summarized in Tables S.2 and 2.2; for assessment purposes it was assumed that cylinders damaged during handling would be restacked without knowledge of the damage so that the breach and subsequent material loss would proceed slowly over a period of 4 years. In practice, these conditions are highly unlikely because any abnormal occurrences during handling are recorded and the involved cylinders carefully monitored thereafter. However, the breaches and material loss were assumed in order to assess potential impacts of releases of depleted UF_6 to soil, surface water, air and groundwater (and associated human health and ecological impacts).

Another reasonably foreseeable scenario for cylinder breaches would be the possibility that the painting program would not be effective in controlling further corrosion, or that the required painting schedule could not be maintained. In order to address this possible (but less likely)

scenario, a second assessment based on the assumption that external corrosion was not halted by improved storage conditions and painting was also conducted. Based on these assumptions, the total numbers of breaches estimated through 2039 were 444 for the Paducah site, 74 for the Portsmouth site, and 213 for the K-25 site. The impacts based on these assumptions are presented in Section D.3 of Appendix D as a supplemental analysis.

Comment 7

Conversion of DUF_6 to U_3O_8 should be expedited in order to minimize the risk to human health and the environment from continued storage of deteriorating cylinders. In order to implement the preferred alternative in the Draft PEIS, DOE recommends storing cylinders until 2010. Then, a period of twenty years, at a cost of $200 million per year, would be required to convert the entire DUF_6 inventory to either depleted metals or oxide at one conversion plant, the site of which has not yet been determined. During conversion, aqueous HF would be generated and marketed. According to the National Research Council, a twenty year conversion rate and was chosen to reduce the cost of plant investment (spread the cost out over twenty years) and to render the HF production rate less disruptive to the market. The rate at which HF would be generated over twenty years is equal to approximately 2% of the estimated annual market in North America. It is recommended that conversion be completed by 2018 or earlier. Expediting conversion will minimize the risk of continued storage and defray the annual cost for cylinder maintenance and surveillance, which is estimated by DOE at $12 to 15 million.

Response 7

The commentor's recommendation for completing conversion by 2018 is noted. The timetable presented in the PEIS was developed to provide a basis for the calculation of potential environmental impacts (see Section 2.1 of the PEIS). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. The PEIS does not recommend storing the cylinders until 2010, rather, for the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. Facility operations were based on a 20-year period for processing all of the inventory for all alternatives, independent of whether or not HF is produced and marketed. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable. In response to comments received, DOE has revised its preferred alternative. As indicated in the response to comment one above, it now includes prompt conversion of DOE's depleted UF_6 inventory into uranium oxide and HF or CaF_2.

Comment 8

Rather than construct a conversion plant at a single location and transport all cylinders to the conversion site, DOE should evaluate the feasibility of on-site conversion of DUF_6 to U_3O_8. According to DOE, 50% to 95% of the DUF_6 cylinders have corroded to the point that they are not capable of being handled and transported without undue risk. The Draft PEIS states that cylinders would be over packed or their contents transferred into new containers prior to transporting them to an undetermined conversion plant. If cylinders can be converted onsite without transporting them, this will minimize the number of times they are handled, therefore, limiting the risks associated with transferring cylinder contents and transporting them to conversion sites. In addition, the time required for over packing, transferring contents, and transporting cylinders could be saved. The use of a mobile treatment unit that could be transported to each GDP site should be considered. In the alternative, DOE could construct a plant onsite at each GDP (if seismic conditions allow), within an existing, unused gaseous diffusion building.

Response 8

The State of Ohio's preference for on-site conversion is noted. In the PEIS analysis, to provide a conservative estimate of potential environmental impacts, it was assumed that conversion facilities would be located at separate sites, requiring transportation between them. If conversion were required by the alternative ultimately selected by DOE, locating a conversion facility at one or more of the existing storage sites or using mobile treatment facilities would indeed reduce the transportation and cylinder preparation requirements. However, the location and number of conversion facilities is beyond the scope of the PEIS and will be addressed in future planning and environmental analyses.

Comment 9

Seismic and flooding concerns were not adequately discussed in the Draft PEIS. For example, Paducah, Kentucky is located approximately 60 miles from the New Madrid fault. Earthquakes of a magnitude of 8.4 to 8.8 on the Richter scale have been measured in the region. These have the potential to damage stored cylinders. The majority of cylinders are stored at Paducah. Seismic issues for Ohio, Kentucky and Tennessee must be adequately considered in the PEIS, especially in light of continued storage of cylinders until at least 2010, and conversion at an unknown site.

Response 9

The safety of current storage of depleted UF_6 cylinders was addressed in the safety analysis reports (SARs) recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes and floods. The accidents considered in the PEIS for continued cylinder storage (Appendix D) were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake

scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 10

DOE should evaluate a long-term strategy for DUF_6 that would include DOE's entire cylinder inventory including heel and small cylinders as well as the current inventory of 10,000+ cylinders of DUF_6 generated by USEC since it's 1993 inception. When privatization occurs, these USEC-generated cylinders will become the responsibility of DOE. Pursuant to the federal privatization legislation, funds have been accrued for each kilogram of DUF_6 generated by USEC in order to pay for future treatment of tails. Currently, this fund may now hold as much as $480 million. When USEC is privatized, this fund will be turned over to the federal treasury. DOE should take steps to secure these funds to offset the cost of conversion of the DUF_6 to be acquired from USEC, as well its existing inventory of DUF_6.

Response 10

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). In addition, the PEIS has been expanded to include the treatment of several hundred cylinders containing depleted UF_6 heels that are stored at the three current storage sites. (See Sections 1.5.2 and 4.2.1 of the PEIS.)

Issues related to DOE program funding, including any funds obtained from USEC, are beyond the scope of the PEIS. Budget submissions are consistent with implementing required safety practices to protect workers, the public, and the environment. However, a bill (S.2316) was recently passed by Congress and signed by the President (Public Law 105-204) directing DOE to submit to Congress a plan to ensure that amounts accrued by USEC for the disposition of depleted UF_6 will be used to treat and recycle depleted UF_6.

Commentor No. 77: **Watkin, Mary Ellen / Monteith, Jerry**
See responses to Commentor No. 51

Commentor No. 78: **Belletire, Kathy**
See responses to Commentor No. 51

Commentor No. 79: **Coots, Lou**
See responses to Commentor No. 51

Commentor No. 80: Colley, Vina
Portsmouth-Piketon Residents for Environmental Safety and Security

Comment 1

We are here today to speak about one of the biggest problems facing the public from the DOE/DOD programs: the uranium hexafluoride tails (UF6) DU cylinders. A hazardous materials specialist, David Kozlowski was quoted as saying "Uranium hexafluoride is highly corrosive," its effect to those hydrochloric acid. Sites such as Piketon, he said, are regarded as potential "general emergency" sites by the DOE, meaning if there were gas formation, it could require evacuation of nearby areas. While in DC last year with the national groups we were told by another top person for the DOE that painting these cylinders was like putting lipstick on a corpse. Slightly contaminated DU cylinders become a problem equal to high level radioactive waste as they age because of the decay daughter product to radium.

Response 1

It is true that uranium hexafluoride reacts with water to form toxic chemicals. However, as explained in Appendix A, Section A.2.1 of the PEIS, it is inert to clean aluminum, steel and some other materials. Therefore, as long as it is inside the cylinders, which are made of steel, isolated from moist air, it does not react. The Portsmouth site, as other DOE sites, does have an Emergency Plan (see the response to comment No. 4 from this same commentor below). DOE recognizes that painting the cylinders is not a permanent solution. The paint wears out over time. As long as the cylinders are kept in storage, DOE plans to repaint them every 10 years. It is true that after millions of years the radioactivity in depleted uranium would become comparable to the radioactivity in what is high-level waste today. That is because all that would remain in those materials (aside from the stable radioisotopes that don't decay) would be the long-lived radionuclides such as uranium-238 and their decay products such as radium-226. The risks from such materials would be comparable to risks from natural uranium ores in the crust of the earth where uranium has been in existence throughout the earth's history.

Comment 2

I would like to remind you of the 1978 spill here at the plant when over 21 thousand LBS left this site by air, ground and water many workers where affected.

Response 2

On March 7, 1978, there was an incident that resulted in a liquid uranium hexafluoride release at the Portsmouth Gaseous Diffusion Plant. At approximately 4:36 p.m., in the X-745B cylinder storage lot, a 14-ton cylinder, 5/16" wall thickness, containing liquid natural uranium hexafluoride, was dropped 8-10 inches and ruptured. The result was the release of 21,125 pounds of feed material in less than five minutes. Emergency notifications and responses were rapid and there were no injuries to personnel and all exposure to radioactive materials were within allowable limits of the plant. The time of the release, having occurred after shift change, reduced the number of persons on site. Additionally, the wind direction from the northeast to southwest caused the path

of the UO_2F_2-HF cloud to be in a direction which affected the least number of facilities with the distance of travel to the site boundary. Precipitation in the form of snow, coupled with cold temperatures, minimized the off-site impact. There was a reported fish kill as a result of runoff from the incident area caused by treating the runoff with lime and causing a pH change in the water. This lime treatment aided in the prevention of off-site uranium contamination. An investigation of the incident determined that failure of the cylinder handling equipment used to transport the cylinder occurred. As a result, modifications were made to improve this equipment as well as eliminating the transport of uranium hexafluoride in the liquid state.

Comment 3

In September of 1996 another airborne plume went off site in between the lithium storage building and the national guards building. This airborne plume headed toward Wakefield. I have been told that workers were paid over time and to stay inside, I also called a reporter when this was happening, he called the plant and they lied about the release and two days later put there own story in the paper.

Response 3

On September 19, 1996, during routine movement of empty UF_6 cylinders, the operator of a cylinder handler inadvertently backed into one of the empty UF_6 cylinders that contained approximately 15 pounds of depleted uranium hexafluoride. This action resulted in the rear tire of the cylinder handler striking and severing a pipe nipple in the valve port of the cylinder, which resulted in a release of uranium hexafluoride. Two employees were in the immediate area at the time of the incident and both were evacuated. One employee contacted the Plant Shift Superintendent via hand-held radio and requested emergency assistance. An emergency 911 call was also made. A small, low-lying plume, which is the result of the chemical reaction of UF_6 and air, was evident at the base of the cylinder. This plume dissipated rather rapidly and there was no off-site impact. The area was isolated and the leak was stopped utilizing a standard plug. Health Physics surveys were conducted and the radiological contamination was verified to be contained within a four-foot square area beneath the valve end of the cylinder. An "all clear" for the area outside this boundary was given approximately 1-1/2 hours later. A DOE news release was issued within two hours of the incident to five area newspapers and four local radio stations. Environmental Compliance personnel determined that there was no CERCLA Reportable Quantity exceeded and no Emergency Planning and Community Right to Know Act (EPCRA) reportable quantity exceeded.

Comment 4

I would like someone to tell me why we have alarms and run through drills and when there is an actual potential dangerous releases there is no sound of alarms to warn the citizens of the surrounding communities. Residents didn't know about the situation so therefore didn't know to stay inside.

Response 4

The Portsmouth Site has an Emergency Plan in effect and conducts periodic emergency drills and exercises to prepare for any emergency situation. There are two levels of emergencies at the Site: (1) Alert — An Alert is declared if emergency hazards could affect plant personnel, but not the general public outside the plant boundaries. Local government officials are advised so that their resources and emergency responders are ready to assist on-site if needed. (2) Site Area Emergency — A Site Area Emergency is declared if the hazards could affect the general public within a two-mile radius of the plant boundaries. This is the most serious emergency situation and means that a significant release of hazardous materials may occur. All individuals within this notification area would be notified immediately by audible voice alert from the plant. Additionally, messages can be directed immediately to local radio and television stations which provide protective actions that are recommended. These recommendations could be to evacuate or to shelter in place. Local government officials are also notified immediately so that their resources, which may include deputies and officers as well as volunteer fire personnel, may quickly focus on protecting the general public. Experts from the Site, Federal Agencies, and State and Local Officials coordinate emergency actions. Warning sirens are in place to sound for public alert should a Site Area Emergency be declared. There have been no such emergencies requiring warning sirens since the warning system was placed in operation in 1988. Periodically, the sirens are sounded for routine testing or during drills.

Comment 5

Charles Bradley you didn't seem to believe me about the airborne plume from the DU cylinder could form, you thought it would suck back inside the cylinder like the video that was shown here. That video is misleading in ways.

Response 5

The video referred to was shown at the public hearings. In part it illustrated how, when the workers opened the valve on a depleted UF_6 cylinder, air was drawn into the cylinder rapidly due to the less-than-atmospheric pressure inside the cylinder, making an audible sound. After a short while, a cloud of mist containing HF gas started to come out of the cylinder slowly. However, in the PEIS a wide spectrum of cylinder accidents was analyzed, including small breaches similar to the opening of the valve as illustrated in the video, and large catastrophic breaches. Details of the cylinder accident scenarios are provided in Section D.3 of Appendix D, and the impacts are discussed and summarized in Section 2.4.2 and Table 2.2.

Comment 6

I would like to view another picture of children standing around DU cylinders. This should not be allowed with all the information about the hazard of this product, and the problems with on site hazards here at Piketon.

Response 6

The commentor is referring to a photograph of a tour conducted by Martin Marietta Energy Systems Public Affairs on March 11, 1993 for a group of high school students enrolled in the vocational school's electricity class. The purpose of the tour was to provide information regarding the uranium enrichment process and the ultimate customer of this process, the nuclear industry. The students were pictured at the plant's Product Sampling and Shipping Facility where cylinders of enriched uranium product are readied to ship to customers. Plant tours are conducted to better inform the public and are strictly governed by plant safety procedures regarding access to different areas of the plant. The depleted uranium hexafluoride storage yards are not typically on a tour route unless specifically requested by the tour group.

Comment 7

PRESS (Portsmouth-Piketon Residents for Environmental Safety and Security) considers a decision that there is little effect to the public and it's workforce to be a serious environmental justice concern and was not address adequately in the Draft PEIS.

PRESS along with the Military Toxic Project is asking for the comment period to be extended to six months to give folks the opportunity to meet with you in a roundtable meetings, much like the Federal Facilities Restoration Dialogue meetings. We need to have the opportunity to discuss the strategies that have been proposed.

I am putting in records the letter form the Military Toxic Project.

Response 7

The approach used in the PEIS to assess environmental justice concerns is consistent with guidelines in "Environmental Justice: Guidance Under the National Environmental Policy Act" (Council on Environmental Quality 1997; the full citation is provided in Chapter 8 of the PEIS). The approach taken involved a two-step process to identify impacts associated with environmental justice (see Section 4.3.12 of the PEIS). The first step concerns the presence of disproportionately high percentages of low-income or minority populations in those areas anticipated to experience high and adverse impacts. The second step concerns the presence of high and adverse impacts in general, and thus affecting the total population. Section C.8 of the PEIS provides a detailed discussion of the methods used to identify and assess potential environmental justice impacts.

For the response to the request for extension of the comment response period and for responses to other comments included in the letter from the Military Toxics Project, please see the responses provided to the Comment Document No. 9.

Comment 8

PRESS, an(d) other viewer(s) should see in writing all agreement(s) between the state's of all three facilities Oak Ridge, Paducah, and Piketon. All agreements between CONGRESS, the USEC, DOD, DOE, and any others involved.

Response 8

The commentor's preference is noted. Public documents containing information about the three storage sites are available in the DOE reading rooms located near each storage site, specifically, Waverly, Ohio; Kevil, Kentucky; and Oak Ridge, Tennessee. Specific requests for public documents related to depleted UF_6 management may also be made at these locations.

Comment 9

I would like to remind you that Piketon has never been licensed to accept or store radioactive waste and we have broken many laws by doing so. You have consistently withheld information from the citizens about radioactive release whether planned, routine, or accidentally. PRESS feels that there is a number of cylinders no longer (in) inventory and would like to know who is hiding them, or were they stolen, or is someone already doing conversion?

Response 9

The Ohio EPA has issued permits for the DOE Site to have storage areas for hazardous and mixed (radioactive and hazardous) wastes. These permits do not apply to the depleted uranium cylinders because the uranium is considered a source material and not a waste; however, the Ohio EPA has entered into an agreement with DOE for the management of the depleted uranium stored at the site. This agreement is entitled " Ohio EPA Director's Final Findings and Orders" and is the result of the State's Notice of Violation issued against DOE.

DOE's depleted UF_6 cylinder inventory at Portsmouth was the same until May 1998. In May and June of 1998, two memoranda of agreement were signed between DOE and USEC (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS) that transferred management responsibility of a certain number of cylinders from USEC to DOE. All of the cylinders being transferred are already at Portsmouth. Therefore, no new depleted UF_6 cylinders are being brought to Portsmouth. Also, no DOE cylinders have been shipped off the Portsmouth site.

No one is doing conversion on a commercial scale in the United States, however, several companies may be looking into the economics of performing conversion in the future.

Comment 10

PRESS is worried that a earthquake would create multiple cylinder failures at all the sites, also worried over the possibly of aircraft wrecking and hitting the cylinders.

Response 10

The seismic risk text in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1 of the PEIS has been modified to be consistent with material presented in the safety analysis reports (SAR) for the three sites (LMES 1997a-c; the full citations are provided in Appendix C of the PEIS). The SARs do recognize and discuss the potential for multiple cylinder failures in association with an earthquake. The PEIS considered potential accident scenarios with frequencies as low as 1 in 10 million years, in accordance with NEPA guidance for environmental impact statements (EISs). This frequency range includes small plane crashes, which are analyzed in the PEIS. The flight paths of large planes avoid

the site leading to an extremely low accident probability. Large plane crashes occur in the beyond incredible probability range (less than once per 10 million years), which the PEIS does not analyze.

Comment 11

PRESS feels we need to look at some real problem that the National Research Council as put on the table.

Response 11

It is not clear what National Research Council study the commentor is referring to, however, it is believed that the referenced study is the National Research Council report entitled "Affordable Cleanup? Opportunities for Cost reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities." A chapter in that report (Chapter 7) is on the disposition of depleted UF6. The report was reviewed as part of the preparation of this PEIS; the results from this review were included in the PEIS analyses as appropriate. The report is referenced and discussed in Section 1.7 of the PEIS.

Comment 12

We feel that until we find a safe way to handle these cylinders they should be put in earthquake proff containers or maybe find a way to neat them up in the place where stored, then put them in new cylinders until new safe technology comes along.

Response 12

As noted in the PEIS, (see discussion of impacts under the no action alternative in Sections 2.4 and 5.1 and Appendix D), the continued storage of depleted UF_6 cylinders at the three current storage sites would be safe. The safety of current cylinder storage is supported by the revised safety analysis reports (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). In support of the PEIS, a number of options for off-site transportation of depleted UF_6 cylinders were reviewed and evaluated. One option for overfilled cylinders was a mobile system which would remove the overfilled portion of an existing depleted UF_6 cylinder while stored. Preliminary analysis of this option and other relevant options resulted in the consideration of the two cylinder preparation options in Appendix E of the PEIS, one of which transfers the contents of a substandard cylinder into a new cylinder, using cold feeding, a process similar to the one suggested by the commentor, except the transfer occurs in an onsite facility instead of in the cylinder yard.

Comment 13

I would like to put in record a report from Gene Hoffman. At request, I will make a copy for people here that would like one. Also a letter sent to NY TIMES BUREAU Leonard A. Dietz about the DU issue.

Response 13

A copy of the report attributed to Mr. Gene Hoffman can be found in the attachment to Mr. Hoffman's comment document (No. 53) in Chapter 2 of this document. Responses to comment document No. 53 are provided in this chapter. Mr. Hoffman was also a speaker at the Oak Ridge, Washington, D.C., and Paducah public hearings. Detailed responses to his hearing comments are

provided in Oak Ridge public hearing comments and responses 29-41 and in D.C. public hearing comments and responses 24-48.

Leonard Dietz's letter was printed as an attachment to comment document No. 80 (see Chapter 2 of this document). The concern raised in the letter focuses on the increased radioactivity of depleted uranium due to the build up of U-238 decay products. The PEIS analyses considered the impacts associated with the build up of U-238 decay products. In fact, the PEIS analyses assumed that Th-234 and Pa-234, the two short-lived decay products of U-238, were in secular equilibrium with U-238. See Section F.2 of the PEIS.

Commentor No. 81: Quapp, W. J.
Starmet Corporation

Comment 1

These comments are prepared to identify the required research in depleted uranium production that must be funded by the DOE to reduce the production cost. Without such cost reduction, some applications, while technically feasible, will never be economic compared to alternative metal options such as steel, lead, and copper. As will be discussed later, the performance advantage of depleted uranium metal must be very high to overcome the high product cost of metallic uranium components. This paper identifies some opportunities and offers suggestions for reducing the economic penalty of using metallic depleted uranium.

Response 1

Comment noted.

Comment 2

3. Metallic Uranium Applications, 2.1 Radiation Shielding Applications: Depleted uranium is an excellent gamma shield having 2.4 times the density of steel and 1.7 times the density of lead. Depleted uranium offers a significant advantage over lead in transportation casks during the postulated fire accident scenario due to its much higher melting point — 1135°C compared to 327°C. Depleted uranium offers advantages over steel in radiation attenuation in proportion to its density efficiency for spent fuel shielding applications. For some specific isotopes (specific photon energies), uranium is much more efficient than the density ratio alone would imply. However, depleted uranium alloys have never been established as an ASME code material so that no structural credit for depleted uranium is given by the NRC in cask applications regulated under 10 CFR Part 71. Consequently, the surrounding steel, which is also required to preclude oxygen from reaching the depleted uranium, must provide the structural requirements even though some depleted uranium alloys have very high strength and toughness.

Given that selected depleted uranium alloys have been used by the US Army for penetrators and tank armor, it appears that there is ample precedent for using depleted uranium metal in high technology and demanding applications where corrosion protection can be assured.

Response 2

Comment noted. DOE plans to continue its support for the development of government applications for depleted uranium products based on their unique properties.

Comment 3

3.2 Counterweight Applications: As stated previously, aircraft counterweights have been in use in wide-body aircraft for about 30 years. These counterweights are generally very small and are used to adjust the center of gravity and to balance loads on various aircraft components. Modern aircraft design techniques have reduced the need for counterweights. In addition, some aircraft owners are switching to tungsten to avoid issues associated with radioactive materiel. For example, Japan prohibits any aircraft using depleted uranium counterweights. Consequently, this market is relatively stagnant and little future use is projected.

Other potential counterweight applications include equipment such as fork lifts which require massive (several ton) counter weights to balance lifting loads. This market does not currently exist but if economic issues could be overcome (as well as regulatory and public acceptance issues), a large market might develop. One promoter of this application has suggested major warehouse cost savings and forklift safety improvements associated with forklifts using depleted uranium counterweights. The claimed cost savings come from more compact warehouses. The safety benefits come from a lower center of gravity. If all forklift production was converted to using depleted uranium counterweights, the entire inventory of depleted uranium could be consumed in a few years.

However, regulatory and public acceptance issues aside, the major barrier to commercial depleted uranium counterweight use is the cost of production. This is addressed in the next section.

Response 3

Comment noted. DOE plans to continue its support for the development of government applications for depleted uranium products.

Comment 4

4. Depleted Uranium Metal Production Costs, 3.1 Current Production Costs: The method used commercially for uranium metal production is the Ames process. In this process, UF_6 is reacted with hydrogen to produce UF_4 or "greensalt" and HF. In a separate step, the greensalt is mixed with magnesium metal chips and is ignited in a graphite lined retort (a high temperature chemical reactor) at about 800°C. The magnesium reduces the UF_4 to uranium metal and forms MgF_2. This solid phase reaction liberates tremendous heat and the entire mass of uranium and MgF_2 become molten. Due to density differences, the U metal liquid phase separates by gravity from the MgF_2 salt to form a "derby" which takes the shape of the crucible. After this material is cooled, the uranium metal derby is manually separated from the MgF_2 salt. The MgF_2 salt is disposed as a radioactive waste as it typically contains 1% to 2% uranium by weight. The metal is then cleaned and alloyed, as required, in a vacuum casting furnace. The metal is then shaped via extrusion, rolling or casting into its product form.

The Starmet CMI facility in Barnwell, SC, is the only remaining commercial US producer that manufactures uranium metal from UF_6. Some DOE conversion capability exists at the Y-12 and Los Alamos weapons facilities. Starmet CMI uses the Ames process. This facility has converted UF_4 to metal since 1983 for use by the US Army (as well as the British and French) for depleted uranium penetrators. The UF_6 to UF_4 capability was added in about 1987. These are the same processes that were employed at the DOE Fernald site prior to its shutdown.

Uranium derbies are shipped from Starmet CMI in South Carolina to the Starmet facility in Concord, MA, for alloying, casting and forming into products. After alloying, the uranium is cast into either ingots or slabs. Ingots to be used for penetrators are extruded into rods for subsequent machining operations. Starmet also casts slabs that are sent to the DOE INEEL facility in Idaho for use in fabricating armor for the Abrahms tank. These uranium slabs are fabricated at the Concord facility in vacuum melters from scrap uranium being recycled from prior operations at the INEEL facility.

The biggest non-regulatory impediment to the use of depleted uranium metal in commercial applications is the high cost of converting from UF_6 to uranium metal. In a survey performed for DOE in 1993 by Technics Corporation, the cost was identified to be about $11.70 per kg-U ($5.30 per lb-U) for conversion of UF_6 to metal and casting into a shape. Any forming or machining cost was additional and was priced at $4.40 to $22 per kg-U. Some cost reductions could be forecast through larger conversion facilities but these would not be expected to be sufficient to dramatically reduce the costs below those cited.

3.2 Market Production Cost Requirements: In a recent meeting between Starmet personnel and a Japanese forklift manufacturer, the manufacturer stated that the counterweight must not cost more than its steel equivalent. Thus, unless the performance advantage of forklifts designed with uranium counterweights justifies the higher costs, none will be sold unless the cost of uranium metal production is reduced.

Response 4

Comment noted.

Comment 5

3.3 Cost Reduction Opportunities, 3.3.1 Continuous Metallothermic Reduction: This process was developed at Oak Ridge National Laboratory in support of the AVLIS Enrichment process that uses a uranium-iron eutectic as feed material. The process uses a bath of molten magnesium into which uranium tetrachloride is injected. The magnesium reduces the uranium tetrachloride and forms magnesium chloride that can be recycled to recover the magnesium. The molten uranium is alloyed with iron during this process to reduce the melting point from 1135°C to about 700°C. This reduces the uranium vapor pressure and simplifies subsequent operations. The potential cost reduction for this process, compared to the AMES process, is not known due to proprietary restrictions associated with the AVLIS technology.

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Conceptually, this process might be adapted to uranium hexafluoride however, the process has not yet been successfully demonstrated at production scale. Furthermore, the advantages of using the eutectic mixture for AVLIS would probably be unavailable for counterweight applications since the metallurgical properties of the uranium-iron alloy are very poor. During cooling, shrinkage cracks develop and the alloy is very brittle at room temperature. By casting the alloy in a steel sheath, these metallurgical property deficiencies might be made irrelevant.

Response 5

Comment noted.

Comment 6

Cost Reduction Opportunities: 3.3.2 Direct Plasma Conversion of UF_6 to Uranium Metal Technology Description: This technology was conceived at the INEEL as a possible method for a lower cost production of uranium metal from UF_6. Conceptually, the process operates as shown in Figure 1. The UF_6 is injected as a gas into the center of a hydrogen-rich plasma operating at about 5000°C. At this temperature, the UF_6 dissociates to U metal and elemental fluorine. The fluorine combines with the hydrogen to form HF. As the gas exits the plasma reactor, it must be cooled rapidly to avoid the back reaction of HF with U. At the exit of the reactor, the gas (HF and unreacted H_2)with the entrained U metal vapor enters a cyclone where the cooled metal particles are separated from the gas stream. The system operates with excess hydrogen and to maximize conversion of the fluorine to HF. This excess hydrogen must be separated from the HF gas and recycled.

Advantages of this direct conversion approach must be contrasted with the traditional method for uranium metal production — the Ames process. The INEEL plasma conversion process consumes only hydrogen and liberates only anhydrous HF and H_2 as byproducts. The H_2 is extracted from the HF and recycled. The HF gas is comparably easy to purify of uranium using filtration techniques. The metal formed from this process is nanometer sized particles that are very pyrophoric. A method must be developed to solidify the uranium particles into an ingot before exposure to air.

In all past uranium metal production operations, because of the relatively small production, the HF was captured in a scrubber to form aqueous HF that was subsequently reacted with $Ca(OH)_2$ to form CaF_2 and water. The water was evaporated and the CaF_2 was disposed as a radioactive waste. The greensalt reduction reaction to produce uranium metal consumes magnesium and produces MgF_2 as a radioactive by-product waste. Methods to separate the uranium contamination from the MgF_2 have been considered but not deployed.

The INEEL process was successfully demonstrated at the small bench scale under a program funded by DOE EM-50 in 1994. The major challenge with the plasma reduction process is associated with the design and maintenance of a plasma reactor operating at such high temperature. INEEL researchers identified methods for designing such plasma reactors but further demonstration was beyond the scope of the funded program.

Estimated Cost Savings: After the proof-of-concept, bench scale test was successfully completed, an engineering conceptual design was performed for INEEL by Morrison Knudsen to estimate the total life cycle cost of this approach. In summary, this report identified that a reasonably sized facility could produce uranium metal at about $3.00 per kg-U. This compares to estimated commercial costs from the Ames process of about $8.80 per kg-U.

To achieve this production cost reduction, substantial research support will be required and probably at least ten years of effort will be needed before large-scale production could be achieved.

Response 6

Comment noted.

Comment 7

5. Conclusions: Applications for depleted uranium metal have been identified. These applications include radiation shields and industrial counterweights.

Barriers to using radiation shielding applications are minimal as numerous precedents have been set for use in transportation casks. Barriers to industrial counterweight applications are institutional and economic. The institutional barriers are public acceptance and legal possession limits. Such regulatory barriers may be resolvable, as the real toxic health effects of depleted uranium are less than for lead. The radiation issues from depleted uranium are minuscule provided the material is not ingested into the lungs. Resolution of public acceptance issues are difficult to predict but in an industrial setting, but they must be solved.

Thus, the largest barrier to the use of depleted uranium metal is production costs. Unless the forklift industry can sell the concept of substantially increased performance for the depleted uranium counterweight forklift designs, then the counterweight must have a similar cost to a steel counterweight. With steel casting costing in the range of $1.54 per kg versus uranium casting costing over $12 per kg, it is clear that reduced manufacturing costs are needed for commercial applications.

The direct plasma conversion of UF_6 to uranium metal offers significant cost reduction potential but will require substantial research investment to demonstrate commercial feasibility. Even then, assuming success and that the economics are as predicted, the estimated costs are still over a factor of two greater than a cast steel counterweight.

Consequently, wide scale application would be contingent upon either 1.) justifying to forklift buyers that the increased performance of a forklift with depleted uranium counterweights justifies a higher price, or 2.) alternatively, DOE could subsidize the conversion cost to neutralize the cost differential as a preferred action to managing the UF_6 for disposal. If the direct plasma conversion process were successful, the DOE subsidy would be less than the currently expected

disposal costs — assuming the counterweights remained continuously in commerce and ultimately did not require disposal.

In summary, large scale industrial use of depleted uranium metal in applications such as counterweights will require development of a lower cost production technology for economic deployment. The INEEL process is one potential process which comes close to the needed production cost point.

Response 7

Comment noted. DOE plans to continue its support for the development of government applications for depleted uranium products; however, issues of DOE program funding are beyond the scope of the PEIS.

Commentor No. 82: Hollister, Nancy P.
State of Ohio Lieutenant Governor

Comment 1

With this in mind, I support the near-term conversion of the significant stockpile of DUF_6 to U_3O_8 at the Portsmouth plant. Under "normal" circumstances, one would wait until a market for a given product develops before engaging in such an activity. However, the DUF_6 is stored in canisters of somewhat questionable integrity, and for which funding for long-term maintenance is noted in the PEIS as "uncertain." Thus, converting the DUF_6 to a "safer" product as soon as possible is the more prudent option.

Response 1

The Ohio Lieutenant Governor's preference for the conversion of UF_6 to U_3O_8 at the Portsmouth plant as soon as possible is noted. In response to comments received on the Draft PEIS, DOE has revised its preferred alternative. As explained in Section 2.5.1 of the PEIS, the preferred alternative now includes prompt conversion of DOE's depleted UF_6 inventory into uranium oxide or CaF_2.

Comment 2

Assuming that conversion is chosen as the preferred option, U.S. DOE should carefully reassess the status of these cylinders and the practicality (safety) of transporting them through the region to a central conversion site. The deteriorating condition of the cylinders may make on-site conversion at each plant a safer, preferred alternative. On-site conversion may also serve to maintain employment in each region.

Response 2

The commentor's preference for on-site conversion is noted by DOE. Due to the deteriorated condition of some of the cylinders, the DOE included in the PEIS evaluation of two

methods for transport of cylinders which do not meet DOT transportation requirements: (1) the use of overcontainers which would meet DOT requirements, and (2) on-site transfer of the substandard cylinder contents to new cylinders. Because the number of cylinders which will not meet DOT requirements at the time of transport is not known, the analysis assumed a range of values, including a worst-case assumption of 100% of the cylinders at each site. The details of the analysis of cylinder preparation for transport are given in Appendix E of the PEIS.

Comment 3

DOE should work with Congress now to ensure that funds presently accrued by the US Enrichment Corporation to offset DUF_6 conversion are maintained for that specific purpose, and to lay the groundwork for the on-site conversion efforts.

Response 3

Issues of program funding are beyond the scope of this PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Commentor No. 83: Miller, Jane E.
See responses to Commentor No. 51

Commentor No. 84: Bailey, Susan

Comment 1

I am concerned that the Draft PEIS does not include the alternative of disposing of depleted uranium per the rules of 40 CFR 191. Long-terms storage of uranium poses serious risks which makes the no action alternative and the new containers (for long term storage) option inappropriate and unacceptable. The waste classification of depleted uranium should be re-examined and should be put in the same category as transuranic waste. The scientific basis for this concern was well-documented in the comments of the Institute for Energy and Environmental Research.

Response 1

Depleted UF_6 is a source material. For purposes of evaluating disposal options in the PEIS, it has been assumed that depleted UF_6 would be converted into an oxide. This oxide form would be considered to be a LLW. Only waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years is classified as TRU waste. Waste containing depleted uranium with no or little TRU radionuclides does not fall within this definition. Therefore, disposal of depleted uranium oxides resulting from the conversion of DOE's depleted UF_6 inventory would not be subject to the regulations specified in 40 CFR 191. The material would be classified as LLW and the disposal alternative evaluated in the PEIS considered it to be LLW.

The results of analyses presented in the PEIS show that the risks posed by either the no action alternative or the long-term storage as UF_6 alternative would be acceptable. Please see Section 2.4 of the PEIS for further details on the comparison of impacts between alternatives.

Commentor No. 85: Cavazos, Alberto, Sgt.

Comment 1

My question is, if someone comes is exposed to depleted uranium . . . what are some of the symptoms? I am curious to know . . . I read an article in the Army Times recently and also I served in the Persian Gulf War from 901216 to 910427.

Response 1

The primary toxic effect of exposure to uranium compounds is kidney damage. The extent of the kidney damage depends on how much uranium gets into the body and the chemical form of the uranium. For example, water-soluble uranium compounds are more toxic than insoluble compounds because they are more readily absorbed into the body. If exposure is severe, acute renal damage and renal failure may result in death. However, for smaller exposures, there are often no clinical symptoms. Although some damage to kidney tissue may occur that can be detected through laboratory tests, once the exposure stops the tissue is regenerated and recovery of the kidney occurs. Symptoms of lower-level uranium exposures include weight loss and urine containing abnormally high levels of protein and damaged kidney cells.

Uranium is also a radioactive substance. A portion of ingested uranium is eventually deposited in the bones and tissues of the body, with some portion of inhaled uranium deposited in lung tissue. This retained uranium will emit low-levels of radiation, which can potentially cause an increased cancer risk over a lifetime. Different uranium isotopes exhibit differing levels of radioactivity. The most abundant isotope in depleted uranium (U-238) has a relatively low level of radioactivity, so that increased cancer risk from exposure to depleted uranium compounds is fairly low. Both the potential for kidney toxicity and increased cancer risks from uranium exposures are evaluated for all the alternatives addressed in the PEIS. See Sections 4.3.1.2, 4.3.2.1, C.5.1.2, C.5.2.1.1, and C.5.2.1.2 of the PEIS for further details on how uranium toxicity was addressed in the PEIS.

Commentor No. 86: Rustin, Ruth / Rustin, Frank / Casteel, Nathan
See responses to Commentor No. 51

Commentor No. 87: Wilson, Justin P. / Leming, Earl C. / Mobley, Michael H. / Hoyal, Mike
State of Tennessee

Comment 1

We prefer conversion of the entire inventory of stored Uranium Hexafluoride (UF_6) material which is recommended by the proposed alternative; however, the time line presented for the proposed alternative is unduly long considering the questionable condition of the stored inventory and potential health and environmental risks associated with leakage. As Governor Sundquist emphasized in his joint letter with the Governors of Kentucky and Ohio, the State of Tennessee urges the DOE to "consider the immediate conversion" of UF_6. The proposed alternative will provide the most rapid reduction of hazard to the environment and public if the time line for conversion is shortened . This recommendation applies only to the current scope of alternatives presented.

After review, the Division would like to express its support of the preferred alternative of converting uranium hexafluoride to oxide and/or metal. Tennessee has joined with Kentucky and Ohio in challenging DOE to begin the conversion immediately and complete the conversion by 2018, The PEIS has not properly addressed the need to provide adequate funding for the safe maintenance of the cylinder yards and implement requirements that protect the workers, public, and environment at and adjacent to the sites.

The State agrees with the preferred alternative as stated in Section 2.5, Page 2-54 of converting uranium hexafluoride to oxide and/or metal. Given, however, the numerous reports that cast doubts on the integrity of uranium hexafluoride cylinders and their environmental safety, the State, as shown in a recent letter from the Governors to Secretary Pena on the same subject, would prefer that fabrication and conversion facilities be sought as early as possible and not wait until the year 2005 as stated in the PEIS.

Page S-3, Section S.1.1. Background: "Under the current management plan, if alternative uses for the depleted uranium have not been found to be feasible by approximately the year 2010, steps would then be taken to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020." Conversion to an oxide should be completed by 2018 whether the material has a useful purpose or not.

The PEIS document considers a number of different options for dealing with the Depleted Uranium Hexafluoride. Several of the options include the conversion of the material from UF_6 to either uranium oxide or uranium metal. In their analysis of this option, they always consider the conversion beginning in the year 2008 (PEIS 2-6, 2-9, 2-12, 2-15). This seems to be an unreasonably long time before starting conversion. Even considering that it will take time to decide what to do with the material, and to build the facilities if conversion is the chosen option, it does not seem that 10 years should be necessary before conversion can begin.

Response 1

At the beginning of the PEIS preparation, the 40-year timetable appeared to be the most reasonable, based on consistency among alternatives. It was chosen as a reasonable period over which to estimate and compare the environmental impacts of the alternative management strategies considered in the PEIS (see Section 2.1). The representative schedule for facility construction and operation was determined on the basis of engineering judgment that was applied consistently to allow for a meaningful comparison among the PEIS alternatives; it does not represent a definitive schedule. For the purposes of the analysis, it was generally assumed that it would take approximately 10 years for activities such as technology selection, facility design, site selection and preparation, facility construction, and appropriate environmental reviews. Initial facility operations were based on a 20-year period for processing all of the inventory, which was extended in the Final PEIS to approximately 26 years to account for processing up to an additional 15,000 cylinders that were previously the responsibility of USEC.

In response to comments on the Draft PEIS, DOE has determined that, if an alternative requiring conversion is selected, that it is in the best interests of the public and the government to begin conversion as soon as possible. The actual implementation schedule will depend on a number of factors, including the management strategy selected in the Record of Decision, site and technology selection activities, budget constraints, and procurement requirements. However, DOE is committed to implementing the selected alternative as early as practicable and, for as long as necessary, to continuing the safe management of its depleted UF_6 cylinder inventory. (Please see also the response to comment number 2 below).

In addition, on February 2, 1999, DOE entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the UF_6 stored at the ETTP. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from ETTP or complete the conversion of their contents by December 31, 2009.

Comment 2

Up to this point the DOE has not fully funded the proper storage, inspection, testing and maintenance of stored cylinders of material nor does the PEIS address this pressing need for funding. Previous DOE documents have underscored its importance. Current inventories, however, remain in improper storage conditions and inspections of these inventories are limited, Improperly stored cylinders are at risk to natural catastrophes such as earthquakes and tornadoes. In order to fully assess the hazards associated with long-term storage versus conversion of UF_6, the DOE must address these funding concerns in the PEIS.

Funding must be addressed in the PEIS to provide for regulatory compliance and the continued storage of Cylinders including the heel and smaller cylinders. The "Draft Preliminary Report-DOE Independent UF_6 Cylinder Assessment Team" dated 03-25-92, still in draft form states the primary issues with cylinder management is funding to properly store, inspect, and maintain. Site

visits by the State in July 1997, confirmed that funding has not been fully appropriated to maintain the yards or the cylinders.

Page S-8, Table S-1: The No Action and Long-Term Storage alternatives state ". . . cylinders would be subject to a comprehensive monitoring and maintenance program...." Describe how this program differs from those already proposed. The document "Draft Preliminary Report-DOE Independent UF_6 Cylinder Assessment Team," dated 03-25-92, made specific observations and recommendations for UF_6 cylinder management, but is still in draft form. DOE has proposed many plans, but has failed to appropriate the funding to fully carry out those plans. The PEIS must take into consideration historical management plans and DOE's failure to fund or comply with its own requirements.

DOE continues to state there is to be maintenance and monitoring plans, but the PEIS state that funding is questionable for some cylinder activities, such as coating. Current cylinder conditions leave no question that funding has been less than adequate. DOE must take aggressive action to ensure whatever alternative is selected and there will be no reduction or elimination of necessary maintenance and inspection activities due to lack of funding.

Page 1-5, paragraph 2, Section 1.1, Background Information: The Division concurs "The DOE has responsibility for continued management of the depleted UF_6 cylinders generated by DOE and stored at the Paducah, Portsmouth and K-25 sites." However, the proposed time table does not adequately address the safety and environmental concerns of the State of Tennessee. It has been estimated that there are an additional 12 undiscovered breached cylinders in the inventory, in addition to 7 already identified, and that the number may be as high as 200. Since some cylinders (with approximately 3 curies per cylinder) have experienced a 1/3 to 1/2 wall thickness loss due to corrosion, the continued storage of cylinders does not seem prudent or reasonable. The timetable should be accelerated to convert the UF_6 to triuranium octaoxide (U_3O_8) as soon as possible. The U_3O_8 or metal form of depleted uranium represents "safe" storage of depleted uranium.

Response 2

Issues of DOE program funding are beyond the scope of the PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

DOE's current systems engineering approach to safe cylinder storage includes visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, cylinder coating maintenance, and cylinder yard maintenance (see LMES 1997i, UF_6 Cylinder Project Management Plan, K/TO-30, Rev 2; the full citation is provided in Chapter 8 of the PEIS). This comprehensive monitoring and maintenance program would be modified to meet any new or revised requirements or to incorporate improved practices or technologies that become available for protecting the safety and health of workers, the public, and the environment.

Periodic cylinder inspections and other cylinder maintenance activities have revealed no additional cylinder breaches other than the seven previously identified.

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use.

The State of Tennessee's preference for accelerated conversion to U_3O_8 is noted.

Comment 3

Beyond the condition of stored cylinders, issues concerning the handling of cylinders for transport have been insufficiently addressed or neglected in the PEIS. DOE's inspection of stored cylinders has been limited raising the concern that breaches in corroded cylinders may exist. Handling such corroded cylinders as well as cylinders that have been overfilled or cylinders containing "heel." materials--conditions which do not meet Department of Transportation's specifications for transport--will require costly training of personnel to repackage materials, The DOE cannot adequately assess alternatives for long-term management of stored inventory without realistically assessing these hazards and costs in the PEIS.

More than 50% of the cylinders were not constructed to Department of Transportation (DOT) specifications. After thirty years in storage, a much higher percentage of the cylinders may not meet DOT specifications for transportation purposes and may need to be overpacked if they are moved for processing. Also, deteriorated cylinders may require cold extraction of the contents. The personnel needed to handle the cylinders will need to be trained for extreme conditions. The costs of recruiting and training appropriate personnel for the duration of the processing operations will have to be factored in the cost-benefit analysis.

Response 3

The PEIS evaluated the impacts from continued storage of the cylinders in Appendix D, including impacts from possible cylinder breaches, and from handling cylinders. Additionally, Appendix E of the PEIS evaluated the potential impacts of preparation for transport of cylinders not meeting DOT transportation requirements. Cylinders not meeting transportation requirements were defined as (1) overfilled cylinders; (2) overpressured cylinders; and (3) substandard cylinders (that is, dented, damaged, or corroded). Two technologies were evaluated for cylinders not meeting DOT transportation requirements: the use of overcontainers to ship the cylinders, and transfer of cylinder contents to new cylinders using cold extraction. Because the number of cylinders not meeting DOT transport requirements which would exist at each site at the time of shipping is unknown, the PEIS evaluated the cylinder preparation options assuming a range of numbers of such cylinders; for each site an evaluation was conducted assuming the worst case of 100% of the cylinders not meeting

requirements. The activities of cold feeding, cylinder inspection, transporting, and overpacking, are all activities associated with an operating gaseous diffusion plant, and therefore, are not new technologies that require extensive training and testing. The cost of cylinder preparation for shipment assuming the same range of numbers of cylinders as the PEIS assumed was evaluated in the cost analysis report (CAR) (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The CAR and other supporting reports are available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

With respect to cylinders not constructed to DOT transportation requirements, in fact only a small percentage of cylinders used to store depleted uranium today were not code stamped at the time of fabrication. Title 49, Code of Federal Regulations, Transportation, while quite specific in many requirements, defers this particular requirement to ANSI N14.1, American National Standard for Nuclear Materials–Uranium Hexafluoride–Packaging for Transport. Should any cylinder not meet the requirements of 49 CFR or those deferred to by this regulation, a request for exemption would need to be submitted to DOT. In order to receive this exemption, DOE would be required to demonstrate that the cylinder in question provided the equivalent safety of one that met all of the requirements.

DOE has evaluated the number of cylinders which are filled in excess of the 62% solid volume required by the Department of Transportation under 49 CFR 173.420. It is estimated that only 29% of the cylinders exceed this fill capacity. An exemption from DOT would also be required in order to transport these cylinders. Many of the cylinders still meet the requirements of 49 CFR 173.420 today. Each cylinder would be inspected individually by a certified code inspector prior to being approved for shipment. Cylinders containing "heel" amounts of depleted UF_6 pose no special handling problems. DOE believes that issues related to the handling of cylinders for transport have been adequately addressed in the PEIS.

Comment 4

We further request that the PEIS address the Inventory of the United States Enrichment Corporation (USEC) which may come into DOE possession. Omission of this significant inventory represents an incomplete analysis.

United States Enrichment Corporation (USEC) since its privatization, has produced about 8000 cylinders (now reported to be upwards of 10,000) and is estimated to be currently producing 2 to 4 cylinders daily. The exact number of cylinders in question must be identified in the PEIS. The ownership of these cylinders has yet to be determined. The decision regarding USEC's 8000 cylinders should be made now, not as described in a "future Memorandum of Agreement between the USEC and the Office of Management and Budget." If the 8000-10,000 cylinders were considered part of DOE's inventory, it would represent a significant increase in total cylinder inventory.

A long-term strategy for DUF_6 must include DOE's entire cylinder inventory, including heel and small cylinders as well as the 10,000+ cylinders of DUF_6 generated by USEC since 1993. The USEC cylinders will revert to DOE ownership upon privatization of USEC. DOE might consider partnering with the future owner of USEC in a long-term strategy for managing and converting DUF_6 in order to avoid redundancy of efforts, so long as the partnering does not slow progress toward conversion. An estimated $480 million has been accrued by USEC since 1993 in order to offset the cost of future conversion of the DUF_6 generated. DOE should take steps now to ensure that this fund is not diverted into the federal treasury for an unrelated use.

Response 4

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS) after publication of the Draft PEIS (see Sections 1, 2, 6, F.3, and Summary of the PEIS). In addition, the treatment of several hundred heels cylinders has been added to the PEIS. Issues of DOE program funding are beyond the scope of the PEIS. Budget submissions are consistent with implementing required safety practices to protect workers, the public, and the environment.

Comment 5

In order for Tennessee to effectively evaluate the potential impacts of the preferred alternative, the PEIS must provide information on the location of the sites where conversion might occur and how waste and materials generated from this process will be managed.

Response 5

The PEIS evaluates broad programmatic strategies for the long-term management of the depleted UF_6 cylinder inventory, including strategies of long-term storage, use, and disposal. The evaluation of potential environmental impacts in the PEIS includes all of the activities that would be necessary to implement each of the alternatives (see Sections 2.1 and 2.2 of the PEIS). However, as a programmatic EIS (PEIS), it does not propose any site-specific projects. Consequently, the impacts of some management activities, such as conversion, long-term storage, manufacture and use, and disposal, were evaluated using representative facility designs and environmental setting information. The characteristics of these representative designs and settings were selected to provide as substantive an assessment as possible and to allow for a comprehensive comparison of the strategy alternatives. The potential impacts from construction and operation of such representative facilities, including waste management impacts, are included in the PEIS. Upon implementation of the strategy to be selected in the Record of Decision for the PEIS, site-specific evaluations will be performed, including the effects of site-specific projects and range of alternative actions, including a "no action" alternative.

In the PEIS, site-specific impacts were evaluated only for components of the alternatives for which the locations of the actions were already known. These components were continued

cylinder storage and cylinder preparation for shipment, which were individually evaluated for each of the three current storage sites. The cumulative impacts of these components are described in Section 5.8 of the PEIS. Management of wastes and materials that would be generated under each of the management alternatives and options is addressed throughout the PEIS. See for example Sections S.4.8, 5.1.7, 5.2.7, 5.3.7, 5.4.7, 5.5.7, 5.6, 5.7.8, D.2.7, D.4.7, E.3.7, F.3.7, G.3.7, H.3.7, Appendices I and J.

Comment 6

The Draft PEIS fails to address two major issues. The first is the treatment, recycling, or reuse of Uranium Hexafluoride (UF_6) in a timely manner. The second issue is the final safe disposition of the "heels" component of the UF_6 cylinders containing a high energy (gamma emitting) RCRA mixed waste like material. The Division estimates there to be 120 million pounds of this material in cylinders stored on the Oak Ridge Reservation. Of paramount concern under the No Action or Long-Term Storage alternatives, is the slow migration of the "heel" material into the groundwater/surface water and the release of UF_6 into the air, due to the corrosion and failure of the cylinders. The Draft PEIS is unclear on the criteria used for hazard modeling. The PEIS must identify the "worst-case" cylinder conditions and explicitly use this information in the hazard modeling descriptions. The PEIS must describe the modeling parameters such as total wall area found to be less than minimum thickness, age of the cylinder, manufacturing requirements (ASME or other design/construction), denting/bulging, and if the cylinder is in an "overfilled" condition. These conditions then must be coupled with the natural phenomenon hazards in determining the risk. The PEIS must accurately identify the cylinder population with these conditions.

Page 5-119 and 5-120. Section 5.13, Pollution Protection And Waste Minimization. This section should address the "heels" component of the UF_6 cylinders. These heels contain a high energy (gamma emitting) RCRA like mixed waste.

Response 6

With respect to the first issue of treatment, recycling, or reuse of Uranium Hexafluoride (UF_6) in a timely manner, the PEIS addresses the alternatives of continued storage as UF_6, long-term storage as UF_6 at a consolidated site, conversion and long-term storage as oxide, conversion and use as either oxide or metal, and conversion and disposal. A comparison of the potential impacts from these alternatives is provided in Section 2.4 of the PEIS. The preferred alternative in the PEIS has been revised to indicate that conversion of the depleted UF_6 would start promptly.

On the second issue regarding the final safe disposition of the "heels" component of the cylinders, as long as the cylinders remain in storage at ambient temperatures there is minimal health and safety concern with respect to the high energy decay products from uranium-238 present in the cylinders, because as long as the uranium-238 remains in the cylinders, it has the effect of shielding the gamma emissions from the decay products, so that the dose rate at the cylinder surface is fairly low (typically about 2-3 mrem/h at the surface, decreasing to about 1 mrem/h at a distance

of 1 foot). (This is confirmed by actual measurements at the cylinder surfaces). Also, if breaches develop in a few of the cylinders, the property of the UF_6 of forming a plug of solid uranium and iron compound would limit the amount of depleted UF_6 leaving the cylinders (see Section 1.1 of the PEIS). Because of the fact that U-238 decay products are uniformly distributed in solid depleted UF_6 in full cylinders (they concentrate in the bottom of the cylinder only after the cylinder is emptied) and that their concentration is low compared to U-238, any effect their release from breached cylinders would have on human health and safety would be negligible compared to the effect of UO_2F_2 and HF (reaction products of UF_6 and H_2O in air). The potential impacts from releases of UF_6 in the form of UO_2F_2 and HF from breached cylinders are analyzed in the PEIS in Sections D. 2, D.3, and D.4 of Appendix D. In these analyses, both a most likely and a worst-case number of cylinder breaches are assumed in order to fully characterize the possible impacts from an unknown number of cylinder breaches that could occur in the future. Furthermore, the potential impacts from accidents during continued storage, including natural phenomenon hazards, have been analyzed and presented in Sections D.2.2 and D.4.2 of Appendix D.

For alternatives that include conversion of the UF_6 to oxide or metal, removal of the cylinder contents would be required. After the bulk removal of depleted UF_6 from a cylinder, some depleted UF_6 (i.e., less than 50 lb) that contains a small amount of uranium decay products remains in the cylinder; this material is called the cylinder "heel" and is not a RCRA material. For conversion options, it was assumed in the PEIS that a cylinder treatment facility would be co-located with the conversion facility (see Appendix F). Prior to treatment at the cylinder treatment facility the cylinders containing heels would be stored for 3 months, during which time most of the activity from the short-lived daughter products of uranium-238 would decay away. The cylinders could then be handled safely. The empty cylinders would be washed with an aqueous solution and would then become part of the DOE scrap metal inventory. Text has been added to Section 5.14 to clarify that the heels would be removed from the empty cylinders under the cylinder treatment facility option.

A small number of "heels" cylinders (less than 500) each containing less than 50 lb of depleted UF_6 are also currently in storage at the sites. These cylinders have been in storage for more than 3 months and thus do not present a hazard due to the radiological activity of U-238 daughter products. The PEIS has been expanded to include the treatment of these heels cylinders. (See Sections 1.5.2 and 4.2.1 of the PEIS.)

Comment 7

The PEIS does not identify storage and maintenance of the overfilled cylinders. The K-25 site has determined there are approximately 2300 14-ton and two 10-ton cylinders that contain more UF_6 than is allowed for off-site shipment by DOT regulations. Although the cylinders are determined to be overfilled for transportation, they must also be properly evaluated for long-term handling and storage.

Response 7

The limit on the amount of depleted UF_6 that can be placed in a cylinder is based on a safety factor of heating a cylinder to 250°F to evacuate the contents and the cylinder's design envelope which includes the size, design pressure, and wall thickness. DOE has evaluated the entire inventory of depleted UF_6 cylinders with regards to the requirements in Title 49, Code of Federal Regulations. Some of these requirements are deferred to ANSI N14.1, American National Standard for Nuclear Material–Uranium Hexafluoride–Packaging for Transport. 49 CFR 173.420 requires that the volume of solid depleted UF_6 may not exceed 62% of the certified volumetric capacity of the packaging. Each type of cylinder that has been used over the years is listed in ANSI N14.1 with it's required minimum volume. It is a requirement, when fabricating a cylinder, that each cylinder be filled with water, the water measured, and the "certified" volume in pounds of water be stamped on the cylinder's nameplate. Cylinders fabricated prior to this requirement must be considered to meet the minimum volume requirement listed in ANSI N14.1, when in fact they might possibly be larger. From this information, DOE has determined that a percentage of the inventory is filled to 65% of the minimum volume instead of 62%.

Cylinders that are overfilled do not pose any special handling problems or storage problems. The volume of depleted UF_6 inside the cylinder is only a concern if the cylinder is heated, as in the process for emptying a cylinder. Based on the actual volume in the cylinder and the density of the depleted UF_6, temperatures can be lowered to provide safe evacuation of the contents. An assumption in the PEIS is that all cylinders would be emptied at reduced heat which eliminated the need for special evaluation.

Comment 8

The document does not address potential waste issues arising out of leaks (breach or rupture) in the cylinders and/or leaks caused by the handling of the cylinders. Prolonged storage of the UF_6 in outdoor yards can and has been shown to cause corrosion events. The products of corrosion include radioactive and hazardous wastes. In so far as the products of corrosion are not collected and recycled, they are wastes. With age, the probability of corrosion and external breach for the cylinders increases. Thus leakage from the long-term storage of Uranium hexafluoride cylinders could result in hazardous waste violations and non-compliance with applicable DOE Orders.

Response 8

The major objective of the current cylinder management project is to safely store the inventory until ultimate disposition. A cylinder inspection schedule has been put in place to ensure that if a cylinder was breached, it would be discovered in ample time to alleviate the environmental effects. The amount of waste created, if a breached cylinder should be discovered, should be minimal due to the schedule now in place for inspections and the chemical characteristics of UF_6 in its present storage condition. The PEIS evaluated the waste management implications of continued storage of the cylinders, both under the No Action Alternative (Section D.2.7 of Appendix D) and under the Action Alternatives (Section D.4.7 of Appendix D). As detailed in those

Sections, the analysis included low-level-waste generated from breached cylinders (the emptied cylinders themselves and materials released from them), failed valves, and solid process residue from cylinder painting. The number of cylinder breaches assumed through the period of evaluation is summarized in Appendix B.

The possibility of cylinder rupture during handling was also addressed in Section D.2.2 of Appendix D. Assuming the most-likely scenario that the rupture would occur during dry weather conditions, the amount of UF_6 assumed released would be 24 lb (see Table D.6). In the Draft PEIS, this type of accident was estimated to have a probability of occurring 3 times during the 40 year period evaluated (three is the total estimated number of occurrences for all the sites combined). With the addition of the USEC cylinders, the estimated number of occurrences in the Final PEIS is four. The amount of waste generated from these accidents could readily be accommodated by the existing waste management facilities at the sites.

If a breached cylinder is discovered or if a cylinder rupture should occur, the situation will be handled with approved procedures, in compliance with any storage site requirements, including any DOE Orders, or state and federal regulations.

Comment 9

The PEIS has not presented supporting evidence that mines, shallow earthen trenches, and other underground sites are suitable for long-term storage. The State cannot continue to rely on "later determinations," "future treatments," or other vague options for storage and/or disposal. DOE has failed to approve long-term storage and disposal sites for other materials/wastes thus the State could expect the same lengthy time period for decision making on UF_6. Placing any of the UF_6 materials for long-term storage or disposal in shallow earthen structures, below ground vaults, and/or underground mines should not be an alternative consideration.

Response 9

The PEIS considers several options for long-term storage, including yards, buildings, below-ground vaults, and underground mines; shallow-earthen structures ("trenches") are considered only as a disposal option. The technical suitability of these options is addressed in two reports. The first report is the "Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1995), available through the National Technical Information Service (NTIS) by calling 1-800-553-NTIS (6847) or (703) 605-6000. The second report is the "Depleted Uranium Hexafluoride Management Program; Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS), which is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), or by contacting the DOE program manager identified on the cover sheet of the PEIS. As required by NEPA, the PEIS has considered all reasonable alternatives for long-term management and use of DOE's depleted UF_6 inventory. The selected alternative will be announced in the Record of Decision. The results from the PEIS, costs of alternatives and other factors will be

considered in the selection process, which will be documented in the ROD. DOE is committed to implementing the selected management strategy as early as practicable. The State's opposition to long-term storage or disposal in shallow earthen structures, below ground vaults, and/or underground mines is noted.

Comment 10

The PEIS must give a clear definition for "heel" and list the word in the definition section.

Response 10

The term "heels" was included and defined in the glossary of the PEIS (Chapter 9).

Comment 11

Page S-6. Section S.2, Description of Action: This section describes an alternative for "long-term" management. DOE has defined long-term in previous NEPA documents as storage for up to 50 years. This document does not identify any time frame in its definitions. The continued storage of these cylinders under the No Action alternative has already reached the long-term storage definition.

Response 11

The time frame considered in the PEIS is defined and discussed in Section S.1.3 and Section S.2 of the summary, as well as in Chapter 1 (Section 1.3), Chapter 2 (Sections 2.1 and 2.2), and Chapter 4 (Section 4.2). As discussed in these sections, the PEIS considers an approximately 40-year time frame, 1999 through 2039, for the evaluation of all alternatives. (Generally 10 years for siting, design, and construction of any required new facilities; about 26 years for operations; and, when appropriate, about 4 years for monitoring.) These timeframe estimates were meant to provide a consistent analytical timeframe for the evaluation of PEIS alternatives and do not represent a definitive schedule. Although some previous NEPA documents may have defined "long-term storage" as storage for up to 50 years, there is no standard definition of this term.

Comment 12

Page S-13. Section S.3.3 K-25 Site on the Oak Ridge Reservation: "Which consists of three major facilities. . . ." The K-25 site contains more than three storage yards.

Response 12

The reference to three major facilities was intended to be for the Oak Ridge Reservation facilities of the K-25 site, the Y-12 site, and the Oak Ridge National Laboratory. The referenced text in Section S.3.3 has been modified to clarify this point. In the same Section (Section S.3.3) the PEIS does state that the K-25 site contains three storage yards for DOE-managed depleted UF_6 cylinders. Although there are more than three storage yards at the K-25 site, the other storage yards contain cylinders that are not included in the depleted UF_6 cylinder inventory addressed in the PEIS (for example, cylinders containing natural uranium or enriched uranium).

Comment 13

Page S-32, Section S.4.1: "... exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations." The K-25 facility is no longer in normal operation status, and yet poses a significant gamma exposure risk to members of the public and to "reindustrialization workers." The Division has recorded the annual radiation dose (by method of thermoluminescent dosimetry monitoring) at the fences of K-1066-K Yard to be 1240 mrem, E yard to be 950 mrem, and J Yard to be 260 mrem. Members of the public have access to the fence line at the K-1066-K area. The Division questions the methods DOE used for the estimated radiation exposures of "workers and members of the public."

Response 13

For the continued storage options (Appendix D), radiation exposures of involved workers in the cylinder storage yard were estimated by using the MicroShield computer code, information on the radioisotopes in the cylinders, and the projected worker activities in the yards throughout the period of cylinder management addressed in the PEIS. The dose rates estimated by MicroShield at the cylinder surface and at a distance of 1 m away from a cylinder were in good agreement with the actual measurement data. After the dose rate was estimated, it was multiplied by the predicted activity duration, number of workers involved, and number of performances required each year to get the total annual dose for that activity. The total annual doses from all the activities were added to give the total annual exposure for workers. The total annual exposure was then divided by the total number of workers predicted to get the average annual dose for individual workers. The average individual dose for workers was estimated to be 410 mrem per year for the K-25 site for the continued storage alternative. This can be compared to the measured dose of current workers in the K-25 cylinder yards which ranges from 32 to 92 mrem/yr (given in Table 3.13 of the PEIS).

The worker dose estimates stated above were obtained assuming that each individual worker would spend 5 hours per day, 228 days per year in the cylinder yard. The doses cited in the comment appear to have been estimated using an assumption that the receptor would stand at the fence line of the cylinder yards for 24 hours per day, 365 days per year. Such an exposure situation could not occur at this time, because the fence line of the cylinder yard could not be an area used as a residential location.

Direct gamma radiation from the depleted UF_6 cylinders was not considered for the off-site public because the radiation would be negligible at the locations where the public resides. This assumption was consistent with the current distribution of the off-site public around the K-25 site. To receive an external dose equal to the allowable limit for a member of the general public (100 mrem/yr), an individual would have to stay at the fence line for an extended period of time (about 700 hrs per year). Considering the remote location of the cylinder yards on the Oak Ridge Reservation at the K-25 site, and that residential use of Oak Ridge Reservation property is not allowed, it is very unlikely that anyone would remain at the fence line of any of the cylinder yards

for that period of time annually. DOE believes that based on the discussion given, the analyses performed are appropriate for the PEIS.

Comment 14

Page S-38, Section S.4.5, Water and Soil: ". . . (based on the U. S. Environmental Protection Agency (EPA) proposed maximum contaminant level (MCL) of 20 micrograms/L for drinking water, and on the EPA health-based guideline of 230 micrograms/g for residential soil)." This is not the spirit or the letter of environmental and nuclear regulatory acts and the laws that codify these regulations. The spirit or the letter of environmental and nuclear regulatory limits and the laws is to minimize contaminant migration at its earliest and most effective point.

Response 14

The proposed maximum contaminant level (MCL) for uranium (20 µg/L for drinking water at the tap) and the soil guideline were used in the evaluation as guidelines to estimate the potential for adverse environmental effects of the various alternatives to groundwater, surface water, and soil. Use of these guidelines in this context, provides a more conservative estimate of the impacts than would actually occur in practice. For example, since the MCL is applicable to drinking water at the tap, its application to groundwater at the boundary of a release site is fairly stringent. Similarly, the soil guideline was derived on the basis of residential land use assumptions; whereas the hypothetical locations at which it was used for comparison were generally industrial. Nonetheless, the use of these levels as guidelines in the PEIS in no way is intended to indicate an acceptance of contamination to these levels. The DOE is committed to its "As Low As Reasonably Achievable" (ALARA) policy for both emissions and environmental contamination levels, which means the best available technology is used to limit levels to as low as reasonably achievable BELOW standards and guidelines. The cylinder project management plan (LMES 1997d; the full citation is provided in Appendix D of the PEIS) described in the introduction to Appendix D is an example. The plan is designed to provide sufficient inspection and maintenance of the cylinder inventory such that no releases would occur during continued storage. However, for purposes of analysis in the PEIS, cylinder breaches and releases were assumed to occur, and resulting contamination levels in water and soil were estimated and compared with the guideline levels stated above. This analysis was conducted only to provide a basis for comparison of the potential environmental impacts of the various alternatives. Because of the provisions of the cylinder project management plan, DOE considers that safety of stored UF_6 cylinders can be effectively maintained and that storage is a viable option for the depleted UF_6 management program.

Comment 15

Page S-42, Section S.5. DOE's Preferred Alternative: The State supports DOE's Preferred Alternative of simultaneously implementing both use as uranium oxide and use as uranium metal as described in this section. Disposal as Oxide should be retained as an option as these uses progress, since it may be necessary to pursue the disposal options for some of the material.

Response 15

The State's preference for implementing both use as uranium oxide and metal while retaining a disposal option is noted.

Comment 16

Pages 2-54 and 2-55, Section 2.5, DOE's Preferred Alternative: "... (1) continuing the safe, effective management of the cylinders and (2) beginning conversion of the depleted UF_6 into depleted uranium oxide and/or metal products as uses for these products become available."

This document should address the safety concerns raised by the National Defense Facilities Nuclear Safety Board (DNFSB) in 1995 on the integrity of Uranium Hexafluoride Cylinders.

In its conclusions, DNFSB noted in 1995 "DOE has stored depleted UF_6 in transportation cylinders for more than 40 years and may continue to store them for an additional 30 years. The analysis of the adequacy of the existing cylinders for use as storage systems over this extended time period has not been systematic and has not addressed all the pertinent concerns.
Specifically, the following areas need further assessment:
1. the potential for failure by accelerated corrosion mechanisms needs to be better characterized and then quantified;
2. the inspection program, used to characterize the condition of the cylinder population and monitor continued adequacy for storage, needs significant overhaul to achieve these purposes;
3. cylinder handling procedures need to be analyzed and then revised to incorporate precautions for handling degraded cylinders; and
4. the safety analysis for the cylinder storage yards need to he upgraded to: include insights gained through the above reviews; investigate the unique problems presented by a breach in the vapor space; investigate the hazards associated with moving degraded cylinders; and incorporate structural analyses of the cylinders.

The PEIS does not include the DNFSB report in its Reference Section. In the absence of effective management reactions to these recommendations, storage of the cylinders in their present location and present condition may not be continued safely. Continued safety is questionable as the probability of loss of container integrity and external corrosion increase with time.

Response 16

The DNFSB recommendation 95-1 of May 1995 was listed in the reference section of the Draft PEIS, but on review of the text it is agreed that further details on the recommendation and its relationship to this PEIS would be informative. A summary of the DNFSB report and DOE's actions in response to the DNFSB recommendations has been added to the PEIS (see new Section 1.7).

The UF_6 cylinder project management plan (LMES l997i; the full citation is provided in Chapter 8 of the PEIS) was developed to address the concerns of the DNFSB through elimination of substandard cylinder storage conditions and through control of further corrosion through a

cylinder recoating program. The management plan addresses all phases of the current UF_6 cylinder management project and is based on risk analysis and technical evaluations which determine the activities to be performed. Under this management plan, all cylinders must be stored out of ground-contact. Any cylinders discovered through periodic inspections to be in ground contact are relocated. Additionally, there are relocation plans to place all cylinders in a configuration which improves the ability of inspectors to make visual inspections from each end of the stacked cylinders. These plans are being implemented in a graded approach by relocating cylinders in the poorest storage conditions first. This plan is being implemented concurrently with extensive construction and recoating projects which will provide well-drained storage yards for the cylinders and also provide protection for the exterior of the cylinders by recoating.

The sites have also implemented an extensive cylinder inspection program to allow identification of any damaged or breached cylinders. This inspection program also identifies those cylinders requiring maintenance activities such as valve replacement and nameplate replacement. Annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of pitting or heavy corrosion. All other cylinders must be inspected once every four years. Most of this work has already been completed at the three sites or is planned for completion by the year 2002.

The DOE is committed to maintaining adequate safety of the depleted UF_6 cylinder inventory through use of the UF_6 cylinder project management plan. The plan is discussed and referenced in the Introduction to Appendix D of the PEIS. The plan was used in the PEIS as the basis for assumptions to estimate possible adverse environmental impacts of continued storage of UF_6. For example, the cylinder painting and relocation schedules from the plan were used to estimate worker radiological doses, and also to estimate future cylinder breach rates.

Comment 17

Also continued long-term storage of the cylinders is in conflict with the accelerated clean-up program of DOE. The availability of skilled and trained workers for the extraction and treatment of UF_6, ten or twenty years beyond 2006 will be more expensive. If the present conditions of storage persist, a greater population of the containers will be structurally unsound and the risk of release by rupture will be compounded.

Response 17

Continued storage of depleted UF_6 cylinders is not considered to be in conflict with DOE's accelerated clean-up program. The accelerated clean-up program is concerned with the clean-up of waste material (primarily contaminated media such as soil and groundwater) from historical DOE activities. Depleted UF_6 is outside the scope of the clean-up program because it is not considered nor managed as a waste material. Issues related to the costs associated with the management of UF_6 cylinders for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available to the public

through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

In regard to the future condition of cylinders, DOE is committed to continuing the safe management of its depleted UF_6 cylinder inventory for as long as necessary. Current practices for managing the cylinders include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, surveillance and maintenance of the cylinders and cylinder yards, and the coating of a portion of the inventory to prevent continued corrosion. These practices will continue or be modified, as necessary, to meet any changing requirements or to incorporate improved practices or technologies that become available for protection of worker and public health and safety and the environment.

Comment 18

Page 3-42, Section 3.3. 1. Cylinder Yards: "The four breached cylinders have been patched to restore their integrity, segregated from other cylinders in K- and E-yards, and placed under temporary awnings. No estimates of material loss are available for these cylinders. "

Appendix B-2: Breached cylinders and material loss — conflicts with the statement above. The following information has been obtained from the "Investigation of Breached Depleted UF_6 Cylinders at the K-25 Site " dated 10-94:

Cylinder Number	Hole Diameter	Total Weight of Material Collected External to the Cylinder	Uranium Content of Material
101244	6 inch	Not Available	0.160
114951	8 - 12 inch width by 15-17 inch length	11.8 kg	1.8 kg
7953	9 inch	9.8 kg	2.2 kg
116797	2 inch	-----	-----

Breach of the Cylinder 116797 is presumed to be mechanically induced cylinder breach and the reason for the absence of Uranium containing deposits. Estimated amount of UF_6 lost is 0-4 pounds for cylinder 116797 versus 17 pounds to greater than 109 pounds of estimated loss for Cylinder 114951.

Response 18

The report the commentor is referring to (Barber, E.J. et al, 1994; the full citation is provided in Appendix B of the PEIS) gave the additional information: " . . . without measurements of the present cylinder weights, the extent of uranium loss from the four breached cylinders at the K-25 Site cannot be determined at this time. In the case of cylinders 114951 and 116797, rough

estimates of uranium lost to the environment can be derived from the calculated losses for the PORTS breached cylinders . . ."

The referenced report also stated ". . . these values for the two K-25 breaches in K-1066-E yard are provided only as a comparison to the PORTS experience and not as calculated values for the material loss estimates."

The text in Section 3.3.1 has been revised to indicate that because the present cylinder weights are not available at this time, the extent of uranium loss from the four breached cylinders was not determined. The estimates given in the report referenced by the commentor are highly uncertain, and therefore are not be included in the PEIS text. For PEIS analyses of the impacts from material loss from breached cylinders, the data on loss from a breached cylinder at the Portsmouth site that had been in storage 4 years prior to breach detection were considered representative of the material loss that might occur during the time period assessed in the PEIS (i.e., 1999 through 2039). See Appendix B, Section B.3 for further details.

Comment 19

Page 3-46, Chapter 3, Section 3.3.5.1, Surface Water: Monthly sampling plan does not include a means to identify, contamination of the storage yards and run-off from the UF_6 material, The timing of the sampling with that objective should be immediately after a precipitation event, since Uranyl fluoride is extremely soluble in water. Thus the discussion of the results of the monthly sampling and analyses is not relevant to the storage of UF_6 cylinders.

Response 19

The surface water and sediment data provided in Section 3.3.5.1 were intended to provide a general picture of the affected environment for the whole K-25 site, and not just for the cylinder storage yards. The sampling conducted at the K-25 site meets all state and federal permit requirements.

Comment 20

Pages 4-2 through 4-5, Section 4.2. Major Assessment Assumptions and Parameters. The reports from the Oak Ridge and Paducah assessment teams on the UF_6 Cylinders, 1992 and 1994 respectively, have noted many deficiencies with regard to cylinder integrity and thinning of walls due to internal and external corrosion. Corrosion has occurred to the extent that special training is required for personnel engaged in the monitoring of the cylinders. Also, the safety analysis performed on the cylinders is incomplete and does not include effects due to high winds, tornadoes, earth movements, and etc. Some of the cylinders have been reported to have thinning of the walls in the middle. Handling of such cylinders may be cause for concern. Under these circumstances, the No Action alternative will be a potentially hazardous alternative.

Response 20

The mission of the UF_6 cylinder project is to safely store the DOE-owned UF_6 inventory until its ultimate disposition. The major objectives identified are:

1. Achieve and maintain acceptable risks
2. Achieve and maintain cylinder integrity
3. Improve conduct of operations
4. Evaluate and monitor containment integrity
5. Administer the system

Cylinder conditions, such as thinning walls, have been baselined and cylinder personnel have been trained in the safe handling of cylinders. Steps are being taken to arrest the external corrosion rate with the recoating of cylinder bodies. The condition of the cylinders was considered in the PEIS hazard modeling through the analysis of accident events in which corroded cylinders would be breached during handling (see Section D.2.2 of Appendix D).

The Site's Safety Analysis Reports (SARs) were revised in 1997 and include natural phenomena threats (earthquakes, floods, and wind) as well as external man-made threats such as aircraft crashes, highway accidents, barge traffic accidents, natural gas pipeline ruptures, and toxin and asphyxiant releases (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes and tornadoes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake scenarios which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point.

The analyses in the SARs and the PEIS indicate that continued cylinder storage at the three current storage sites is safe. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 21

In addition, the stated assessment period of forty years is in conflict with DOE's accelerated clean-up plan for K-25. While the cylinder storage yards have not been identified as hazardous waste sites, the fact that breached cylinders exist and have the potential to leak out toxic substances is of major concern to the State of Tennessee. While the release so far may not meet the reportable quantity requirements, DOE has a responsibility for any environmental impact due to the breaches. Also, there is the possibility that future leaks will be of a greater magnitude. In spite of known breached cylinders, DOE has not undertaken any action to determine the degree of contamination to the soil and to the water stemming from the breaches.

1822

Response 21

DOE and its operating contractor take full responsibility for the cylinders and their contents. Many activities of the cylinder project are funded to prevent future breached cylinders, to determine which cylinders might breached and when, and to discover breached cylinders before they have lost any appreciable quantity of material to the environment.

This program is aware of other DOE cleanup efforts at the three storage sites and plans to coordinate actions with other activities even though the objectives and time periods may differ.

Water samples are taken monthly at each storage site from the sampling locations listed on the NPDES water permits. When cylinder breaches were identified soil samples were obtained from areas impacted by the breaches; soil with elevated contaminant levels was excavated and disposed of.

Comment 22

Page 5-69, Section 5.5.1.1.2, General Public: ". . . the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million." The risk of dying from a radiation-induced latent cancer associated with a total dose of 1 mrem is closer to 1 in 30,000. Please provide a citation or reasoning to support a 1 in 1 million radiation-induced latent cancer risk.

Response 22

As described in Section 4.3.1.1 of the PEIS, the risk of developing a fatal latent cancer following radiation exposure is calculated by multiplying the radiation dose by an appropriate health risk conversion factor. The health risk conversion factors used in the PEIS to relate radiation dose to potential latent cancer fatalities were those recommended by the International Commission on Radiological Protection ("1990 Recommendations of the International Commission on Radiological Protection," ICRP Publication 60), as described in Section 4.3.1.1 and Appendix C. The conversion factors are 0.0004 latent cancer fatalities per person-rem for workers, and 0.0005 latent cancer fatalities per person-rem for members of the public. For a total dose of 1 mrem to a member of the public, the risk of a latent cancer fatality is calculated as 1 mrem x 0.001 rem/mrem × 0.0005 latent cancer fatalities/rem = 0.0000005. This risk is equivalent to a 1 in 2 million chance, which is less than 1 in 1 million, as stated in the PEIS.

Comment 23

Page 5-72, Section 5.5.1.2.2, Accidents Involving Releases of Radiation or Chemicals. "All doses would be considerably below the 25 rem maximum allowable dose specified in NRC regulations (10 CFR Part 76)." The regulation with which 10 CFR 76 refers is 10 CFR 20, which is the regulation with the widest applicability "Standards for Protection Against Radiation." The 10 CFR 20 applies to all activities licensed by the NRC which encompasses all commercial uses of radioactive material. Part 20 provides extensive details on "subsets" of exposure such as hourly exposure and exposure of minors. For comparative purposes, Part 20 ties whole body dose to 5 rem

for personnel in restricted areas and 0.5 rem for personnel in unrestricted areas. The term "unrestricted area" is usually interpreted to extend to the site boundary, but not beyond to the "environment." This interpretation keeps 10 CFR 20 from conflicting with 40 CFR 190. It also assumes that the licensee has at least some minimal control over the personnel exposed.

The 40 CFR 190 regulates doses received by members of the general public in the "general environment" resulting from the nuclear fuel cycle. This is a different scope than 10 CFR 20 since 40 CFR 190 includes all processes and facilities in the nuclear fuel cycle (excluded is any dose due to occupational exposure as part of the nuclear fuel cycle). The "general environment" means the environment outside the boundary of the facility covered by the regulation. This keeps 40 CFR 190 from conflicting with 10 CFR 20. The whole body exposure limit specified by 40 CFR 190 is 25 mrem. The 25 rem "maximum allowable dose" is not really a "maximum allowable dose" at all, but rather, the dose at which notification to the NRC must be made. Section 20.403 states that "Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause: (1) Exposure of the whole body of any individual to 25 rems or more . . ."

Response 23

The Part 76 NRC regulation cited in the PEIS is relevant because this regulation is used for the certification of gaseous diffusion plants, and is the basis for the certification of both the Paducah and Portsmouth plants. The 25 rem dose given in 10 CFR Part 76 is specified as a benchmark for assessing the adequacy of protecting public health and safety from potential accidents (the radiation level at the facility boundaries caused by hypothetical accidents within the facility are compared to the 25 rem level). The text of Section 5.5.1.2.2 has been modified to indicate that all doses would be considerably below the 25 rem dose specified for assessing the adequacy of protecting public health and safety from potential accidents in NRC regulations (10 CFR Part 76).

Comment 24

Page 5-76, Section 5.5.7, Waste Management: Generation of "1 cubic meter/yr- of LLMW" seriously underestimates the "heels" component of the UF_6 cylinders containing a high energy (gamma emitting) RCRA mixed waste. The Division estimates there to be 120 million pounds of this material in cylinders stored on the Oak Ridge Reservation.

Response 24

The generation rate of 1 m^3/yr LLMW in the referenced text pertains only to LLMW waste generation from the metal conversion facility operations, and does not include waste generation from the cylinder treatment facility, which would treat the "heels" component of cylinders emptied for conversion. The cylinder treatment facility would generate about 0.2 m^3/yr of LLMW. A summary of the LLMW and other waste generation from a cylinder treatment facility is included in Section F.3.7.4 of the PEIS; text has been added to Sections 2.4.8, 5.3.7, and 5.5.7 to summarize potential waste management impacts from such a facility, including the "heels" component of the

UF_6 cylinders. Based on information provided in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) it was assumed that each cylinder would contain a maximum of 50 lbs of residual depleted UF_6 after being emptied. Other details on the design and operation of a cylinder treatment facility are provided in the engineering analysis report. The empty cylinders would be washed with an aqueous solution to remove the heels. The UF_6 from the heels would be converted to U_3O_8 which would be sent either for disposal as LLW or storage. Wastewater generation from a cylinder treatment facility is discussed in Section F.3.4.1 of the PEIS.

The statements made in the comment with regards to the "heels" material being a RCRA mixed waste and weighing 120 million pounds at ORR are both incorrect. The "heels" component of the cylinders is not a RCRA mixed waste. If all the K-25 cylinders were emptied at K-25, the total quantity of heels (assuming 50 pounds per cylinder) would be about 230,000 pounds. The amount of U_3O_8 generated at the cylinder treatment facility from the treatment of all of the depleted UF_6 cylinders currently at K-25 would be about 190,000 pounds. It is likely that the cylinder treatment facility would be colocated with the conversion facility. (Please see response to comment 6 above from commentor 87 for more discussion of "heels.")

Comment 25
Page 5-108, Paragraph 3, Section 5.8.2.1, Paducah Site
Page 5-110, Paragraph 3, Section 5.9.2.2, Portsmouth Site
Page 5-112, Paragraph 3, Section 5.8.2.1, Oak Ridge Reservation K-25 Site
Page 5-115, First bullet, Section 5.9, Mitigation

The Clean Air Act contains a Particulate Matter 2.5 (PM2.5) standard.

Response 25

The setting of air quality standards is a process that, although required by the Clean Air Act, is literally done separately from the Act. The new standards for PM2.5 were announced on July 17, 1997. In the fact sheet accompanying the announcement, distinction is drawn between "coarse" fraction particles (from 2.5 to 10 micrometers in diameter, for which the PM10 standards still apply) and "fine" particles (those smaller than 2.5 micrometers in diameter, which are the concern of the new standards). Coarse particles are said in the fact sheet to "come from sources such as windblown dust from the desert or agricultural fields and dust kicked up on unpaved roads by vehicle traffic," while fine particles "are generally emitted from activities such as industrial and residential combustion and from vehicle exhaust." The major particulate emissions anticipated for the depleted UF_6 options would come during construction and would be mainly coarse particles (dust) associated with earth moving operations. Particulate emissions anticipated from combustion sources during any phase of the options would be of substantially smaller magnitude. The PM10 analyses currently included in the PEIS are believed to assess the worst case for particulate concentrations for the various options, and are adequate for NEPA analysis. Text has been added to Section C.1 of the PEIS relative to the PM2.5 standard and appropriateness of analyses conducted for the PEIS.

Comment 26

Page 5-108, Paragraph 4, Section 5.8.2.1, Paducah Site: "Cylinder breaches occurring at Paducah before the year 2020 could result in groundwater concentrations of uranium exceeding 20 µg/L" is not provided for under the Clean Water Act.
Page 5-110, paragraph 4, Section S.5.8.2.2, Portsmouth Site
Page 5-112, Paragraph 5, Section 5.8.2.3, Oak Ridge Reservation K-25 Site
"Uncontrolled corrosion until about 2025 before groundwater concentrations of uranium would approach 20 µg/L" is not provided for under the Clean Water Act or SDWA.

Response 26

The proposed maximum contaminant level (MCL) for uranium (20 µg/L for drinking water at the tap) was used as an evaluation guideline to estimate the potential for adverse environmental effects of the various alternatives to groundwater and surface water. This analysis was conducted only to provide a basis for comparison of the potential environmental impacts of the various alternatives. The text of the three Sections listed in the comment has been revised to indicate that the 20 µg/L level was used as an evaluation guideline, and is not applicable as a standard.

Comment 27

Page 5-115, Third bullet, Section 5.9, Mitigation: "Future impacts on groundwater from failure of a disposal facility could be minimized by selection of a site in a dry environmental setting" should be highlighted and recognized as a major siting factor. The same argument could be made for the storage of "awaiting conversion" cylinders, that are currently deteriorating and corroding.

Response 27

Comment noted. Such factors would be addressed in future studies and analyses if disposal were selected as the management strategy in the Record of Decision for the PEIS.

With respect to cylinders currently in storage, previous substandard conditions such as ground contact and poor drainage in cylinder storage yards have been identified as the cause of external cylinder corrosion. The UF_6 cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS) was developed to eliminate these substandard conditions. (The plan is discussed and referenced as LMES 1997d in the Introduction to Appendix D of the PEIS.) Under this management plan, all cylinders must be stored out of ground-contact with enough space to allow for periodic complete inspections. These requirements have necessitated some yard reconstruction and cylinder relocations; most of this work has already been completed at the three sites. The DOE is confident that the activities required under the cylinder project management plan will maintain adequate safety of the depleted UF_6 cylinder inventory. If the long term storage as UF_6 alternative is chosen in the Record of Decision for the PEIS, future planning and analysis documents would consider a wet versus dry environment as one of the factors in selecting the storage site.

Comment 28

Page 6-1, Section 6, Environmental, Occupational Safety, and Health Permits And Compliance Requirements: The Clean Water Act/SDWA should also be included as a "potential requirement."

Response 28

The text in Section 6, paragraph 2, states that under Executive Order 12088, federal agencies (including DOE) must comply with applicable administrative and procedural pollution control standards of the Clean Water Act and Safe Drinking Water Act (among others). The next paragraph lists potential requirements "in addition to those in Executive Order 12088." Therefore, the text already states that the Clean Water Act/SDWA must be complied with.

Comment 29

The Division of Radiological Health has the following comments: The discussion of the statistical nature of the hazards posed by radiation exposure was a good addition to this report.

Response 29

The comment is noted by DOE.

Comment 30

Chapter 5 of the PEIS discusses the environmental impacts of the various alternatives. As support for the discussion several graphs are included. On page 5-20 a single graph compares the long term cancer risk (radiation risk) if the material is maintained as UF_6. Pages 5-37 and 5-39 compare the long term cancer risk (radiation risk) for conversion to an oxide and the probability of injury (nonradiation risk) if the material is converted to an oxide. While the report states that the chemical hazards of the material in its UF_6 form are greater than if it is converted to an oxide the omission of a graph showing the probability of injury if the material is maintained as UF_6, leads to an unbalanced representation of the hazards of these two options for the disposition of the material. Also, the combination of all non-radiation hazards as "risk of injury" is a misleading representation.

Response 30

The PEIS presents results in a graphical format in cases in which it was determined that the graphs provide information that supplements that presented in the text. In some cases, such as the number of estimated injuries from on-the-job accidents for long-term storage of UF_6, it was determined that a graphic did not supplement the material presented in the text. The PEIS does not combine all non-radiation hazards as "risk of injury" as implied by the commentor. The graph on page 5-39 referred to by the commentor is titled "Total Estimated Number of On-the-Job Injuries" and is presented in the section on physical hazards (on-the-job injuries and fatalities from physical accidents). As described in the accompanying text, this graph presents the estimated number of injuries from physical causes and does not present either risk or probability of injury.

Comment 31

References to the usefulness of the depleted uranium in either its oxide or metallic forms are unsupported. The document states that changing circumstances have made the specific uses mentioned unlikely for the future and yet no other possible uses are adequately addressed. (PEIS 2-20) This makes the position that this material is a resource as opposed to a waste tentative at best. If there are realistic scenarios for the future use of this material, they should be presented in the PEIS. If there are no realistic future uses, then the material should be treated and disposed of as waste.

Response 31

The section referenced in the comment (PEIS 2-20) presents a discussion of uses that were not considered in detail in the PEIS for various reasons. Other uses, such as use as radiation shielding, that are feasible and realistic are discussed in Section 2.2.4, Section 2.2.5, and Appendix H of the PEIS. Depleted UF_6 is not considered a waste material because it contains usable quantities of uranium that under current regulations is considered a source material. The DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products. The State of Tennessee's suggestion that the material should be disposed of if no realistic future uses are identified is noted.

Comment 32

Recommendation number 15 of the Draft Preliminary Report — DOE Independent UF_6 Cylinder Assessment Team dated March 25, 1992, states "All cylinders in or near ground contact should be removed from those conditions, . . . and ultrasonic wall thickness examinations be performed of all cylinders with significant corrosion to determine the amount of residual thickness remaining." At the time of the PEIS, it is mentioned that ultrasonic testing is now part of the cylinder maintenance. (PEIS 2-56) It is also stated. however, that "Because the ultrasonic tests are time consuming and costly only a small portion of the entire inventory has been measured." (PEIS B-2) This is a problem for two reasons. First, it does not begin to meet the minimum of testing all cylinders with significant corrosion. Second, this brings doubt to statements such as "the cylinder breaches were assumed to go undetected for [at most] 4 years (the inspection interval for most cylinders)." (PEIS 2-5) The inspection for most of the cylinders consists only of a visual inspection. The visual inspection method, as described, does not appear to be adequate since many of the cylinders can not be seen on all sides and cylinders that are leaking may not be detected visually since the color of the paint matches the color of the leaking material exposed to air.

Response 32

The inspection program has been upgraded since the 1992 report with improved procedures and training of personnel. Additionally, the relocation program has removed all cylinders in ground contact and storage conditions are being improved at all storage sites. All cylinders have received a baseline inspection, with those cylinders experiencing accelerated corrosion being inspected on an annual basis. These older cylinders have very little paint left on

the cylinder body and any reaction products would stand out in contract to the rust color on the cylinders.

From the Ultrasonic data, which continues to be collected, a corrosion model of the cylinder yards has been developed. This model predicts the cylinder population that has lost the greatest wall thickness. This population, once identified, becomes the first candidates for recoating to arrest the corrosion and maintain the wall thickness.

Comment 33

The PEIS states on page 4-3 that "While in storage at the three current storage sites, cylinders were assumed to be inspected and maintained in safe storage consistent with current management practices and plans." Based on the number of breaches detected, the rusting of the cylinders, the improper storage conditions and the documented lack of adequate surveillance of these cylinders, the assumption that material is in safe storage is only true when qualified by the phrase "consistent with current management practices and plans." Essentially DOE is defining their practices and procedures as safe. This allows them to say that a process is safe simply because it meets the standards of the procedure, not because an unbiased safety analysis has been performed.

Response 33

In May of 1995, the DNFSB issued to DOE a recommendation (Recommendation 95-1) regarding the storage of the depleted UF_6 cylinders. This recommendation was as follows:

1. Start an early program to review the protective coating of cylinders containing the tails from the historical production of enriched uranium.
2. Explore the possibility of additional measures to protect these cylinders from the damaging effects of exposure to the elements, as well as any additional handling that may be called for.
3. Institute a study to determine whether a more suitable chemical form should be selected for long-term storage of the depleted uranium.

In June of 1995, DOE accepted Recommendation 95-1 and emphasized five focus areas for DOE response:
1. Removing cylinders from ground contact and keeping cylinders from further ground contact;
2. Relocating all cylinders into adequate inspection configuration;
3. Repainting cylinders as needed to avoid excessive corrosion;
4. Updating handling and inspection procedures and site-specific Safety Analysis Reports; and
5. Completing an ongoing study that will include an analysis of alternative chemical forms for the material

In October of 1995, DOE submitted an Implementation Plan that incorporated completed and near-term actions in accordance with these five focus areas. This plan also committed to managing the cylinders using a systems engineering approach. Through this approach and open dialogue among the DNFSB staff, the following objectives segment the safe storage mission of the

program in response to the current condition of the system and the projected life cycle schedule for completing the last phase of the system (Decontamination and Decommissioning).

1. *Achieve and maintain acceptable risks*
2. *Achieve and maintain cylinder integrity*
3. *Improve conduct of operations*
4. *Evaluate and monitor containment integrity, and*
5. *Administer the system*

The DNFSB reviews DOE's progress on these items regularly. Additionally, the Board visits the storage sites on a regular basis and has a resident member in Oak Ridge. Therefore, DOE's cylinder management program has been independently evaluated and responses to these evaluations have been undertaken. Accordingly, the safe long-term storage of depleted UF_6 cylinders is a viable option to be considered in the PEIS analysis of management alternatives.

Comment 34

Appendix G of the PEIS, table G-6 compares accident consequences associated with the long term, storage of the material in different chemical forms. Why are the accidents considered differently for the different forms. For example, an earthquake or a tornado are considered under unlikely accidents for the uranium oxide but neither scenario is considered for the UF_6. A comparison of this type would seem to be most useful if it compares the same types of accidents. Another difference is that "unlikely" accidents, for UF_6, are described as having a possible frequency of "1 in 10,000 to 1 in 1 million years," while under the uranium oxide option the "unlikely accident" is described as having a frequency of "1 in 100 years to 1 in 10,000 years." It is not clear why an "unlikely accidents" would have a different probability associated with it for a different chemical composition?

Response 34

Appendix G of the PEIS describes long-term storage of depleted uranium in three forms: as UF_6, UO_2, and U_3O_8. The difference in the accident scenarios and the frequency of these accidents between the three uranium chemical forms is due to differences in the container holding the material (UF_6 is stored in 14-ton cylinders, while UO_2 and U_3O_8 are stored in 30-gallon and 55-gallon drums, respectively), the response of the uranium physical form to the accident (U_3O_8 is a powder that is relatively unaffected by fire, while solid UF_6 becomes a gas at higher temperatures that reacts with water to form HF and UO_2F_2), and type of storage facility (UF_6 can be stored on outdoor concrete pads while UO_2 and U_3O_8 are stored in buildings). Each of these differences result in accident scenarios being relatively more important for one chemical form than another. (As an example, a mishandling and drop of a UF_6 cylinder would not lead to any appreciable releases, because UF_6 is a monolithic solid, while a mishandling and drop of a U_3O_8 drum could result in drum failure and entrainment of the particulate U_3O_8 by atmospheric air. The consequences of this postulated accident scenario would be greater for U_3O_8 compared to UF_6.)

The description of the frequency range for "Unlikely Accidents" in Table G.6 has been corrected to indicate that an Unlikely Accident will have a frequency of between 1 in 100 years to 1 in 10,000 years.

Comment 35

There are a number of questions about the characterization of the hazards from earthquakes at the Paducah, KY location. These questions are outlined in an attached memo from a State geologist.

Regarding the information you provided on the above referenced document, please refer to the attached information from the Center for Earthquake Research and Information (CERI), at Memphis University.

The Draft PEIS seems to not only down-play past seismic events but gives very little information on future potential events. By all accounts, the Paducah area is located in a high-risk area for major damage from earthquakes (see attached seismic risk map). In comparison, the Oak Ridge, area is located in a moderate-risk area and experiences fewer and less severe earthquakes. The information presented by this document might be more accurate for the East Tennessee area but seems to be an understatement for the Paducah plant area.

Response 35

Specific questions from the State of Tennessee about the characterization of earthquake hazards at the Paducah site are addressed in individual responses to specific comments (i.e., see responses 34 and 36 to Commentor No. 87. The safety of current storage of depleted UF_6 cylinders was addressed in the safety analysis reports (SARs) for each of the three storage sites that the Department issued in February 1997 (LMES 1197f-h). The PEIS reference list (Chapter 8 of the PEIS) provides the full citations for these references.

The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes and tornadoes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include the earthquake scenarios which were found in the SAR analyses to have lessor consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the safety analysis reports are revised in the future, DOE will modify its cylinder mangement program to ensure that the safety of the cylinders is maintained.

Comment 36

The article on earthquake intensity gives a good explanation for how we can determine the extent of damage a seismic event can cause to manmade and natural objects in a particular place.

The Modified Mercalli Scale describes intensities in physical terms that can be related by personal or observable results, thus more subjective. By contrast, the Richter Scale is a specific measurement of magnitude or energy released during an earthquake and is determined at the time of the event. While every earthquake can have many intensities, depending on distance from the epicenter, it can only have one measurement of magnitude. While magnitude measurement provide useful data for scientific research, including accurate comparison of earthquakes, they give no specific information about the damage or other effects caused by an earthquake.

For specific information an the probability or frequency of significant seismic events, please refer to the CERI attachment.

Response 36

The discussion on seismic events for all three sites for continued storage has been modified to include references to Safety Analysis Reports in which much more detailed information on seismic risk can be found. (See Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1 of the PEIS.)

Commentor No. 88: Thornton, Tara
Military Toxics Project

Comment 1

The Military Toxics Project adamantly opposes any use of the depleted uranium for military purposes such as in weaponry and munitions. First used in the Persian Gulf War in 1991, U.S. and British forces used depleted uranium as both armor piercing bullets and as tank armor. When uranium weapons burn, when they corrode and when they are machined, uranium oxide dust is created. The U.S. Department of Defense estimates approximately 315 tons (630,000 pounds) of depleted uranium were fired in the Gulf. This firing resulted in the release of large amounts of DU dust which contaminated thousands of tanks, vehicles and land.

Response 1

Comment noted.

Comment 2

Recently, the Military Toxics Project released a report with Swords to Plowshares and the National Gulf War Resource Center called the Depleted Uranium Case Narrative. The report details how hundreds of thousands Gulf War Veterans may have been exposed to DU radioactive dust in the Gulf War. I have enclosed a copy for your review.

The task you are charged with now is to find the most safe and effective way to manage/use DU. When reviewing the comment for the Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride, we hope you will weigh these comments on how DU is used. Dealing with the tremendous stockpiles of

Depleted Uranium Hexafluoride is a monumental task. We wish you well and if you have any questions, please don't hesitate to call.

Response 2

Comment noted. The DOE is using all available information to determine the most appropriate management strategy for the depleted UF_6 inventory.

Comment 3

All too often we see industry and government with end of the pipe mentality, redefining waste as a product to be used. For example the paper industry's waste they call fertilizer and spread sludge on unsuspecting communities, further exposing citizens to toxics. Changing the medium doesn't necessarily reduce the risk. We hope the Department of Energy will start working towards more preventative based solutions in the future.

Response 3

Comment noted.

Commentor No. 89: Paperiello, Carl J.
U.S. Nuclear Regulatory Commission

Comment 1

Assumption of Future Potential Use: While we agree that the use of UF_6 is desirable, we recommend that DOE include in the PEIS an alternative that addresses UF_6 for which no use can be found. The PEIS does not provide information indicating a market demand capable of consuming 100% of the depleted uranium (DU) inventory and notes that "potential uses that are capable of consuming a substantial fraction or all of the inventory . . . are not yet fully developed . . . ." In fact, very little of the material has been used in the decades over which it has been generated and it is not clear that all of it will be used in the future, as DOE has assumed in its preferred alternative. The existing management plan for depleted uranium described on page S-3 explicitly recognizes that future uses may not be found. In this regard, the Council on Environmental Quality (CEQ) recommends that an environmental impact statement (EIS) contain ". . . all reasonable alternatives . . . Reasonable alternatives include those that are practical or feasible [emphasis in original text] from the technical and economic standpoint and using common sense, rather than simply 'desirable' [emphasis in original text] from the standpoint of the applicant." ["Forty Most Frequently Asked Questions Concerning CEQ's NEPA Regulations, 46 FR 18027, March 23,1981]. An alternative that recognizes that uses may not be found seems appropriate for the PEIS, given this CEQ guidance.

Furthermore, CEQ recommends that existing management plans be included as alternatives in EISs. One of the two CEQ interpretations of the "no action" alternative is "no change" from current management direction, i.e, continuing with the present course of action. Under the current

DOE management plan for UF_6, if alternative uses have not been found to be feasible by approximately the year 2010, steps would be taken to convert the UF_6, to U_3O_8, beginning in the year 2020. The U_3O_8 would be safely stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste. Thus, our concern about future uses not developing as projected in the PEIS would be addressed by following this CEQ guidance.

Response 1

After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Sections S.5.1 and 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under the revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal product become available. The impacts of the preferred alternative are discussed in Sections S.5.2, 2.5.2, 5.7, and 6.3.7 of the PEIS.

The no action alternative evaluated in the PEIS involves continued storage and maintenance of depleted UF_6 in cylinders at the three current storage sites through the year 2039. This definition of the no action alternative is consistent with the CEQ guidance as outlined in the comment. The no action alternative was intended to provide a baseline against which other management strategies could be measured, including strategies involving conversion, storage, and disposal of depleted uranium oxide.

Comment 2

Also, the discussion does not address regulatory and licensing requirements for the DU applications. It is recommended that (1) DOE identifies the likely market consumption of DU oxides and metals over the time frame of the EIS, (2) DOE estimates the impacts from these potential DU uses, (3) DOE considers the potential of the converted DU materials becoming a waste, thus, requiring conversion into forms compatible with disposal, and (4) DOE evaluates the likely regulatory and licensing aspects of potential uses.

Response 2

The U.S. NRC's recommendations are addressed below in the order that they are listed in the comment:

1. The PEIS evaluates two representative use options, use as uranium oxide and use as uranium metal as radiation shielding. As stated in Appendix H of the PEIS, these options were intended to be representative only, and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Consequently, discussion of issues related to specific uses is considered beyond the scope of the PEIS. Such issues would be considered and evaluated in more detail in future planning and environmental analyses.

2. The impacts associated with a specific use will depend on what use or uses are ultimately identified, which is beyond the scope of the PEIS. As mentioned above, the PEIS is not intended to select a specific end-use or preclude other potential uses in the future. Any commercial use of depleted uranium would take place under a U.S. Nuclear Regulatory Commission (NRC) license or a waiver from the NRC. Potential impacts from such use would be analyzed before a license or waiver could be obtained. The impact analysis would focus on demonstrating the protection of the health and safety of both the public and workers from the proposed use and would consider both normal and accident conditions. As with the use of any radioactive material, careful consideration would be given to whether the benefits of the proposed use outweigh the potential risks.

3. The PEIS did not address in detail the ultimate disposition of uranium after use because actions to be taken beyond the 40 year period considered in the PEIS (with the exception of long-term disposal impacts) are considered highly uncertain and speculative at this time. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

4. The purpose of the PEIS is to provide an evaluation and comparison of potential environmental impacts associated with the alternatives considered. Regulatory and licensing aspects are outside the scope of the PEIS, but would be addressed, as appropriate, when specific uses are identified.

Comment 3

In addition, DOE's assumption that all of the depleted uranium can be used in the future appears to mean that the UF_6 would be stored onsite as it is stored now, until uses actually develop. The PEIS states that conversion to metal or oxide would not begin until uses for these products become available, and that safe management of the cylinder inventory in accordance with existing practices would continue until all of it had been converted for use. Thus, if no significant uses were to develop, the PEIS would in effect be endorsing an alternative that continues to spend resources indefinitely on maintaining and monitoring the steel containers, to expose workers to radiation in performing these functions, and to put off a long-term plan for disposal.

Response 3

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be

available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of applications for depleted uranium products. There is currently no long-term plan for disposal.

Comment 4

Additional Evaluation of Combination of Alternatives: While the combination of 50% use as uranium oxide and 50% use as uranium metal is evaluated in the PEIS, other combinations, assuming DU applications are not forthcoming, would be beneficial. One example would be to assume only 50% inventory use altogether, and the remaining 50% requiring conversion to a more stable form and disposal. Again, this seems appropriate due to the uncertainty of inventory use.

Response 4

It is possible that DOE will select as a management strategy a combination of two or more of the six PEIS alternatives, such as converting and using some portion of the inventory and storing the remainder. Because it is impossible to evaluate all possible combinations of alternatives, the parametric analysis presented in Appendix K of the PEIS was included to allow the environmental impacts of such combinations to be estimated. The discussions of the preferred alternative in Sections 2.5.2 and 5.7 show one example combination. Additional examples of how the impacts are calculated for different combinations of alternatives are provided in Section K.7 of Appendix K.

Comment 5

Ranking of the Alternatives: The summary of the results (page S-15 et seq) does not include a ranking of alternatives, and implies that all of the alternatives are acceptable, but that there is one "preferred alternative." DOE may wish to rank or identify those alternative(s) that appear more favorable than others based upon the analysis. DOE may also want to consider and mention if any of the proposed alternatives are precluded by the analysis. For example, page 5-84 mentions individual doses from groundwater ingestion of 100 mrem/yr from disposal in shallow earthen structures, far in excess of 10 CFR Part 61 standards of 25 mrem/yr. Page 5-84 also mentions a scenario for a hypothetical future resident living on the disposal site and receiving radiation doses as high as 10 rem/yr. These limitations should be included in the summary.

Response 5

The purpose of the PEIS is to provide a meaningful evaluation and comparison of the potential environmental impacts of broad alternative management strategies. Thus, the summary and main body of the PEIS provide a discussion and comparison of potential impacts among the alternatives. In general, alternatives cannot be easily or meaningfully "ranked" in an overall sense because potential impacts occur in several different environmental areas, such as impacts to human health and safety, groundwater, air quality, and ecology. No one alternative offers advantages in all environmental areas, making any "ranking" of alternatives very subjective. Consequently, the PEIS discusses and compares the potential impacts of the alternatives in each area separately. The results of the PEIS indicate that all alternatives have generally similar environmental impacts,

although differences do exist in the types and magnitude of impacts for some areas assessed, as discussed.

In addition, the PEIS indicates that no alternatives are precluded on purely environmental grounds. Although the results of the disposal alternative indicate that radiation doses to individuals could potentially exceed regulatory limits for disposal in a "wet" environment at some point in the distant future, the analysis also indicates that impacts would remain within regulatory limits for a disposal facility in a "dry" environment. The PEIS also stresses (see Appendix I) that the post-closure disposal analysis is based on generic information and is subject to a great deal of uncertainty. Actual impacts from disposal would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required.

Comment 6

Use of the Term "Uranium Oxides": The PEIS generally combines all uranium oxide compounds, U_3O_8, and UO_2, under the title "uranium oxides" for consideration in the alternatives and strategies (see page S-6 et seq). This seems too all inclusive, as uranium oxides have significantly different chemical and physical properties that produce a wide range of environmental health and safety impacts. For example, U_3O_8 is a high porosity powder, with a low density and a significant respirable fraction. UO_2 powder is also porous, and can spontaneously ignite in air. On the other hand, when UO_2 is sintered, a process involving high temperatures to reduce porosity, increase density, and decrease volume, it has the highest density of the uranium oxides and is essentially pore free. The presence (or absence) of pores also has significant implications for the potential disposal of the material, either as a management option or as an end-use item; a denser, essentially pore free material would appear to be advantageous due to lower leaching potential. Thus, a dioxide material sintered to a lower density (i.e. 4-5 g/cm^3) would not be expected to perform as well in a disposal environment as a uranium dioxide sintered to a high density (i.e. 9-10 g/cm^3). It is recommended that more qualifiers are given to the term "uranium oxides," perhaps including low and high density as the principal discriminator.

Response 6

The PEIS recognizes the differences noted in the comment among different chemical forms of uranium oxides. In fact, the analyses were done separately for conversion to and storage and disposal of U_3O_8 and UO_2. The results are also reported separately for these two chemical forms (see Section 5 and Appendices D through K of the PEIS). The impacts of long-term storage as oxide and disposal as oxide alternatives are reported in Section 2 and in the Summary as ranges covering both forms of uranium oxide as well as differences in assumptions concerning environmental settings (see section 4.2.3 of the PEIS). The reason for this was to clearly define the differences among the alternatives and at the same time, allow the reader to explore the chemical specific aspects of the management options considered in the PEIS. Although the headings of sections and the names of

management options and alternatives refer only to oxides, the results in Section 5 and Appendices are reported as chemical specific. In evaluating the impacts of the long-term storage as oxide, use as oxide, disposal alternatives, and the preferred alternative, the PEIS evaluated two conversion technologies that produce UO_2 with vastly different densities. Therefore, included in the ranges of impacts provided for options involving UO_2 are differences in performance due to density variations. Because the PEIS is not intended to select specific technologies, the advantages or disadvantages of the density variations among the various forms of depleted uranium oxides are sufficiently addressed in the PEIS for the comparison of the broad programmatic alternatives.

Comment 7

Equivalent Bases and Life-Cycle Effects, the Cradle-to-Grave Approach: The text does not seem to incorporate a life-cycle approach to the different management alternatives and compare them on an equivalent basis (see pages S-7 et seq). For example, even if a market exists for potential uses of the depleted uranium (DU), at the end of the product's useful life it is still radioactive ($t_{1/2} = 4.5 \times 10^9$ years) and will require disposition. Thus, disposal would seem to be the logical endpoint for all of the alternative branches shown in Figure S-2, instead of only for the disposal as oxide alternative. Following the DU product from cradle to grave thereby influences the impacts and potentially the alternative(s) selected. It would seem that the "manufacture and use" alternatives will ultimately result in impacts from the DU component, for example, the material (perhaps as itself or in a product) could be shipped to a disposal facility. Such potential impacts do not appear to be included in the analysis, and may even preclude some options or require additional conversion and conditioning. For example, without supporting analyses, it is unlikely that significant quantities of DU metal can meet the regulatory requirements of disposal sites due to high solubility and the formation of hydrides. Thus, pursuit of use as a metal option may require another conversion facility to convert the DU metal into a form compatible with disposal. In addition, the long-term storage alternative also appears to lack the realization of ultimate disposal in the future. The PEIS should consider and analyze the alternatives on an equivalent basis with the same/comparable endpoints and include life-cycle effects.

Other examples of the need for equivalent bases include the oxide conversion routes, due to fundamental differences in the uranium oxide forms. One of the specific oxide conversion routes (gelation) appears to be manufacturing UO_2 with properties comparable to high density nuclear fuel. This process would be anticipated to have improved stability and related properties as compared to the other oxides. The gelation route detailed in the PEIS appears to include two plants — one for U_3O_8 production and one for dissolution/UO_2 production:

$$UF_6 \rightarrow U_3O_8 \rightarrow UO_2$$

This appears inconsistent with literature reports on the process which maintain that no production of U_3O_8 is necessary. The process described in the PEIS would cause double the impacts by performing a two step process when the same result is achievable in a one step conversion from UF_6 to UO_2.

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Response 7

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for a 40 year assessment period for all alternatives. In addition to this analysis, an evaluation of the long-term impacts from disposal was included in the PEIS because such impacts can be reasonably predicted. A life-cycle analysis for the alternatives other than disposal was not performed at this time because actions to be taken beyond the 40 year period considered in the analysis are considered highly uncertain and speculative. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

The gelation process analyzed in the PEIS includes U_3O_8 production and dissolution, but does not require two plants. The basis for the gelation process in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) is the Oak Ridge Report ORNL/TM-6850, "Chemical Flowsheet Conditions for Preparing Urania Spheres by Internal Gelation" (July 1979). The ORNL flowsheet provided a complete design to convert UF_6 to U_3O_8, and supplied the process information needed to prepare a material balance and flowsheet to convert U_3O_8 to UO_2 microspheres by gelation. The gelation process described in the above referenced ORNL report and used in the PEIS was judged to be the best available. However, this technology has not yet been fully developed and improvements are likely to occur. The process used for the PEIS can be considered to be reasonable and suitable for impact analysis.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 8

Results of the Analyses: Pages S-15 et seq summarize and compare the results of the impacts for the alternative management strategies. Some of these results seem inconsistent and are not intuitively obvious. For example, it is not clear why the use as uranium oxide results in higher impacts than the use as uranium metal (see pages S-20 and S-49)- the opposite would be anticipated. A more rigorous analysis of the assumptions made in the Engineering Analysis UCRL-AR-124080 is recommended (see specific comments #20 (now 35)). In V2, Section 6.11, Potential Shielding Applications, a large disparity is evident between the damage fractions assumed for uranium metal (1%) and those assumed for uranium dioxide (100%). Again, this seems questionable based on the pyrophoricity of uranium metal upon heating. Furthermore, the airborne release fractions are orders of magnitude lower than what is recommended in the DOE Accident Analysis Handbook 3010-94. These calculations should be examined more closely to confirm DOE's conclusion.

Furthermore, it is unclear whether or not the disposal analyses include all of the potential long-term impacts and doses from uranium leaching from the disposal area. It is recommended that DOE consider greater consistency in the results and clarify the summary.

Response 8

With respect to differences in impacts from accidents between the use as oxide and use as metal alternatives, many categories of accidents are summarized in Tables S.2 and 2.2 of the PEIS. In general, the impacts of accidents from use as oxide and use as metal are the same (see Categories "Likely Cylinder Accidents," Low Frequency-High Consequence Cylinder Accidents, Low Frequency-High Consequence Accidents at All Facilities-Chemical Accident). One category of accident, namely Low Frequency-High Consequence Accidents at All Facilities-Radiological Accident, does have higher consequences for the use as oxide alternative than the use as metal alternative. This is due to the specific accident scenarios appropriate to the technologies being evaluated (see also response to Commentor No. 89, Comment 35); additional information on the accident scenario assumptions for manufacture and use is given in Section H.3.2 of Appendix H, and in the engineering analysis report (LLNL 1997; the full citation is provided I Appendix H of the PEIS). However, in general the results of accident impact analyses for the use as oxide and use as metal alternatives were considered to be approximately the same. (The engineering analysis report is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC [listed in the Notice of Availability], and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.)

Much of the difference in predicted consequences for accidents involving U_3O_8, UO_2, and uranium metal are associated with the form of the material. U_3O_8 is an easily-dispersed powder, whereas only the oxide coating on uranium metal billets can be readily dispersed. Releases from drops of UO_2 pellets are somewhat more similar to releases from drops of metal billets. Text has been added to Section 5.5.1.2.2 (page 5-71 of the Draft PEIS) to clarify the reasons that the consequences of some of the accidents associated with the use as metal alternative are lower than those associated with the use as oxide alternative.

The DOE accident handbook (DOE-HDBK-3010-94) was used in deriving release fractions for the accidents modeled; in instances where the conditions of the modeled accident supported it, the median values were used instead of the bounding values. See the response to Commentor No. 89, comment 35 for further details. In general, the methods used in the engineering analysis report required that the damage fraction and release fraction be considered together.

The disposal analyses do include long-term impacts and doses from leaching from the disposal area; these impacts are discussed in detail in Section I.4 of Appendix I and presented in Tables S.2 and 2.2 under "Water and Soil." Text has been added to Tables S.2 and 2.2 under "Human Health and Safety-Normal Operations" to indicate long-term post-closure impacts from disposal.

Comment 9

Waste Management: In Section S.4.8 on page S-40, waste management impacts are discussed. DOE should consider briefly highlighting the potential uranium content of the secondary streams (i.e. CaF_2, MgF_2), along with a brief assessment of acceptability for either reuse/nonradioactive disposal or disposal as radioactive waste. The uses and demands for the by-products of conversion (HF, CaF_2,) should be explored and discussed. DOE should expand the discussion in the last paragraph about uranium disposal as low-level waste (LLW).

Response 9

Although there are uncertainties in the predicted uranium content of secondary waste streams, estimates of the potential uranium content of CaF_2 are given in Sections S.4.8, 2.4.8, 5.3.7, F.3.7.1, and F.3.7.2 (i.e., less than 1 ppm). An estimate of the potential uranium content of MgF_2 is given in Section F.3.7.3 of the PEIS (i.e., 90 ppm). This estimate has been added to Sections S.4.8, 2.4.8, and 5.5.7, as requested by the commentor.

With respect to the fate of the CaF_2, the PEIS does state in Sections S.4.8 and 2.4.8 that "the low level of uranium contamination expected (i.e.,less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste is most likely." If disposal of CaF_2 is required, the PEIS acknowledges that it may be considered LLW, and assesses the impacts for both disposal as nonhazardous solid waste and disposal as LLW. Currently there are no known uses for the MgF_2 that would be produced if the use as metal alternative were to be selected; it is therefore assumed that this MgF_2 would require disposal either as nonhazardous solid waste or as LLW. Brief discussions of the market for anhydrous HF and historical industrial experience showing that if produced, it could be purified to contain less than 1 ppm uranium, are provided in Sections 2.3.3 and F.2.1 of the PEIS. Text has been added to Sections S.4.8 and 2.4.8 to clarify the assumption made in the PEIS that if HF were produced, it would be sold for use subject to appropriate review and approval by the U.S. NRC or DOE..

As noted in Section I.4 of Appendix I, the disposal calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. Rather than cite regulatory agency positions that may not be applicable to the disposal of depleted uranium oxide in the summary of potential waste impacts, text has been added to Sections S.4.5 and 2.4.5 (Water and Soil Impacts) detailing some of the uncertainties of the non-site-specific analysis for disposal, and stating that if disposal were implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option).

Comment 10

Furthermore, the DOE may wish to cite the Louisiana Enrichment Services (LES) Final EIS (NUREG-1484) analysis. The NRC documents provide analyses supporting DU disposal as a LLW, but note that its disposal could require a mine or another means of "deep" (rather than near-surface) disposal. Similar to the conclusion drawn in the PEIS, the LES EIS determined near-surface disposal would cause accedence of 10 CFR Part 61.41 requirements. Currently, no "deep" disposal sites exist, and all current LLW disposal sites (existing and planned) use near-surface facilities.

Response 10

A brief discussion of the LES EIS, including comparison of doses from disposal in near surface and deep disposal sites, has been added as part of the new Section 1.7 of the PEIS. It should also be noted that the disposal calculations in the PEIS are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. Text has been added to Sections S.4.5 and 2.4.5 (Water and Soil Impacts) detailing some of the uncertainties of the non-site-specific analysis for disposal, and stating that if disposal were implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option). (Please see also the response to comment number 5 from Commentor 89.)

Comment 11

DU Use as Spent Nuclear Fuel (SNF) Cask Shielding: DOE appears to be relying upon the potential future use of DU as SNF cask shielding for a large consumption of its DU inventory (see page S-43 and 1-8, and Volume 2 of the EAR, which analyzes a DU cask manufacturing facility as the only use of DU). If this is indeed the case, DOE may wish to discuss it in more detail in the PEIS summary, and it should be noted that no currently licensed or planned SNF cask uses of DU.

Response 11

As described in Section 2.2 of the PEIS and in detail in Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected as representative options to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses. While it is true that depleted uranium is not used in currently licensed spent fuel storage or transportation casks, this does not preclude development of such a use in the future.

Comment 12

Fate of DU SNF Cask Shielding: As currently written, the PEIS does not include a discussion of the eventual fate and potential impacts of the DU SNF cask after use (pages 2-14 and 2-15). Pages 5-55 and 5-65 mention that "no assumptions are made regarding the fate of the cask after use," and page 5-65 notes that disposal would amount to an additional 180,000 cubic meters (6.4 million cubic feet) of waste requiring disposal, with a (calculated) average specific gravity of 2.2. This does not seem inconsequential, particularly if a dedicated disposal facility is required and the impacts are estimated to be similar to disposal (e.g., page 5-83 et seq; exceeding 10 CFR Part 61.41 dose limits). Also, there are statements in the document that question if significant quantities of DU metal are suitable for disposal (e.g., last paragraph on page 2-21). Inclusion of a discussion about the disposition of the DU cask after use, and potential impacts, is recommended.

Response 12

The PEIS acknowledges that at the end of their useful lives, products containing depleted uranium could be stored, recycled for other uses, or treated and disposed of as low-level waste (see Sections 2.2.4, Section 2.2.5, and Section 5.9 of the PEIS). At this time, any analysis of disposal after use would be too speculative as it is not known when and at what rate the material would be declared surplus and would be disposed of. These issues are discussed in Section 5.9 of the PEIS.

Comment 13

Technology and Equipment Development: The PEIS encompasses numerous technologies that are at different stages of development, in terms of process, understanding, equipment, (potential) impacts, and uncertainties. For example, of the conversion, application, and disposal impacts discussed within the summary, none are practiced on any scale domestically, and only conversion to U_3O_8 is practiced on a large scale internationally, producing a low density product. Thus, there is only one direct analogy. DOE should consider including a technology discussion, with status and assessment, perhaps with either a time schedule or probability of success, for some of these technologies. For example, it seems like a significant extension of existing uranium dioxide sintering technology to take pellets from 100 te(U)/yr/line to 7,000 te(U)/yr/line. From the uranium dioxide technology perspective, microspheres (e.g., from gelation) may be the more mature technology because of the (potential) use of tube furnaces and pilot plant tests with equipment processing rates an order of magnitude larger. Similarly, a uranium dioxide/concrete cask approach appears to be a significantly easier technology to understand and scale then casting a 40 te(U) metal shield.

Response 13

Subsection 1.2.6 in each Section 6.0 of the engineering analysis report (EAR)(LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS) discusses the process and equipment uncertainties associated with each option. In general, the conversion to oxide and the batch conversion to metal processes are well known with extensive operating experience. The continuous reduction to metal process requires development and extensive scale up. Oxide shielding

manufacture is a simple process but needs to be demonstrated. Metal shield manufacture requires large-scale melting, casting, and machining that needs development.

Conversion of UF_6 to U_3O_8, recovery of 70% HF, oxide compaction, packaging in bins, and storage inside buildings is performed on a large scale (15,000 tonnes per year) by COGEMA in France, to stabilize depleted UF_6. Recovery and upgrade of the 70% HF to anhydrous HF (AHF) has not been demonstrated. The EAR assumed production of AHF using a process patented by J. Mestepey of Sequoyah Fuels. The AHF process needs verification and demonstration.

Conversion of UF_6 to UO_2 ceramic pellets is performed in nuclear fuel fabrication plants (500 tonnes per year). The pusher-type furnaces used for fuel pellet sintering would not be suitable for large throughputs. Equipment development is needed for the sintering furnaces. But the throughput for pressing and sintering is not unusual for the ceramic industry.

Production of UO_2 nuclear fuel microspheres by gelation has been successfully tested in pilot-scale units. For large throughputs, the gelation liquid effluent must be recycled to avoid high reagent costs and waste disposal costs. A recycle process must be developed for gelation to be viable.

Batch reduction to uranium metal is a mature industrial process used to produce metal for nuclear fuel, penetrators, and armor. Higher production rates can be achieved by adding more batch furnaces. A system to decontaminate the MgF_2 product was installed at Aerojet (Jonesborough, TN).

Continuous reduction to metal research was conducted at Oak Ridge Y-12. Extensive development and scale-up would be needed.

Oxide shielding applications (DUCRETE cask) was researched at the INEEL. Development work is continuing at Nuclear Metals Inc. The process is similar to concrete mixing.

Batch melting and casting to produce uranium metal fuel and other products is a standard industrial process. Metal shielding applications (metal cask) will require large-scale melting and casting of uranium metal. The single pour concept to cast the annular shield requires extensive development.

The technologies used in the PEIS to analyze the environmental impacts of the management options and the alternatives were selected based on the evaluation and recommendations of a panel of independent technical reviewers (ITRs). One of the criteria used by the ITRs to evaluate the technologies was the technical maturity. For the technologies that had no prior history, the ITRs were asked to estimate time-to-availability and consider the probability of success. Only those technologies that were estimated to be available in the time frame when they would be needed were considered in the engineering analysis report and the PEIS. The reviews by

and the recommendations of the ITRs are documented in "Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1995). The technology assessment report is available through the National Technical Information Service (NTIS) by calling 1-800-553-NTIS (6847) or (703) 605-6000. The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 14

Existing Facilities and Experience: There are obvious analogies with existing, commercial fuel cycle facilities, which process uranium hexafluoride into uranium dioxide (for nuclear fuel) and (to a lesser extent) uranium metal. On an international scale, COGEMA has been converting UF_6 to U_3O_8, compressing it in steel containers, and storing the containers in metal reinforced seismic buildings since 1977 to avoid the hazards of storing UF_6. These facilities are already licensed by the appropriate regulatory agencies. The PEIS does not mention these facilities, either as a source of experience or as a source of processing capacity, particularly during the development of uses for the DU materials and as a means for surge capacity. The PEIS also does not appear to draw upon the operating experience of these facilities, including waste generation and uranium content of byproducts. Reliance upon existing facilities may lessen environmental impacts associated with the construction of a new facility. Thus, DOE may wish to include the experience of operating commercial facilities and comment upon their potential use (or nonuse) during the development of applications for the DU.

Response 14

Information on commercial uranium facilities were used in the development of the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). Emission and waste generation data from UO_2 fuel fabrication facilities (Columbia, SC; Wilmington, NC; and Hanford, WA) and UF_6 plants (Metropolis, IL; Gore, OK) were reviewed. The data were used as guidelines, but extrapolation was not possible due to different plant design, process, and off-gas treatment.

The UF_6 to U_3O_8 conversion process in Section 6.5 ("U_3O_8: Defluorination/HF Neutralization Facility") of the EAR is based on the COGEMA process practiced in France. Similarities included using identical chemical reactions, reagents, and temperatures to convert UF_6 to U_3O_8, and compacting the oxide product to increase its bulk density. Differences included using two separate reactors in series instead of a single reactor for conversion, and neutralizing the 70% HF product to form CaF_2.

Nuclear Metals Inc. (Concord, MA), a producer of uranium metal for commercial applications, is assisting in the development of depleted uranium uses. The company currently has a contract to develop oxide (DUCRETE) shielding material.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 15

Economic/ Socioeconomic Analyses: The PEIS mentions a separate Cost Analysis Report (CAR) as providing input to the PEIS (page 1-7). However, program costs do not appear to be included in the analyses. DOE should consider including a brief comparison of the costs and other economic impacts in the PEIS, perhaps as part of the summary (e.g., in Table S-2). Also, from a socioeconomic standpoint, all the alternatives considered will create jobs. DOE should address whether or not the areas chosen for construction can sustain the necessary development that will accompany the influx of workers.

Response 15

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives is generally not considered an environmental impact; consequently, cost information is not provided in the PEIS. However, cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

In addition, the cost information is used as input to the socioeconomic analysis presented in both the summary and main body of the PEIS. The PEIS addresses socioeconomic impacts on human communities, including changes in employment, local housing demand, public finances, and population in-migration. More detailed site-specific analysis including whether or not the areas chosen for construction can sustain the necessary development that will accompany the influx of workers would be addressed in future planning and analysis documents.

Comment 16

Fuel Cycle Process: In the background section of the summary on pages S-1, S-2, DOE may want to briefly explain the fuel cycle process and point out the various forms of uranium at each stage. This would help elucidate the natural occurrence of U_3O_8 and substantiate its suitability for disposal alternatives.

Response 16

The discussion of the properties of depleted uranium hexafluoride has been expanded in the background section of the summary and Chapter 1 of the PEIS to provide additional information concerning the material's properties. However, a discussion of the fuel cycle was not considered necessary for the purposes of the PEIS in that the PEIS considers management options for the

by-product (depleted UF_6) of one phase (enrichment) of the entire fuel cycle. The suitability of different uranium compounds for disposal is summarized in Appendix I of the PEIS.

Comment 17

Mass of DU: The insert on page S-2 identifies some 46,422 DU cylinders distributed between the three sites. While the total quantity is listed in the main text of the report, it would be helpful to have the approximate masses (as either MTU or $MTUF_6$) for the three sites listed in the summary as well.

Response 17

The text of the insert in Section S.1.1 and the text in Chapter 1 of the PEIS have been revised to include the quantity of depleted UF_6 in metric tons.

Comment 18

United States Enrichment Corporation DU: The insert on page S-2 also notes that an additional 8,000 cylinders have been produced by USEC. It is suggested that this number is also divided between the sites and expressed in mass quantities. It is also recommended that a brief discussion about the USEC DU be included, perhaps as part of the first paragraph on page S-4. While the EIS excludes the USEC DU from its analysis, it also implies that there is a reasonable probability of it becoming DOE's responsibility. Consequently, DOE may want to consider that possibility in its impact analysis.

Response 18

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). In addition, the text in the summary and in Chapter 1 of the PEIS have been revised to include the quantity of depleted UF_6 in metric tons.

Comment 19

Summary Table S.2: On pages S-17 and S-18, irreversible adverse health effects as well as adverse effects are identified for cylinder accidents. This terminology should be defined and explained by a footnote in the table. A more quantitative measure of chemical effects should be included, as uranium toxicity is a major concern that needs to be addressed. In addition, the cylinder accident scenarios should indicate estimated quantities of the releases of uranium and HF shown in the table including the time period of exposure and length of time of the release. Finally, DOE should indicate exposures to involved workers instead of only exposures to the public and non-involved workers.

Response 19

Due to the great volume of material summarized in Table S.2 (titled "Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies), when additional information is desired, it is necessary to consult the accompanying text. Brief definitions of the terms "adverse effects" (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function) and "irreversible adverse effects" (effects permanent in nature, such as lung or kidney damage) are given in Section S.4.2.2. A more detailed discussion of these terms is provided in Section 4.3.2.1 of the document. The quantitative levels that are associated with these effects are stated in Section 4.3.2.1.

Again, because Table S.2 is summarizing impact analyses for all technical areas (not just accident impacts), the inclusion of release quantities and durations for specific accidents was considered to be too detailed for this table. These release quantities and durations are given in Tables D.6, E.4, F.7, G.6, H.5 and I.9 for all the accidents evaluated for the various management options. The supporting document entitled "Facility Accident Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement" (Policastro et al. 1997) also discusses the assumption that the period of exposure is approximately equal to the length of time of the release. This document is available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

The reason that effects of accidents on involved workers are not quantitatively estimated is summarized in the text of Sections S.4.2.2 and 4.3.2.1. The risk to involved workers is very sensitive to the specific circumstances of each accident and would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved works under accident conditions would likely be dominated by physical forces from accidents themselves so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in the PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

Comment 20

New Madrid Seismic Zone: Page S-34 mentions "the conversion accidents estimated to have the largest potential consequences were . . . involving the rupture of tanks of anhydrous HF or ammonia" would be caused by a large earthquake which has an assumed frequency of less than 1 in 1 million per year of operations. DOE should mention that a facility built near the Paducah Gaseous Diffusion Plant would be located near the New Madrid seismic zone. Additional seismic analyses would need to be performed for such a facility as well as an accident analysis taking into account the seismicity of this area.

Response 20

If a conversion facility were to be constructed at the Paducah site, seismic hazards associated with such a facility would be considered. Future planning and environmental analysis will address issues related to selection of sites (including site-specific seismic considerations) for the depleted UF_6 management strategy selected in the Record of Decision for this PEIS.

Comment 21

Non-Shield Use of DU: Page 2-21 mentions uses for DU such as developing penetrators, vehicle armor, and industrial ballasts. No mention is made of quantities or relative percentages of the DU inventory that these uses would require. Also, it is not self-explanatory that DU cask manufacturing and uses bound all of the potential uses. For example, metal uses would appear to require a significant amount of alloying and/or machining, and involve handling and disposal concerns. DOE may wish to include a longer discussion and a more comprehensive explanation.

Response 21

As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected as representative options to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to bound the impacts associated with any future use, but rather to identify the types and general magnitude of impacts associated with manufacturing products containing depleted uranium. The impacts associated with specific uses will depend on what use or uses are ultimately identified, and would be considered and evaluated in more detail in future planning and environmental analyses. Existing analyses using the representative use options are considered to be appropriate for the PEIS.

Comment 22

Leach Rates for Disposal: Page 2-22 briefly mentions leach rates and waste forms, and states that grouted wastes are representative of immobilized waste forms with low leach rates, with the implication that grouting is also representative of vitrification. DOE should clarify this text, as grouting may be representative of vitrification for some parameters (e.g., facility size) but not representative in others (e.g., energy usage, emissions). Also, while grouting should provide for somewhat lower leach rates as compared to the ungrouted material, vitrification would be expected to provide 5 to 6 orders of magnitude lower leach rates than grouting. Furthermore, a quantitative mention of the values of the leach rates is beneficial, as each uranium form will exhibit different rates. These factors may be an issue for some disposal options and consequently should be discussed.

Response 22

Vitrification of depleted uranium oxides for the purposes of disposal is discussed on Section 2.3.4 of the PEIS and in the technical backup report by Swanstrom et al. (1997). The backup report is available for review at DOE public reading rooms near the three current storage sites and

in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS. As discussed in the PEIS and in the backup report, technologies for vitrification of depleted uranium oxides are in the early stages of development, and since the PEIS is intended to provide an analysis of broad, programmatic alternatives, a mature and common technology, grouting, was used as the representative technology to evaluate and compare the impacts of stabilization for disposal. If vitrification proves to be a better technology in the future, nothing in the PEIS would preclude its use.

Comment 23

Disposition of Empty Cylinders: Often when a cylinder is processed, an amount of UF_6 (the heel, containing U-235 daughter products) remains in the cylinder. DOE should describe how the cylinders will be cleaned and how the heels are going to be dealt with. Furthermore, though potential options for the disposition of empty DU cylinders are listed on page 2-23, the impacts are not included. It would seem reasonable to provide a brief discussion on these options and include impacts from cylinder disposition in the EIS.

Response 23

The management of empty cylinders is addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). In the PEIS, for each alternative requiring conversion, the impacts of constructing and operating a cylinder treatment facility were included in the impact analysis. This analysis assumed an initial storage period of 3 months after UF_6 removal from the cylinders to allow the level of radioactivity associated with the decay products of uranium to decrease to acceptable levels. The cylinders would then be washed with water to remove the heels; finally the cylinders would become part of the DOE scrap metal inventory. See Appendix F of the PEIS for specific impact analyses for the cylinder treatment facility. As a part of the waste management analyses in the PEIS, the impact of disposal (i.e., burial) of the empty cylinders as low-level waste was also examined (Section F.3.7.4). It was found that the empty cylinders would represent only approximately 3% of the projected DOE complex-wide volume of LLW expected to be generated during the time period examined (i.e., through about 2030).

The above-cited report by Nieves et al. analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 24

Water and Soil impacts from DU Disposal: The summary table of impacts (Table 2-2) and the supporting text for the water and soil section (page 2-50) note that the groundwater uranium concentrations will exceed drinking water guidelines. It is recommended that the expected concentrations are also expressed in terms of individual radiation doses.

Response 24

The potential radiation doses to members of the general public from the use of groundwater at the three current storage sites was calculated for the no action alternative and the action alternatives; the doses are given in Sections 5.1.1.1.2 and 5.2.1.1.2. The doses during the post-closure phase for the disposal as oxide alternative are discussed in Section 5.6.1.1.2.

In Table 2-2 it is stated that uranium groundwater concentrations could exceed guidelines under the Disposal as Oxide Alternative, wet environmental setting. The doses and chemical health risks from this exposure have been added to Table 2.2 under Human Health and Safety — Normal Facility Operations. Supporting text has also been added to Section 2.4.1.

Comment 25

Waste Management: Pages 2-52 et seq present a summary of the waste management impacts from the alternatives. Comparisons of the amounts generated are primarily made relative to the DOE waste management system, however, these facilities could also be commercially operated under NRC or State regulations, Consequently, DOE should consider adding a comparison to commercial LLW generation rates. The section should also include estimated uranium levels for the magnesium fluoride waste (from DU metal production) and discuss the aspects of DU disposal, including the potential need for either a dedicated or a deep disposal facility.

Response 25

Because of the many uncertainties present at this time, the comparison of waste management impacts from depleted UF_6 waste was limited primarily to the DOE waste management system. Currently three commercial facilities (i.e., Barnwell, SC, Richland, WA, and Envirocare in UT) are accepting about 37,000 m^3/yr of commercial LLW, and DOE is disposing of approximately 65,000 m^3/yr LLW at DOE facilities. DOE LLW generation is expected to increase to about 100,000 to 200,000 m^3/yr once environmental restoration operations begin. Commercial facilities which manage LLW have the capability to expand rapidly and may accept DOE LLW in the future if it can be managed profitably. A summary of this information on commercial LLW generation rates has been added to Section C.10 as background information.

An estimate of the potential uranium content of MgF_2 is given in Section F.3.7.3 of the PEIS (i.e., 90 ppm). This estimate has been added to Section 2.4.8 as requested by the commentor, as well as to Sections S.4.8 and 5.5.7.

The detailed analysis presented for disposal in the PEIS does indicate that the dose to a hypothetical receptor from contaminated groundwater would exceed regulatory limits for a disposal facility in a "wet" environment for all three disposal options considered (i.e., disposal in shallow-earthen structures, vaults, or mines). However, the analysis also indicates that groundwater impacts would be less than regulatory limits for a disposal facility located in a "dry" environment for all three disposal options (these results are summarized in Section 2.4.5 and presented in detail in Section I.4 of Appendix I). It must be stressed, as noted in Appendix I, that the disposal calculations are subject to a great deal of uncertainty and would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were required. Text has been added to Sections S.4.5 and 2.4.5 (Water and Soil Impacts) detailing some of the uncertainties of the non-site-specific analysis for disposal, and stating that if disposal were implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW (regardless of whether shallow earthen structures, vaults, or mines were the chosen disposal option).

Comment 26

DOE's Preferred Alternative: Section 2.5 (pages 2-54 et seq) presents DOE's preferred alternative. This section would benefit from a greater discussion of the potential uses of DU, including the SNF storage casks.

Response 26

Comment noted. The PEIS discusses several potential uses for depleted uranium (see Sections 2.2.4, 2.2.5, and Appendix H of the PEIS), including the representative shielding options evaluated in detail.

Comment 27

Generic Sites: Pages 3-58 et seq present information on the generic sites for wet and dry locations for disposal, and mention that the site data for each are derived from actual wet and dry sites. It is suggested that the actual sites which provide the basis for the generic locations be listed.

Response 27

Data for actual sites (i.e. cities within the U.S.) were the meteorological data used in the impact calculations for disposal options. However, the selection of the meteorological data was performance-based, and not related to potential locations, other than a dry or wet setting, for a disposal facility. Thus, the identification of these sites in the PEIS has no value. The meteorological

data used in the characterization of the "dry" and "wet" settings for the location of a disposal facility were taken from archives of the National Weather Service. Meteorological data from cities that met the dry or wet annual rainfall criteria (approximately 10" and less or 40" and more, respectively) were screened to obtain a set of 5 locations in each case that resulted in the largest range of impacts that would be consistent with either a dry or wet setting.

Comment 28

PEIS Time Period: Page 4-2 lists a 41 year time period for the EIS (through the year 2039), and indicates activities beyond 2039 would be subject to appropriate NEPA reviews and decisions in the future. This appears to truncate the analyses for some of the alternatives which might influence the selection of the preferred option; for example, impacts from wastes in a disposal cell are unlikely to occur by 2039, major cylinder/container replacements may be required for the storage option in the 10-20 years after 2039, significant applications for use of the DU may not have developed etc. DOE may wish to consider a time period consistent with the logical conclusion of the options or their "life-cycle," which may require a time frame beyond 2039.

Response 28

The analysis in the PEIS was intended to provide a comparison of reasonably foreseeable environmental impacts for each of the alternatives considered. Consequently, the potential environmental impacts were evaluated for roughly a 40 year assessment period for all alternatives. In addition to this analysis, an evaluation of the long-term impacts from disposal (up to a period of 1,000 years beyond the assumed failure of a disposal facility) was included in the PEIS because such impacts can be reasonably predicted. A life-cycle analysis for the alternatives other than disposal was not performed at this time because actions to be taken beyond the 40 year period considered in the analysis are considered highly uncertain and speculative. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Comment 29

Background Radiation: On page 4-15, the example with background radiation appears to have left "year" out of the units.

Response 29

The referenced example was modified to indicate that the calculation includes a 1 year exposure time which causes the "year" not to appear in the final units.

Comment 30

Waste Management Approach: Page 4-25 lists the waste management approach. Inclusion of waste categorization methods and categories (e.g., per 10 CFR 61), and current commercial

capabilities would be beneficial. DOE may also want to discuss if there are any waste management situations that require the development of additional waste management capabilities and/or capacity.

Response 30

A brief discussion of waste categories has been added to Section 4.3.8. As stated in Section 4.3.8, where new waste management facilities would be required for the various options, the impacts of constructing and operating such facilities are already included in the Appendices addressing those options (e.g., see Figure F.1 of Appendix F, Conversion, which includes waste treatment facilities in the facility design).

Comment 31

No Action and Storage Alternatives: Pages 5-3 and 5-19 discuss the estimated cylinder failure rates for the No Action and UF_6 Storage alternative. These appear to use the opposite ends of the failure rate range — No Action uses the lowest failure rate, while Storage uses the highest failure rate — without explanation. Also, the existing cylinders may not have adequate wall thicknesses under either alternative due to both internal and external corrosion over the years (see Appendix E), and the DU may have to be transferred to new cylinders within the time frame covered by the EIS. Furthermore, if the cylinder wall thicknesses deteriorate significantly, they may not meet American Society of Mechanical Engineering (ASME) code for processing. DOE should consider presenting a discussion on these items in the text.

Response 31

As described in Section 5.1 and Appendix D of the PEIS, the analysis of the No Action alternative considered both the lowest estimated cylinder failure rate (assuming cylinder coating effectively halted corrosion) and the highest estimated failure rate (assuming cylinder coating was not effective in halting corrosion). The results of both analyses are discussed in the PEIS. For the action alternatives, including long-term storage of depleted UF_6, the higher estimated failure rates were used in the analysis for the reasons discussed in Appendix D.

The DOE acknowledges that a fraction of the cylinder inventory may require preparation before shipment or processing due to external corrosion. Consequently, two options for cylinder preparation are considered and discussed in the PEIS for all alternatives, as described in Chapters 1 and 2. A detailed description of cylinder preparation options is provided in Appendix E.

Comment 32

Tank Rupture Frequencies: On page 5-40, Table 5.4 lists tank rupture accidents as "incredible" events, when typically they are assigned a value corresponding to the "extremely unlikely" frequency bin. A brief discussion of the basis for DOE's assessment is recommended.

Response 32

The accident frequencies used in the PEIS analyses were obtained from the engineering analysis report (EAR) (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The HF and ammonia tank rupture accidents in question were described in Section 7.0 of the EAR.

The HF accident involves both tank failure and confinement building failure due to a seismic event (earthquake). The EAR (pp. 6.4-2-12 and 6.4-8-1) states the HF building is category PC-4 and the HF tanks are either PC-3 or PC-4. Based on DOE-STD-1021-93, failure of PC-4 structures, systems, or components (SSC's) caused by a seismic event exceeding the design basis earthquake (DBE), or failure of PC-4 SSC's caused by the DBE, is considered incredible. Similarly, failure of PC-3 SSC's is considered extremely unlikely. Therefore tank failure may be extremely unlikely as suggested, but the accident in question is incredible because the PC-4 building also fails.

The ammonia accident involves an earthquake-induced tank failure that releases the entire tank contents (25,000 gallons) in 20 minutes. The EAR (p. 6.5-8-1) states the ammonia tank is PC-3 or PC-4. If it is PC-4, then failure due to earthquake is indeed incredible. If it is PC-3 as suggested, then failure is extremely unlikely.

The EAR and other supporting reports are available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 33

Surface Water Dilution of Effluents: On page 5-51, the text indicates effluent levels greatly exceeding EPA guidelines for uranium, but notes that the concentration would be much lower and below the guideline after dilution in nearby surface water. This should be clarified, and potential dose consequences of these effluents presented.

Response 33

The referenced text in Section 5.3.4.1 of the document is addressing the conversion component of the long-term storage as oxide alternative. Calculations for the oxide conversion facility were performed for a "representative site." As described in Section 3.4.1 of the PEIS, the representative site characteristics for conversion options were derived from information on the three existing storage facilities (Paducah, Portsmouth, and Oak Ridge). For the estimated range of wastewater generation rates (15 to 140 million gal/yr), dilution in final receiving waters (nearby rivers) would range from about 8,000 to 450,000 (for representative flows, see Tomasko 1997b; the full citation is provided in Appendix C of the PEIS). For this range of dilution, the concentrations of uranium in the receiving water would be below the proposed EPA MCL of 20 µg/L used as a guideline in the PEIS.

If conversion were to be a component of the management strategy selected in the Record of Decision for the PEIS, site-specific calculations would be required prior to construction. These site-specific environmental analyses would address specific contaminant levels to be expected in surface waters near the sites. Text has been added to Section 5.3.4.1 to clarify that all releases from actual conversion facilities would be in compliance with applicable regulations and site-specific permits.

The potential total doses to the general public associated with releases from conversion facilities (including releases to surface waters) were presented in Table F.4 of Appendix 4, and summarized in Sections 5.3.1.1.2 and 5.5.1.1.2. As stated in the text of Sections F.3.1.1.1, F.3.1.1.2, and F.3.1.1.3 pertaining to the general public doses from conversion facilities, the doses associated with drinking contaminated surface water would be at least two orders of magnitude less than those from exposure to airborne emissions. The total doses were all much less than the dose limits specified in DOE Orders (see text).

The Tomasko 1997 report and other supporting reports are available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 34

Land Use Requirements: Page 5-55 identifies land use requirements for the facilities. Contrary to the small land requirements indicated in the PEIS, conversion and metal use plants would be anticipated to have larger land use because of facility size and require potentially larger setbacks for potential accident mitigation from uranium releases. The LES EIS maintains the amount of land required for a generic conversion facility is 1000 acres whereas the PEIS indicates only 30-40 acres are necessary. The text also does not indicate if any major setbacks, protective action distance (PADs), or planning zones are likely to be needed around the facility because of the handling of large quantities of DU, the hexafluoride, and/or the metal (including melting operations). DOE should consider a discussion in the text on these subject matters.

Response 34

Conversion facility land areas presented in the PEIS do not include buffer zones. A nominal facility occupies about 30 acres, or 900 × 1500 ft. NUREG-1140 p. 30 suggests a 1 mile protective action distance (PAD), which is based on a UF_6 cylinder rupture that releases uranium and HF. The PAD is the recommended distance for which emergency planning would be appropriate to mitigate off-site exposure to accidental releases. A conversion facility is not required to have ownership of the area encompassing the PAD. The PAD for a metal or oxide shielding facility would be much less because UF_6 would not be handled at these facilities. Wherever land use for conversion facilities is discussed in the PEIS, text has been added acknowledging the need for a protective action distance.

Comment 35

Oxide and Metal Accident Consequences: Pages 5-55 et seq discuss the use and impacts of uranium dioxide as shielding, and pages 5-66 et seq discuss the use and impacts of uranium metal as shielding. Some of the values imply non-intuitively obvious lower impacts from a metal route as compared to the oxide route; it is recommended that these are discussed and explained in more detail. For example, the text on page 5-71 estimates the highest consequences from an accident with the metal route as 15 mrem (from a fire involving three cylinders, an energetic accident with reactive materials), as compared to 270 mrem (from an earthquake during uranium dioxide storage, a low energy event with non-reactive materials) — there is no explanation for the difference. Also, the supporting information in Appendix H shows similar inconsistencies; the unlikely accidents for the oxide (Table H-5, page H-16) are significantly higher than the corresponding accidents for the metal (page H-17). Page H-17 also contains apparent inconsistencies; the mishandling/dropping of solid DU metal accident releases a greater quantity of uranium than the molten uranium accidents. Upon further review, the source of these apparent anomalies goes back to Section 6.11 of the Engineering Analysis Report (EAR). These anomalies and inconsistencies include:

- Page 6.11-7-6 uses a damage fraction of 30% for the metal and 100% for the oxide; comparable or lower values would seem appropriate for the oxide.

- Page 6.11-7-7 uses a damage fraction of 1% with molten uranium metal and 100% for the oxide for a mixer/melter accident; these values for the damage fraction appear to be contradictory and may have been inadvertently reversed (i.e., they should be 100% for the metal and 1% for the oxide).

-A similar incongruity exists for the Mixer/Melter Discharging Accidents on pages 6.11-7-7 and 6.11-7-8, where the damage fraction for metal use is 1% while 100% is used for the oxide route.

-On page 6.11-7-8, the metal shield failure uses a damage fraction of 0.1% while the oxide shield failure damage fraction uses 100%; again, these appear to be reversed. Also, the failure modes may be completely different, and this does not appear to have been captured by the scenarios and calculations.

- The stated release fractions for the metal accidents on these pages appear to be unconservatively low; DOE-HDBK-3010-94 recommends 1×10^{-2} as bounding for "disturbed molten metal surface with high turbulence" and 1.0 for "small molten metal drops hurled through air or explosion of entire metal mass." The melter failure and discharge accidents would appear to be in the latter category, and most of the other accidents would appear to be bimodal, with some portions of the release in both categories. These effects would increase the source terms for the analyses.

- The oxide and metal design basis events are analyzed with different bases; the high efficiency particulate air (HEPA) filters for the metal facility are assumed to keep functioning, while the oxide HEPA system does not function. This seems inconsistent.

- The oxide release fractions appear to be based upon fuel pellet data sintered from powders (i.e., submicron grain size), sintered too close to the theoretical density of uranium dioxide (11 g/cc). It is not clear how this data applies to the lower density uranium dioxide pellets (i.e., 6 g/cc, expect a somewhat higher release fraction) and the density of the solution formed gelation particles (much larger grain sizes — expect a lower release fraction).

- Table H-5 of the PEIS categorizes a furnace failure as an "incredible" event while the EAR (page 6-11-7-6) implies 8×10^{-5}/yr.

These points should be discussed and explained better in the PEIS, and values corrected as required.

Response 35

The text in Section 5.5.1.2.2 of the PEIS (including page 5-71 of the Draft PEIS) is comparing aggregate results of the highest consequence accidents within 4 frequency categories between the oxide conversion options and the metal conversion options. For the low-probability accidents associated with metal conversion, the highest consequence accident (fire involving three cylinders) still has a relatively low radiation dose of 15 mrem for the maximally-exposed individual (MEI) in the general public, because the accident is associated with a fire, which has a buoyant plume that moves upward and disperses in the atmosphere prior to sinking back to ground level at some distance from the release point. In comparison, the dose of 270 mrem is associated with an earthquake at a U_3O_8 (not UO_2) conversion facility (see Table F.9 for details on each highest consequence accident in each frequency category). Much of the difference in predicted consequences for accidents involving U_3O_8, UO_2, and uranium metal are associated with the form of the material. U_3O_8 is an easily-dispersed powder, whereas only the oxide coating on uranium metal billets can be readily dispersed. Releases from drops of UO_2 pellets are somewhat more similar to releases from drops of metal billets. Text has been added to Section 5.5.1.2.2 (page 5-71 of the Draft PEIS) to clarify the reasons that the consequences of some of the accidents associated with the use as metal alternative are lower than those associated with the use as oxide alternative.

The size of releases from UO_2 shielding- and metal shielding-manufacturing facility accidents would depend on the exact accident scenarios; in some cases releases from accidents involving UO_2 pellets will be smaller than those associated with uranium metal billets. The mishandling/dropping of solid DU metal accident questioned in the comment did have a higher assumed release than the mishandling/dropping of a UO_2 drum; this was mainly because the metal billet contained more uranium than the drum, so there was more material at risk (see Section 6.11.7 of the EAR for further details). The other specific questions regarding the EAR assumptions are addressed individually below.

For page 6.11-7-6, the release fraction and damage fraction must be considered together. For the metal, the 30% damage fraction indicates that 30% of the billet would be "broken up" on hitting the floor; the respirable release fraction was 4×10^{-3}. For the oxide, a damage fraction of 100% was assumed because all the small pellets would be released; however, the respirable release fraction was lower than that for the metal accident (1×10^{-7}).

For pages 6.11-7-7 and 6.11-7-8, again the damage fraction and release fraction must be considered together. The 6×10^{-3} release fraction is for a disturbed molten metal surface, and was measured using very small amounts of material. The damage fraction of 1% was based on the amount of the molten metal that would be exposed to the ideal release conditions, the rest would be part of the "glob" that solidifies on the cool surface on which it lands. The release fraction of 5×10^{-5} for UO_2 pellets is based on the dense, hard nature of the pellets; however, the damage fraction for the pellets is 100%.

For the "Shield Failure After Casting" accident on page 6.11-7-8, again the damage fraction and release fraction must be considered together. For the metal-shielded cask, a damage fraction of 0.1% was assumed in conjunction with a release fraction of 6×10^{-3} (i.e., a combined factor of 6×10^{-6}). For the UO_2-shielded cask, the combined factor of 1×10^{-7} was given in the text. This was comprised of a release fraction of 5×10^{-5} and an assumed damage fraction of 0.2%.

With regard to the release fractions assumed for metal accidents, DOE-HDBK-3010-94 page 4-2 states the bounding ARF (airborne release fraction) is 1×10^{-3} for oxidation of stationary metal, 1×10^{-2} for free-falling metal droplets, and 1.0 for explosive dispersal of metal droplets. Explosive dispersal is based on generating metal drops by the exploding wire technique and accelerating the drops to sonic velocity by an electrostatic device. A molten uranium spill due to loss of containment (failed melter or piping) is not expected to be this violent. The EAR used an ARF of 6×10^{-3}, which is the median ARF for free-falling molten uranium drops (p. 4-40 of DOE-HDBK-3010-94).

For analysis of the oxide and metal design basis events, the earthquake scenario is based on an unlikely accident. The oxide shielding process building is Performance Category (PC)-2, which implies failure of the structure and confinement systems is an unlikely event. Thus the oxide earthquake assumed complete failure of HEPA filtration. The metal shielding process building is PC-3, which implies complete failure of the structure and confinement is an extremely unlikely event. Thus the HEPA filters were assumed to continue to function (with some degradation) in the metal facility. The regulatory basis for the design and assignment of PCs for the two shielding manufacturing facilities is provided in Section 6.11-2 of the EAR. The main reason for assignment of different PC's for the two buildings is the difference in their hazard rating; the low temperature oxide shielding facility is ranked as a low hazard facility whereas the high temperature metal shielding facility is ranked as a moderate risk facility.

With respect to the UO_2 pellet density assumptions, the UO_2 pellets were assumed to be sintered to 90% of the theoretical density, or a particle density of 9.8 g/cc. The bulk density was assumed to be about 5.9 g/cc, based on a pellet packing factor of 0.6. Particle density for UO_2 nuclear fuel pellets, oxide shielding pellets and microspheres will be similar, and the release fractions can also be assumed to be similar.

The incredible event in Table H-5 is the simultaneous failure of eight melters, the structure, and the confinement system. The 1.1×10^{-5}/operation shown on page 6.11-7-7 of the EAR is the frequency of melter failure only, not the structure or confinement. The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 36

Metal Cask Waste: Page 5-76 of the PEIS presents waste management for the metal cask manufacturing route. Waste management appears to have overlooked secondary wastes related to manufacturing, which are unique to uranium metal. For example, induction furnaces for uranium metal are usually lined with graphite, which requires periodic removal and replacement (sometimes as frequently as every ten charges). Also, while the proposed approach appears to use primarily direct casting, some uranium metal machining operations may be required, and, historically, these generate significant wastes containing partially oxidized uranium metal, The PEIS should include these potential impacts that primarily affect only the metal route.

Response 36

The graphite liner wastes from induction furnaces used in casting of uranium metal are included in the operations waste of the metal manufacturing facility (see Section 5.5.7 of the PEIS). Table H.15 of Appendix H lists the operations waste (LLW) for both the uranium oxide and uranium metal facilities. The difference in the quantities (650 m^3/yr and 126 m^3/yr) is due primarily to the graphite liner wastes mentioned in the comment.

While some machining operations may be required during the uranium metal fabrication process, almost all of this machining will be on uncontaminated stainless steel parts. Very little LLW is expected from the machining of uranium metal.

Comment 37

Waste Disposal Section 5.6 (pages 5-78 et seq) and Appendix I present the impacts from disposal of the DU, for both the operational phase and the post-closure period. The radiological impacts from the accidents seem unexpectedly high. For example, public doses of up to 1.1 rem and noninvolved worker doses as high as 140 rem are determined, apparently due to earthquake initiated events, without explanation. The routine impacts also seem high for the post-closure phase and appear to follow the radiological order: mine impacts > vault impacts > trench impacts. Calculations appear to use an infiltration area effect and do not account for chemical form, solubility, and kinetic

effects. Table I.31 contains values of zero for the dry site doses for all three disposal approaches, and no collective dose estimates are included. These points are not obvious and it is recommended that they are explained in more detail.

Response 37

With respect to radiological impacts from accidents associated with disposal options, the earthquake involving release of U_3O_8 was associated with high radiological doses, as noted by the commentor (see Appendix I, Table I.10). The high doses for U_3O_8 are due to the material form and the release height. U_3O_8 is a fibril material which is almost powder-like. This characteristic results in a higher release amount (400 pounds) compared to a similar accident with UO_2 pellets (0.7 pound) (see Appendix I, Table I.9). Additionally, an earthquake is assumed to cause structural failure of the building, during which the uranium oxide containers collapse and release the material at ground level. This is much different than the tornado event assumptions where the wind speeds are larger and there is some upward movement to the released material. The lower wind speed and ground release result in larger releases near the building and the surrounding areas for the earthquake event, and thus result in high worker and public doses. This type of specific accident scenario information is provided in the engineering analysis report (LLNL 1997; the full citation is provided in Appendix I of the PEIS) associated with the PEIS.

The routine impacts for the postclosure phase address the potential impacts from groundwater use. The groundwater could become contaminated as a result of container failures that release U_3O_8 or UO_2 to the environment. Although U_3O_8 and UO_2 are essentially insoluble in water, a conservative estimate of dissolution was obtained by assuming that Schoepite ($UO_3 \cdot H_2O$) would form under the aerobic conditions present in the soil phase. Estimates of groundwater concentrations were then obtained by assuming the leachate concentration in the waste area was equivalent to the solubility of Schoepite. As radionuclides travel downward to the groundwater table, distribution of radionuclides in soil solid and soil liquid phases were assumed in equilibrium. This assumption was acceptable because it would take very long time (at least several hundred years in the calculation cases) for radionuclides to reach the groundwater table and to reach the maximum concentration level. Potential impacts were calculated with the estimated maximum groundwater concentrations within 1,000 year after failure of the disposal facility.

On the basis of the above assumptions, the relative potential impacts would depend only on the dimensions of the disposal area and the infiltration rate. Factors such as solubility, chemical form, and kinetic effects would be the same for a mine, vault, or shallow earthen structure. Impacts for disposal in a mine would be greater because of the larger disposal area required. As noted in Section I.4.1.1.1, impacts for dry sites would be zero, because it would take more than 1000 years for uranium and its decay products to reach the groundwater table [due to a combination of the depth to the watertable (500 ft — Section 3.4.4.1) and the low rate of infiltration (0.1 in./yr — Section 3.4.4.1)]. Additional details on these calculations can be found in Tomasko (1997; the full citation is provided in Appendix I of the PEIS), as indicated in Section I.4.2.

Collective impacts were not estimated because it would require detailed information on the groundwater flow direction and distribution as well as knowledge of the off-site population that would use the groundwater. Since siting of a disposal facility is not addressed in this PEIS, estimation of collective impacts would involve a large degree of uncertainty, and was therefore not conducted.

The engineering analysis report, Tomasko (1997), and other supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 38

Other Uranium Forms: The primary uses the PEIS focuses on are uranium in concrete and DU metal for the shielding material. Other uses exist such as vitrified pellets with UO_2, and UO_2 composite material in a SNF cask. These have been published in the open literature and should be mentioned and referenced.

Response 38

As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. Although several other uses are noted in the PEIS, such as in Sections 2.2, 2.3, and Appendix H, the PEIS is not intended to present an exhaustive list of current or potential future uses of depleted uranium.

Comment 39

Low Estimates of Staffing Levels: The estimated numbers of staff required for several of the alternatives in the PEIS seem low. For example, the UO_2 pellet approaches use similar technologies to existing fuel fabrication facilities of 1,000 te/yr capacity which employ several hundred people. However, the PEIS estimates only 300 workers will be needed for a plant of 20,000 te/yr capacity. This seems low even considering economies of scale.

Response 39

A typical UO_2 fuel fabrication plant processes enriched uranium in numerous production lines with low capacity equipment (due to criticality concerns associated with concentrating a high mass of enriched uranium in a single location). The fuel fabrication plants have strict quality control, criticality control, security, and nuclear material accountability requirements. In addition to producing ceramic pellets, a typical UO_2 fuel fabrication plant perform fuel pin loading and assembly of nuclear fuel, scrap recovery, waste processing, and process development. As a result, the number of employees is high.

The depleted UO_2 conversion plants considered in the PEIS assumed continuous process operation using two or three lines of high-capacity equipment. Plant design and staffing was assumed to be similar to a chemical plant using proven processes and equipment. The process was automated and controlled from a central control room. Process operations were continuous so that startup/shutdown was infrequent. The labor intensive operations were cylinder handling and product drum handling. Each process system was assigned 1 to 2 operators. A supervisor was provided for every 6 operators. Management, technical, maintenance, and administrative personnel were mainly on-day shift. Operators and security personnel were on 3 shifts. Depleted UO_2 conversion plant employees typically numbered 230 persons. An approximate 5% contingency was provided in operation cost estimates for possible labor increase.

Employment data for comparison include: The Cameco Blind River plant purifies uranium concentrates to UO_3 product by dissolution, solvent extraction, and denitration. This is a modern plant built in 1984. Production was 12,000 tonnes uranium per year in 1997 with 100 employees. The Cameco Port Hope plant started up new units in 1980 and 1984 to produce UF_6 and UO_2. Production was 12,000 tonnes per year in 1997 with 300 employees. The LES Clairborne Centrifuge Enrichment Plant Environmental Impact Statement (NUREG-1484, August 1994) stated 180 employees will be needed.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Commentor No. 90: Bowers, Brian

Comment 1

The PEIS describes the preferred alternative as "to use the entire inventory of material." This is misleading. The goal is to use the material but since there is little demand at present, the actual action is continued storage indefinitely. Demand for use of the material, as stated in the PEIS, is quite limited at present. It is accurate to say that the material would be converted and reused as demand dictates but it is misleading to emphasize the speculative portion of the alternative when, in reality, it could be stored as UF_6 for a long time. I agree that the best alternative is to continue the safe storage of the UF_6 and convert/use it as demand dictates, but I think the PEIS needs to clearly present the preferred alternative in those terms rather than mislead the reader into focusing on uses that have yet to be identified.

Response 1

The preferred alternative is described in Section 2.5.1 and in Section 5.7 of the PEIS. The discussion of the preferred alternative in the Final PEIS was modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim

storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products.

Comment 2

The main conclusions of the cost analysis report should be included in the analysis of socioeconomics in the PEIS. It is misleading and irresponsible to analyze only the perceived benefits (employment, increased local revenues) and not consider the costs. Who is going to pay for these actions and how much is it going to cost? In this era of taxpayer dissatisfaction, consideration of costs must be included in any socioeconomic analysis as this is certainly a potential impact on the human environment.

Response 2

The purpose of the PEIS is to provide an analysis and comparison of the potential environmental impacts of alternative management strategies. The cost of alternatives is generally not considered an environmental impact; consequently, cost information is not provided in the PEIS. However, cost information for the PEIS alternatives is provided in the document "Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride" (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). The cost analysis report is available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

In addition, the cost information is used as input to the socioeconomic analysis presented in the PEIS. The PEIS addresses socioeconomic impacts on human communities, including changes in employment, local housing demand, public finances, and population in-migration. These socioeconomic impacts may be either positive (increased employment or revenues) or negative (decreased employment or revenue).

The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, including socioeconomic impacts, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 3

The PEIS does not adequately evaluate the impacts associated with the empty steel cylinders that would be generated in the event of conversion and/or reuse of the material. What to do with over 46,000 14-ton, radioactively contaminated steel cylinders is an extremely important part of the

long-term management strategy and must be appropriately analyzed and considered in any decision making. The PEIS does not demonstrate adequate analysis of this issue.

Response 3

The management of empty cylinders is addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). In the PEIS, for each alternative requiring conversion, the impacts of constructing and operating a cylinder treatment facility were included in the impact analysis. This analysis assumed an initial storage period of 3 months after UF_6 removal from the cylinders to allow the level of radioactivity associated with the decay products of uranium to decrease to acceptable levels. The cylinders would then be washed with water to remove the heels; finally the cylinders would become part of the DOE scrap metal inventory. See Appendix F of the PEIS for specific impact analyses for the cylinder treatment facility. As a part of the waste management analyses in the PEIS, the impact of disposal (i.e., burial) of the empty cylinders as low-level waste was also examined (Section F.3.7.4). It was found that the empty cylinders would represent only approximately 3% of the projected DOE complex-wide volume of LLW expected to be generated during the time period examined (i.e., through about 2030).

The above-cited report by Nieves et al. analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial) as LLW, and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses.

The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 4

General — I understand the accident analysis methodology in terms of probability and consequence. However, I could not find in the PEIS where such "statistical" accidents were matched to real accident scenarios. From comments on other documents, it is clear this is what the public wants to know. They want to know about the probability and consequences of a tornado and an earthquake. I could not tell if such scenarios were adequately represented in the PEIS.

Response 4

The PEIS considered a spectrum of accidents, from accidents that could occur relatively frequently (e.g., handling accidents involving UF_6 cylinders) to those that could potentially occur once during 1,000,000 years (e.g., a vehicle-induced fire that affects a total of 3 cylinders). The summary tables in the PEIS (e.g., Tables S.2 and 2.2) provide information concerning the accidents with the highest consequences for various frequency ranges. Natural phenomena events such as earthquakes and tornadoes were considered and analyzed in the Safety Analysis Reports for the three sites (LMES 1997a-c; the full citations are provided in Appendix C of the PEIS), and in the engineering analysis report (EAR) (LLNL 1997; the full citation is provided in Appendix C of the PEIS); the results were presented in the PEIS when the consequences of the natural phenomena accidents were the highest of all accidents in that frequency category (see Sections D.2.2, E.3.2, F.3.2, G.3.2, H.3.2, and I.3.2 for details on the accidents considered). These sections contain information about both expected frequency and consequences of specific accidents.

Further information concerning the consequences of the various accident scenarios considered in the PEIS is provided in the following document:

Policastro, A.J., et al., 1997, "Facility Accident Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement."

The EAR, the Policastro et al. document, and other supporting reports are available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 5

There are still numerous places where the West Kentucky Wildlife Management Area is incorrectly referred to as the Western Kentucky Wildlife Management Area.

Response 5

The term "Western Kentucky Wildlife Management Area" has been corrected to read "West Kentucky Wildlife Management Area" in Sections S.3, 3.1, and 3.1.6.3 of the PEIS.

Comment 6

p. S-3, para. 2 — I challenge the notion that the current management plan calls for conversion to triuranium octaoxide. Where is this written? How would conversion and disposal be paid for?
This is not considered part of No Action.

Response 6

As stated in Section 1.1 of the PEIS, the former management plan for depleted uranium hexafluoride is described in a 1992 memorandum from P.G. Sewell (Deputy Assistant Secretary for

Uranium Enrichment, Office of Nuclear Energy, NE-30) to L.P. Duffy (Office of Environmental Restoration and Waste Management, EM-1) entitled "Plans for Ultimate Disposition of Depleted Uranium Hexafluoride." This memorandum states that if no alternative uses are found to be feasible by 2010, then steps would be taken to convert UF_6 to triuranium octaoxide beginning in the year 2020 and then stored or disposed of. It is not specified in this memorandum how conversion and disposal would be paid for.

The no action alternative originally announced in the Notice of Intent to prepare the PEIS (61 FR 2239) was based on the actions outlined by Sewell. However, after public scoping and based on internal DOE reviews, it was determined that the no action alternative should consider the continued storage of depleted UF_6 in cylinders at the three current storage sites through the year 2039. This definition of the no action alternative was intended to provide a baseline against which other management strategies could be measured, including strategies involving storage, use, and disposal of uranium oxide.

Comment 7

Section 3, general — Based on the text on page 3-1 and Figure 3.1, the PEIS describes the "Paducah site" as including all of the land owned by DOE including that licensed to the Commonwealth of Kentucky. The PEIS describes the "PGDP" as a 750-acre industrial area within the Paducah site. As there is a security fence around the 750-acre area (actually 748 acres) and the area outside this fence is primarily wooded, it is appropriate to discuss these separately, where necessary, to distinguish differences in the two environments. However, the PEIS makes numerous mistakes when describing various aspects of the two environments, apparently due to confusing the "Paducah site" with the "PGDP." For example, Section 3.1.6.3 states that there are no wetlands "identified on the Paducah site by the National Wetlands Inventory." This statement would be correct for PGDP but not the Paducah site. These errors are pointed out in the specific comments below.

Response 7

The text of Section 3.1.6.3 of the PEIS has been corrected to distinguish the PGDP and the Paducah Site. No other instances of this error in the use of "the Paducah site" term were located.

Comment 8

In addition, the PEIS often does not use the most current and accurate information readily available. For example, the National Wetlands Inventory does not provide very useful information for anyone wanting to know about wetlands that occur on the Paducah site. Two reports that should be used include:

U. S. Department of the Army, Corps of Engineers — Nashville District and Waterways Experiment Station, Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area McCracken County, Kentucky, Volumes I — V, May 1994

CDM Federal Programs Corporation, Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant, August 19, 1994, Document Control Number 7916-003-FR-BBRY

The first document reports on wetlands, flood plains, cultural resources, and threatened/endangered species on and near the PGDP , primarily outside of the plant security fence. The latter document reports on wetlands and threatened/endangered species inside the plant security fence. There have been some informal updates to these reports since they were issued.

Response 8

The National Wetlands Inventory is the only consistent wetland information for U.S. wetlands and is typically included in NEPA analyses. The references indicated in the comment have been included in the Final PEIS, with text added to Section 3.1.6.3.

Comment 9

Two sensitive resources common to the DOE reservation at PGDP but not analyzed in the PEIS are 100-year flood plains and prime farmland. Granted, there would not be much analysis based on the PEIS approach of deferring site-specific evaluations to later NEPA documents. However, the PEIS should include these resources in site descriptions and evaluate for potential impacts at the appropriate time. Information on flood plains at PGDP is reported in the Corps of Engineers report referenced above. Prime farmland information is available from site personnel or local offices of the Natural Resources Conservation Service.

Response 9

As noted by the commentor, as a programmatic EIS (PEIS) this document does not propose new site-specific projects, although site-specific impacts from continued cylinder storage and cylinder preparation for transport are evaluated (Appendix D and Appendix E, respectively). Future planning and environmental analysis will address flooding potential and prime farmland, as appropriate.

Comment 10

Section 3 should be thoroughly reviewed and revised to accurately describe the affected environment. Consequently, analysis of potential impacts should be revised, where necessary.

Response 10

Section 3 has been revised in response to specific comments (for example, discrepancies between use of the term "PGDP" and "the Paducah site" have been eliminated). The background material used to prepare Section 3 consisted mainly of annual site environmental reports prepared for each of the three current storage sites. DOE is not aware of any additional inaccurate information in Section 3 which requires revision.

Comment 11

Sec. 3.1 — The PEIS does not provide an accurate portrayal of the size and location of the West Kentucky Wildlife Management Area (WKWMA). WKWMA totals about 6823 acres of which the state owns 3106, 1986 acres are licensed from DOE, and 1731 acres are licensed from the Tennessee Valley Authority. WKWMA completely surrounds PGDP. Much of the area referred to in the PEIS as the Paducah site is also part of WKWMA. This is not reflected in Figure 3.1 or in some of the analyses of impacts.

Response 11

The Paducah Site Annual Environmental Report for 1996 (LMES 1997c; the full citation is provided in Chapter 8 of the PEIS) states that "Of the 3062 ha (7566 acres) acquired by the Atomic Energy Commission, 551 ha (1361 acres) were subsequently transferred to the Tennessee Valley Authority (Shawnee Steam Plant site) and 1125 ha (2781 acres) were conveyed to the Commonwealth of Kentucky for use in wildlife conservation and for recreational purposes (West Kentucky Wildlife Management Area)." The value of 2781 acres of DOE land licensed to the WKWMA is consistent with the value given in Section 3.1 of the PEIS. However, the text in the Draft PEIS did imply that the land licensed from DOE comprised the entire WKWMA; text has been added to indicate that this is only part of the WKWMA.

Comment 12

Sec. 3.1.5.1 — DOE received a new KPDES permit on March 13, 1998. The PEIS should be revised accordingly to reflect the changes.

Response 12

Section 3.1.5.1 has been revised to incorporate the two new Kentucky pollutant discharge permits (DOE [four outfalls — 3 to Big Bayou Creek at mile points 5.6, 6.2 and 7.1; and 1 outfall to an unnamed tributary of Little Bayou Creek at mile point 0.25] and USEC [10 outfalls — 5 to Little Bayou Creek at mile points 4.6, 4.8, 5.0, 5.3, and 5.6, one to an internal outfall to Big Bayou Creek, and 4 to Big Bayou Creek at mile points 6.0, 6.3, 6.8, and 6.6]

Comment 13

Sec. 3.1.6.3 — The PEIS is incorrect — there are many wetlands on the Paducah site. In fact, some were filled in to build the latest cylinder storage yard.

Response 13

The text of Section 3.1.6.3 has been revised to more clearly differentiate "Paducah site" and "PGDP" wetland occurrences. Additionally, the text has been revised to state that wetlands occur on the Paducah site and in some ditches on the PGDP.

Comment 14

Sec. 3.1.6.4 — The information here with regards to threatened and endangered species is misleading. First, there is a lot of significant potential summer habitat for the federally endangered Indiana bat so it is quite likely it occurs on the Paducah site. Second, there is no state list with any enforceable protection standards. I applaud the PEIS for looking at these "state-listed" species but their legal status should be made clear.

Response 14

The Indiana bat habitat, initially considered to be outside the "site," is in fact outside the PGDP but on the DOE "site." Text in Section 3.1.6.4 has been changed accordingly. The legal status of state-listed species and DOE's consultation requirements would be determined in a future site-specific analysis.

Comment 15

Sec. 3.1.10 — Overall, the description of cultural resources is current and well done. However, there is at least one cemetery on the Paducah site, just north of PGDP.

Response 15

The text has been changed to reflect that no cemeteries are located within the PGDP (rather than on the Paducah site). The two cemeteries north of PGDP, Harmony Cemetery just outside of the PGDP security fence near the landfill, and an unnamed, unmaintained cemetery to the northeast of the PGDP, are mentioned.

Comment 16

Sec. 5.8 — The PEIS purports to include other past, present, and future actions, and non-DOE actions in its cumulative impacts analysis. However, no specific actions are identified. In order for the reader to assess if cumulative impacts were adequately assessed, the PEIS needs to include specific information on what other activities were considered.

Response 16

Footnote "a" on each of Tables 5.12 (Paducah site), 5.13 (Portsmouth site), and 5.14 (K-25 site), which occur in Section 5.8 of the PEIS, documents the other reasonably foreseeable future actions considered at each current storage site for depleted UF_6. The topic of environmental restoration has been reexamined, and the impacts of those activities in the recent past and present for which adequate information on associated impacts is available also have been added to the cumulative impact calculations — identified once again in footnote "a" of each of the above tables. As discussed in Section 5.8, the PEIS assessed cumulative impacts only for those sites as they are the only locations at which activities are certain to occur (and thus where impacts are certain to accumulate).

Comment 17

Pages D-3 to D-5 tell me all I really need to know regarding potential impacts. Continued storage (No Action Alternative) would result in an estimated worst case of 59 cylinder breaches through 2039. Impacts from these breaches would be minimal. On the other hand, the action alternatives would result in an estimated worst case of 731 breaches through 2039. On the basis of potential impacts alone, it is clear that No Action is environmentally preferable. The PEIS needs to clearly state this in all summary text areas.

Response 17

As explained in the Introduction to Section 5.1 and the Introduction to Appendix D, two analyses were actually conducted for the No Action Alternative; one assuming that the cylinder maintenance and painting program would be effective in controlling further corrosion of the cylinders, and a second analysis which assumed that external corrosion was not halted by improved storage conditions and painting so that cylinder corrosion continued at historical rates. The commentor is correct that a total of 59 cylinder breaches through 2039 was estimated for the "base" case of the No Action Alternative (i.e., assuming that further cylinder corrosion is controlled); however, the estimate of 731 breaches through 2039 was actually for the second No Action Alternative analysis (i.e., assuming that cylinder corrosion continued at historical rates), and not for the action alternatives as stated by the commentor. The rationale and supporting references for the assumed breach rates are detailed in Appendix B of the PEIS.

The number of breaches assumed under the action alternatives, including long-term storage as UF_6, fell between the numbers assumed for the two No Action Alternative analyses. Under the action alternatives, corrosion was assumed to continue at historical rates, but the cylinder population was assumed to be decreasing at 5% per year. These were considered to be reasonable assumptions, because it is less certain that ongoing cylinder yard improvements and cylinder painting would be strictly maintained for the decreasing cylinder inventory under the Action Alternatives. The outcome of the increased number of assumed cylinder breaches for the action alternatives was a slightly higher estimate of impacts on groundwater, air quality, and human health and safety for the action alternatives, although the estimated impacts are still within applicable standards or guidelines. Further details on the assumed cylinder breaches under the action alternatives, and the impact of these assumptions on the analyses, are given in the Introduction to Section D.4 of Appendix D.

Comment 18

General (Overall Conclusion) — The PEIS clearly supports continued storage of the material as UF_6 until viable uses are identified (called No Action in the PEIS). Continued storage, with the assumption of at least partial use by the year 2039, is shown to have the fewest environmental impacts. It is also, by far, the least costly alternative although the PEIS is deficient in showing this. Finally, continued storage for several more years with little adverse impact would allow for further demands for the material to be developed and speculative measures, such as conversion or consolidation, would not be necessary at this time. It is disappointing that all of DOE's

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effort did not result in any significant, realistic near-term uses for the material but at least the PEIS shows that continued storage as UF_6 at the current sites would not present unmanageable problems.

Response 18

The commentor's preference for the No Action alternative is noted by DOE. It should be recognized that the results of the PEIS indicate that all alternatives have generally similar environmental impacts, although differences do exist in the types and magnitude of impacts for some areas assessed, as discussed. No alternative offers clear environmental advantages in all areas, and no alternatives are precluded on purely environmental grounds. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products.

Commentor No. 91: MacMullen, Michael W.
U.S. Environmental Protection Agency

Comment 1

It is our agency's opinion that the depleted uranium hexafluoride (UF_6) should be converted to a form that is more stable and less hazardous, such as uranium oxide (U_3O_8) for long term storage or until an alternative use can be found and we applaud your management program for proposing this alternative.

Response 1

The EPA's preference for conversion of depleted UF_6 to uranium oxide for long-term storage until uses are identified is noted. In response to comments received from the U.S. EPA and others on the Draft PEIS, DOE has revised its preferred alternative. As described in Section 2.5.1 of the PEIS, the revised preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and/or metal products for use.

Comment 2

In accordance with our responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, we have reviewed the information that you submitted. Based on the information provided, we have rated this DEIS EC-2. The EC portion of the rating indicates that we have environmental concerns and the 2 portion of the rating indicates additional information data, analyses or discussion should be included in the final EIS. To satisfy these concerns, please provide additional discussion, data, and/or analysis to address the following:

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Response 2

EPA's rating of EC-2 for the PEIS is noted. DOE has reviewed EPA concerns and provided a discussion of these as indicated in response 1 above and in the following responses. These responses indicate where the PEIS has been revised in response to EPA's comments.

Comment 3

A single location for a conversion pilot plant should be identified to evaluate the engineering and other demands of converting the material. After experience has been gained operating a stabilization process in a single location, consideration should be given to whether the single plant, or plants at multiple locations would be best suited to converting any remaining material.

Response 3

The purpose of the PEIS is to provide a meaningful evaluation and comparison of the potential environmental impacts of broad alternative management strategies. The Record of Decision for the PEIS will announce the selection of a management strategy, but will not specify sites or specific technologies to be used. Thus, consideration of the construction and operation of pilot plants is beyond the scope of the PEIS. Future planning and environmental analyses will address issues related to engineering and site-selection for depleted UF_6 management strategies, consistent with all applicable laws and regulations, including the public law 105-204 which was signed into law in July 1998.

Comment 4

Until such time as the DUF_6 is converted to a more stable form, a long-term storage strategy should be developed to address issues surrounding deteriorating storage canisters.

Response 4

A storage strategy has been developed to address continued storage of the cylinders. This plan is described in the cylinder project management plan for the three sites (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS). Under this plan, new storage yards with stabilized concrete bases and improved drainage have been constructed at the Paducah and Portsmouth sites. Cylinders are being relocated to allow space for adequate visual inspections; relocated cylinders are being placed on concrete saddles to keep them out of ground contact. Each site has an intensive cylinder inspection program to allow identification of any damaged or breached cylinders as well as a radiological program to detect leakage from valves. Annual inspections are required for those cylinders that have previously been stored in substandard conditions and/or for those that show areas of heavy pitting or corrosion. All other cylinders must be inspected once every four years. Due to the improved storage conditions and frequent inspections, any breached cylinders identified in the future are expected to be recently breached with little material loss.

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Comment 5

Before transporting DUF_6 in storage canisters with deteriorated or uncertain integrity, secondary containment or other engineering measures should be employed to ensure safety comparable to that provided by new canisters.

Response 5

Due to the deteriorated condition of some of the cylinders, the DOE included in the PEIS evaluation of two methods for transport of cylinders which do not meet Department of Transportation requirements: (1) the use of overcontainers which would meet DOT requirements, and (2) on-site transfer of the substandard cylinder contents to new cylinders. Because the number of cylinders which will not meet DOT requirements at the time of transport is not known, the analysis assumed a range of values, including a worst-case assumption of 100% of the cylinders at each site. The details of the analysis of cylinder preparation for transport are given in Appendix E of the PEIS. It should be noted that if the overcontainer option were selected, the overcontainer would meet the same safety requirements as the conforming cylinders. Therefore, the safety basis for transportation of the cylinders would be the same irrespective of the option chosen for cylinder preparation. For further details on the preconceptual design of the overcontainer, see the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover of the PEIS.

Comment 6

U.S. Department of Energy (US DOE) and the United States Enrichment Corporation (USEC) should apply a single, compatible methodology to discharge their respective responsibilities for the materials.

Response 6

EPA's suggestion is noted. The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993, that became or will become the responsibility of DOE by the signing of two memoranda of agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). USEC, a private corporation, is responsible for decisions regarding the disposition of other depleted UF_6 that it produces. There may be coordination between DOE and USEC on the management of their respective depleted UF_6 inventories in the future but this coordination is outside the scope of the PEIS.

Comment 7

Conversion of this material should not be dependant on market demand. DOE should include plans to seek funds from Congress for conversion of all DUF_6.

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Response 7

The EPA's preference for not basing conversion on market demand is noted. In response to this comment and similar comments from others, the preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Comment 8

An appropriate budget should be submitted to adequately fund this process for the necessary time periods. Funding needs to be provided to insure the reduction of potential risks to the environment and to public health.

Response 8

Issues of DOE program funding are beyond the scope of this PEIS. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Comment 9

Be advised that you may require a Section 404 permit from the U.S. Army Corps of Engineers if wetlands will be impacted during this project. You should be in contact with them to determine whether this project will require such a permit. In accordance with the Section 404(b)(1) guidelines of the Clean Water Act, wetland impacts must be avoided and/or minimized whenever possible, and satisfactory compensation for unavoidable impacts must be provided.

With respect to the provision of compensatory wetlands, our Agency routinely finds that a minimum of 1.5 acres of compensatory wetlands are necessary to offset the loss of each acre of naturally occurring wetlands impacted by the project at issue. In addition, the compensatory wetlands should be designed to replicate as closely as possible the specific mix of types, functions and values provided by the project-impacted wetlands. The compensatory wetlands should be established via the process of restoration to the extent feasible, and they should be located in an area as close as practicable to the project-impacted wetlands.

Response 9

Comment noted. As a programmatic EIS (PEIS), this document does not propose site-specific projects. Future planning and environmental analysis on site-specific projects will address impacts to wetlands, including requirements for compensatory wetlands.

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Commentor No. 92: Barber, Alex / Kuryla, Timothy
Kentucky Department for Environmental Protection

Comment 1

The Division (of Water) finds the current facility emergency response contingency plans appear to be adequate. If UF_6 were to be used or stored in Kentucky, then pursuant to 401 KAR 5:037, a groundwater protection plan would be required.

Response 1

Comment noted.

Commentor No. 93: Elliott, Guy R. B.
Santa Fe Alloys

Comment 1

I believe that DOE offers reasonable evaluations and wise preferences among the alternative strategies, i.e., preferring 100 percent use of the UF_6 (i) for conversion to uranium as oxide or metal and (ii) using as much of the material as DOE can to leave it recoverable.

Roughly 99 times the potential energy of the bomb U-235 material remains with the U-238 DU residue- as some of your readers will know. This DU could all be used in breeder reactors to generate future electric power, and then it would have high economic value.

It would be an environmental tragedy to throw it away, yet many people urge discarding this "useless" metal.

I commend DOE's for trying its best to save the material and for how it has identified DU use for radiation shielding. This would leave the DU available and not wasted. Other uses are sought.

One of the saddest parts of this situation is that all the DU metal could be saved if we would--the DU volume from all UF_6 (and all that energy) could be stored in a cube less than 100 feet on the edge. But such storage is probably not politically feasible at this time.

Response 1

Commentor's support for the conversion and use of uranium metal is noted. The preferred alternative is described in Section 2.5.1 of the PEIS. The discussion of the preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium

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metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. Thus, the impacts of the preferred alternative may be the same as those presented for the use as oxide alternative (alternative 4) or the use as metal alternative (alternative 5), and may also include impacts from the storage of uranium oxide (see Sections 2.5 and 5.7 of the PEIS). The preferred alternative was not described as a distinct, separate alternative because it will, in practice, combine elements from several of the six alternatives evaluated.

It should be noted that there are no current or future plans in the U.S. for a breeder reactor program.

Comment 2

The Draft PEIS serves well in justifying the DOE preference above, but care must be taken that postulated processes are reasonably justified experimentally before they are heavily funded. Sometimes an overall process is not well evaluated to see if the pieces have been combined ways that are not awkward.

Specifically, in the case of the selected CMR production of depleted uranium metal, there should be evaluations and experimental confirmation of whether the old hydrogen reduction of UF_6 should be a precursor of the metal production, or if other approaches are better. Also, features such as minimization of radioactive transport (which the public dislike) should also be considered carefully.

Response 2

Commentor's recommendations for careful evaluation of processes are noted. DOE agrees with the commentor on the need for such careful evaluation. Please note that the implementation of any conversion processes will be by a competitive procurement process, which will allow for such evaluation, as recommended by the commentor.

Comment 3

The people doing the postulated process writeups have done well but further input is needed. Your public meetings may provide the input, especially as combined with private meetings from outside DOE.

Response 3

DOE agrees with the commentor's suggestions. To that end, DOE has held a number of public meetings in and around the three sites, as well as meetings in other locations to obtain the greatest input from public and industry representatives on the disposition of the depleted UF_6. DOE will continue to hold such meetings and to solicit input on the various processes or technical issues of conversion or uses.

4 ORAL COMMENTS AND DOE RESPONSES

4.1 PORTSMOUTH PUBLIC HEARING ORAL COMMENTS AND RESPONSES

Comment 1

David Cosar was quoted as saying uranium hexafluoride is highly corrosive. The affects of those high acids at sites such as Piketon, he says, are regarded as potential general emergency sites by the DOE, meaning if there are gas formations, it could require evacuations of nearby neighbors.

Response 1

If an accidental release were to occur, the uranium hexafluoride would react with water vapor in the air to form hydrogen fluoride (HF) and a uranium compound called uranyl fluoride. The uranium compound is not corrosive, but the HF is highly corrosive. The Portsmouth Site has an Emergency Plan in effect and conducts periodic emergency drills and exercises to prepare for any emergency situation. There are two levels of emergencies at the Site: (1) Alert — An Alert is declared if emergency hazards could affect plant personnel, but not the general public outside the plant boundaries. Local government officials are advised so that their resources and emergency responders are ready to assist on-site if needed. (2) Site Area Emergency — A Site Area Emergency is declared if the hazards could affect the general public within a two-mile radius of the plant boundaries. This is the most serious emergency situation and means that a significant release of hazardous materials may occur. All individuals within this notification area are immediately alerted and instructed on precautions and protection. Local government officials are notified immediately so that their resources may quickly focus on protecting the general public. Experts from the Site, Federal Agencies, and State and Local Officials coordinate emergency actions. Warning sirens are in place to sound for public alert should a Site Area Emergency be declared. There have been no such emergencies requiring warning sirens since the warning system was placed in operation in 1988. Periodically, the sirens are sounded for routine testing or during drills.

Comment 2

I would like to remind you of the 1978 spill here at Piketon plant, when over 28,000 pounds left the site by air, ground, and water and many workers were affected.

Response 2

On March 7, 1978, there was an incident that resulted in a liquid uranium hexafluoride release at the Portsmouth Gaseous Diffusion Plant. At approximately 4:36 p.m., in the X-745B cylinder storage lot, a 14-ton cylinder, 5/16" wall thickness, containing liquid natural uranium hexafluoride, was dropped 8-10 inches and ruptured. The result was the release of 21,125 pounds of feed material in less than five minutes. Emergency notifications and responses were rapid and there were no injuries to personnel and all exposure to radioactive materials were within allowable

limits of the plant. The time of the release, having occurred after shift change, reduced the number of persons on site. Additionally, the wind direction from the northeast to southwest caused the path of the UO_2F_2-HF cloud to be in a direction which affected the least number of facilities with the distance of travel to the site boundary. Precipitation in the form of snow, coupled with cold temperatures, minimized the off-site impact. There was a reported fish kill as a result of runoff from the incident area caused by treating the runoff with lime and causing a pH change in the water. This lime treatment aided in the prevention of off-site uranium contamination. An investigation of the incident determined that failure of the cylinder handling equipment used to transport the cylinder occurred. As a result, modifications were made to improve this equipment as well as eliminating the transport of uranium hexafluoride in the liquid state.

Comment 3

In September of 1996, another airborne plume went off-site. In between the lithium building, the storage building, and the National Guard building, this plume headed toward Wakefield. I have been told that workers were paid overtime and told to stay inside the buildings. I also called a reporter when this was happening. He called the plant and they lied about the release, and two days later, came out with their own release.

Response 3

On September 19, 1996, during routine movement of empty UF_6 cylinders, the operator of a cylinder handler inadvertently backed into one of the empty UF_6 cylinders that contained approximately 15 pounds of depleted uranium hexafluoride. This action resulted in the rear tire of the cylinder handler striking and severing a pipe nipple in the valve port of the cylinder, which resulted in a release of uranium hexafluoride. Two employees were in the immediate area at the time of the incident and both were evacuated. One employee contacted the Plant Shift Superintendent via hand-held radio and requested emergency assistance. An emergency 911 call was also made. A small, low-lying plume, which is the result of the chemical reaction of UF_6 and air, was evident at the base of the cylinder. This plume dissipated rather rapidly and there was no off-site impact. The area was isolated and the leak was stopped utilizing a standard plug. Health Physics surveys were conducted and the radiological contamination was verified to be contained within a four-foot square area beneath the valve end of the cylinder. An "all clear" for the area outside this boundary was given approximately 1-1/2 hours later. A DOE news release was issued within two hours of the incident to five area newspapers and four local radio stations. Environmental Compliance personnel determined that there was no CERCLA Reportable Quantity exceeded and no Emergency Planning and Community Right to Know Act (EPCRA) reportable quantity exceeded.

Comment 4

I would like someone to tell me why we have alarms and run through drills? When there is actually a potential dangerous release, there is no sounds of alarms to warn the citizens of the surrounding communities. Residents didn't know about the situation, so they weren't even told to stay inside.

Response 4

The Portsmouth Site has an Emergency Plan in effect and conducts periodic emergency drills and exercises to prepare for any emergency situation. There are two levels of emergencies at the Site: (1) Alert — An Alert is declared if emergency hazards could affect plant personnel, but not the general public outside the plant boundaries. Local government officials are advised so that their resources and emergency responders are ready to assist on-site if needed. (2) Site Area Emergency — A Site Area Emergency is declared if the hazards could affect the general public within a two-mile radius of the plant boundaries. This is the most serious emergency situation and means that a significant release of hazardous materials may occur. All individuals within this notification area would be notified immediately by audible voice alert from the plant. Additionally, messages can be directed immediately to local radio and television stations which provide protective actions that are recommended. These recommendations could be to evacuate or to shelter in place. Local government officials are also notified immediately so that their resources, which may include deputies and officers as well as volunteer fire personnel, may quickly focus on protecting the general public. Experts from the Site, Federal Agencies, and State and Local Officials coordinate emergency actions. Warning sirens are in place to sound for public alert should a Site Area Emergency be declared. There have been no such emergencies requiring warning sirens since the warning system was placed in operation in 1988. Periodically, the sirens are sounded for routine testing or during drills.

Comment 5

For the record, I would like to ask Mr. Osborne and Mrs. Osborne if they have ever been told that there was a release here at plant or to evacuate their home? MRS. OSBORNE: No. Were you sent documents, the big blue books for this meeting? MRS. OSBORNE: No. They live at the perimeter of the gates. So I am kind of wondering how many people that actually live right around the facility were actually sent these documents.

Response 5

Mr. and Mrs. Mount Osborne are residents within two miles of the Portsmouth Site. The Osbornes responded accurately that there has not been an occasion for plant officials to request an evacuation of their home due to a release from the plant. The "big blue books" the responder is referring to are the volumes of the "Draft Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride," dated December 1997. The Osbornes did not receive these volumes, however, they did receive the "Notice of Availability" mailed from DOE's Office of Nuclear Energy to all two-mile residents and the individuals on the general community relations mailing list. This notice advised them that the PEIS documents were available in the DOE's Environmental Information Center, which is the public information center located in Waverly, Ohio. These documents are available for public review in the Information Center and are provided free of charge to requestors. A news release and advertisements in the local newspapers were issued regarding the February 26, 1998, meeting date in Piketon, Ohio.

Comment 6

Charles Bradley, you didn't seem to believe me when I told you there was an airborne plume from the site when the valve was broken off. When they were moving the cylinders, something hit a valve and the airborne plume left the site.

Response 6

On September 19, 1997, during a routine movement of empty UF_6 cylinders, the operator of a cylinder handler inadvertently backed into one of the empty UF_6 cylinders that contained approximately 15 pounds of depleted uranium hexafluoride. This action resulted in the rear tire of the cylinder handler striking and severing a pipe nipple in the valve port of the cylinder which resulted in a release of uranium hexafluoride. Two employees were in the immediate area at the time of the incident and both were evacuated. One employee contacted the Plant Shift Superintendent via hand-held radio and requested emergency assistance. An emergency 911 call was also made. At that time, the area was isolated and the leak was stopped utilizing a standard plug. Health Physics surveys were conducted and the radiological contamination was verified to be contained within a four-foot square area beneath the valve end of the cylinder. An "all clear" for the area outside this boundary was given approximately 1-1/2 hours later. A DOE news release was issued within two hours of the incident to five area newspapers and four local radio stations. Environmental Compliance personnel determined that there was no CERCLA Reportable Quantity exceeded and no Emergency Planning and Community Right to Know Act (EPCRA) reportable quantity exceeded.

Comment 7

In the cylinders, you show how it comes out and goes back in. That is not the case in every incident with these cylinders. So I say that you either add other potential releases, how it will happen, or do away with the video to the public.

Response 7

The video referred to was shown at the public hearings. In part it illustrated how, when the workers opened the valve on a depleted UF_6 cylinder, air was drawn into the cylinder rapidly due to the less-than-atmospheric pressure inside the cylinder, making an audible sound. After a short while, a cloud of mist containing HF gas started to come out of the cylinder slowly. However, in the PEIS a wide spectrum of cylinder accidents was analyzed, including small breaches similar to the opening of the valve as illustrated in the video, and large catastrophic breaches. Details of the cylinder accident scenarios are provided in Section D.3 of Appendix D, and the impacts are discussed and summarized in Section 2.4.2 and Table 2.2.

Comment 8

I would like to show another picture of children around cylinders. This should not be allowed with all the information about the hazards of this product and the problem with the site hazards here at Piketon.

Response 8

The commentor is referring to a photograph of a tour conducted by Martin Marietta Energy Systems Public Affairs on March 11, 1993 for a group of high school students enrolled in the vocational school's electricity class. The purpose of the tour was to provide information regarding the uranium enrichment process and the ultimate customer of this process, the nuclear industry. The students were pictured at the plant's Product Sampling and Shipping Facility where cylinders of enriched uranium product are readied to ship to customers. Plant tours are conducted to better inform the public and are strictly governed by plant safety procedures regarding access to different areas of the plant. The depleted uranium hexafluoride storage yards are not typically on a tour route unless specifically requested by the tour group.

Comment 9

PRESS (Portsmouth-Piketon Residents for Environmental Safety and Security) considers the view that there is little effect to the public and its workforce to be a serious environmental justice concern. It was not addressed adequately in the Draft PEIS. PRESS, along with the Military Toxic Project, is asking for the comment period to extend to six months to give folks the opportunity to meet with you in a round table meeting, much like the Federal Facility Restoration Dialogue meeting. We need to have the opportunity to discuss the strategies that have been proposed. I am putting on the record the letter from the Military Toxics Project.

Response 9

The approach used in the PEIS to assess environmental justice concerns is consistent with guidelines in "Environmental Justice: Guidance Under the National Environmental Policy Act" (Council on Environmental Quality 1997; the full citation is provided in Chapter 8 of the PEIS). The approach taken involved a two-step process to identify impacts associated with environmental justice (see Section 4.3.12 of the PEIS). The first step concerns the presence of disproportionately high percentages of low-income or minority populations in those areas anticipated to experience high and adverse impacts. The second step concerns the presence of high and adverse impacts in general, and thus affecting the total population. Section C.8 of the PEIS provides a detailed discussion of the methods used to identify and assess potential environmental justice impacts.

Because one must know the economic and racial composition of an area potentially affected in order to assess environmental justice impacts, the assessment must be site-specific. In the PEIS, the only alternative components for which locations are known are continued cylinder storage (Appendix D) and cylinder preparation (Appendix E). For these components, environmental justice issues were examined thoroughly (see Sections D.2.11 and E.3.11 which discuss environmental justice impacts). As discussed in these Sections, no high and adverse human health effects or environmental impacts would be expected from continued storage of cylinders or cylinder preparation activities at the Paducah, Portsmouth, and K-25 sites. Because of this general lack of high and adverse impacts, and because minority and low-income populations would not be more prone than the general population to experience impacts from the two site-specific activities, no

environmental justice impacts are anticipated. With regard to the remaining four alternative components (that is, conversion, long-term storage, manufacture and use, and disposal), because their locations currently are unknown no environmental justice evaluation could be conducted in the PEIS. If in its Record of Decision for this PEIS DOE selects an approach to the management of its depleted uranium inventory that involves any of these alternative components, possible sites will be identified and those sites evaluated in subsequent NEPA documents, as described in Section 1.4 of the PEIS. One component of those evaluations would be an assessment of environmental justice impacts.

DOE announced a 120-day public comment period upon publication of the Draft PEIS in December 1997. This comment period was much longer than the 45 days required by Council on Environmental Quality and DOE regulations implementing the National Environmental Policy Act. As part of the public review process, DOE held public hearings in Oak Ridge, Tennessee; Paducah, Kentucky; Portsmouth, Ohio; and Washington, D.C. DOE believes this comment period was of sufficient duration to allow review of the Draft PEIS and submittal of comments by government agencies, potentially affected communities, and other individuals and organizations.

Comment 10

PRESS, on other views, should see in writing all agreements between the States of all three facilities, Oak Ridge, Paducah, and Piketon, all agreements between Congress, the U.S. DOE, and DOD and others involved.

Response 10

The commentor's preference is noted. Public documents containing information about the three storage sites are available in the DOE reading rooms located near each storage site, specifically, Waverly, Ohio; Kevil, Kentucky; and Oak Ridge, Tennessee. Specific requests for documents related to the Depleted UF_6 Management Program may also be made at these locations.

Comment 11

The EPA was to fine this facility, and I believe over the DU cylinders. We would like to know why and how much and what has happened and the agreement. I would like to remind you that Piketon has never been licensed to store, accept radioactive waste and we have broken many laws by doing so.

Response 11

The Ohio Environmental Protection Agency has issued a Director's Final Findings and Orders (DFF&O) on the management and storage of depleted uranium hexafluoride and lithium hydroxide at the Portsmouth Site, as journalized on February 24, 1998. The DFF&O outlines the management, surveillance and maintenance, inspection requirements, and other requirements for the depleted UF_6 storage yards and cylinders owned by DOE at the Portsmouth Site. The Department of Energy agreed to pay a $193,000 in settlement of a variety of compliance issues

including issues associated with storage of depleted UF_6 and Lithium with the Ohio EPA and the Ohio Attorney General's Office and to implement the management and storage plans addressed under the DFF&O. A Resource Conservation & Recovery Act (RCRA) Part B hazardous waste storage permit was issued in August 1995 to the Portsmouth Gaseous Diffusion Plant by the Ohio Hazardous Waste Facility Board for the storage of mixed (containing both radioactive and hazardous constituents) and hazardous wastes. All wastes are managed in accordance with federal and Ohio hazardous waste management laws.

Comment 12

You have continuously withheld information from the citizens about the radioactive releases, whether planned, routine, or accidentally: PRESS feels there is a number of cylinders no longer inventoried, and would like to know who is hiding them, were they stolen? Is someone also doing conversion?

Response 12

It is the Site's policy to provide information to the public accurately and on a timely basis. News releases are issued on any significant issues and copies of documents are provided upon request. Emergency procedures are in place to notify the public and the appropriate authorities external to the Site should a release or any off-normal event occur that would result in any off-site impacts. Any questions regarding specific incidents may be directed to the Public Affairs Office at the Portsmouth Site, 740/897-2336.

The DOE inventory of depleted uranium hexafluoride cylinders remains constant. There have been no shipments of DOE depleted uranium to perform conversion to another form, although several companies possess the technology and ability to perform this operation. However, since the completion of the draft, the scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS. About 3,000 to 4,000 of all the cylinders that USEC will transfer to DOE are expected to be at Portsmouth.

Comment 13

PRESS is worried that an earthquake could create multiple cylinder failures at all the sites, and are so worried about the possibility of aircraft wreckage. There was a plane wreck here not long ago. One of the jets flew by pretty close to this area and crashed. If one of these planes crashed into this facility, it would be a huge disaster.

Response 13

The seismic risk text in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1 of the PEIS has been modified to be consistent with material presented in the safety analysis reports (SAR) for the three sites (LMES 1997a-c; the full citations are provided in Appendix C of the PEIS). The SARs do recognize

and discuss the potential for multiple cylinder failures in association with an earthquake. The PEIS considered potential accident scenarios with frequencies as low as 1 in 10 million years, in accordance with NEPA guidance for environmental impact statements (EISs). This frequency range includes small plane crashes, which are analyzed in the PEIS. The flight paths of large planes avoid the site leading to an extremely low accident probability. Large plane crashes occur in the beyond incredible probability range (less than once per 10 million years), which the PEIS does not analyze.

Comment 14

We feel that until we find a safe way to handle these cylinders, maybe you could come up with a deal on wheels to heat these cylinders in place where stored and put in a new cylinder until new safety technology comes along.

Response 14

As noted in the PEIS, (see discussion of impacts under the no action alternative in Sections 2.4 and 5.1 and Appendix D), the continued storage of depleted UF_6 cylinders at the three current storage sites would be safe. The safety of current cylinder storage is supported by the revised safety analysis reports (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). In support of the PEIS, a number of options for off-site transportation of depleted UF_6 cylinders were reviewed and evaluated. One option for overfilled cylinders was a mobile system which would remove the overfilled portion of an existing depleted UF_6 cylinder while stored. Preliminary analysis of this option and other relevant options resulted in the consideration of the two cylinder preparation options in Appendix E of the PEIS, one of which transfers the contents of a substandard cylinder into a new cylinder, using cold feeding, a process similar to the one suggested by the commentor, except the transfer occurs in an onsite facility instead of in the cylinder yard.

Comment 15

I had a report from Gene Hoffman. He called and wanted to know if I would submit it on the record here. He has already submitted it to Paducah and Oak Ridge. I would like to put in the record a report from Gene Hoffman. Somebody also made copies. Also, a letter sent to "The New York Times" bureau from Leonard Dietz. I would like to submit that.

Response 15

Mr. Hoffman was a speaker at the Oak Ridge, Washington, D.C., and Paducah public hearings. Detailed responses to his comments are provided in Oak Ridge public hearing comments and responses 29-41 and in D.C. public hearing comments and responses 24-48. Mr. Hoffman also submitted written comments that included the report mentioned in this comment. Mr. Hoffman's written comments are in comment letter No. 53 in Chapter 2 and the responses appear in Chapter 3 of this document.

Leonard Dietz's letter was printed as an attachment to comment document No. 80 (see Chapter 2 of this document). The concern raised in the letter focuses on the increased radioactivity

of depleted uranium due to the build up of U-238 decay products. The PEIS analyses considered the impacts associated with the build up of U-238 decay products. In fact, the PEIS analyses assumed that Th-234 and Pa-234, the two short-lived decay products of U-238, were in secular equilibrium with U-238. See Section F.2 of the PEIS.

Comment 16

It is really a tragedy here that you people keep trying to con this community. Mrs. Osborne here, she is on a respiratory thing. She should have been notified not to have her windows up or shut her windows in September or turn off the air conditioner. There are many people that live on her lane and they live on Big Run Creek there, and many people there are sick. So I think if we are going to be handling this stuff, we need to notify these people when there is an accident.

Response 16

The Portsmouth Site has an Emergency Plan in effect and conducts periodic emergency drills and exercises to prepare for any emergency situation. There are two levels of emergencies at the Site: (1) Alert — An Alert is declared if emergency hazards could affect plant personnel, but not the general public outside the plant boundaries. Local government officials are advised so that their resources and emergency responders are ready to assist on-site if needed. (2) Site Area Emergency — A Site Area Emergency is declared if the hazards could affect the general public within a two-mile radius of the plant boundaries. This is the most serious emergency situation and means that a significant release of hazardous materials may occur. If the conditions existed to set in motion the emergency response for off-site notification, then all residents within a two-mile radius of the plant would have been notified, including Mrs. Osborne. The plant emergency sirens would have been sounded with additional audible voice instructions on recommended actions for the general public. Emergency Notification procedures are in place that require this action. Also, it is also required that the local county officials be notified which would initiate actions from the emergency responders in the county. There has never been an occasion to use this system since it was placed in service in 1988. The system is tested periodically with warning sirens and emergency notifications to ensure its functionality should it ever be needed.

Comment 17

Okay. So there isn't an actual plan, but that is one of the scenarios. I guess a comment on that, I guess, is that treating at the facilities would probably be the safer mechanism than transferring because of the potential loss of jobs for the communities, et cetera, that they are stored out.

Response 17

The transportation analysis in the PEIS, Appendix J, does indicate that the transportation of cylinders and associated materials does pose a potential risk to workers and members of the general public. In addition, depleted uranium management facilities would potentially generate jobs and income in the vicinity of the management sites. However, the selection of locations for future management facilities is beyond the scope of the PEIS which addresses broad program strategies.

Future planning and environmental analysis will address issues related to selection of sites and technologies for depleted UF_6 management strategies.

Comment 18

The other thing is we want to make sure we meet the requirements particularly of the Ohio EPA. We have a variance now to come up with a plan for long-term, and the concern is just planting and staking may or may not meet that. You need to maybe come up with a long-term process. I know that is what this is for. I want to make sure that happens so it meets the expectations of the Ohio EPA because it has other overtones to this facility, and find a way to do that so it is in the best interests of the EPA, as well as the community itself. I think that is all.

Response 18

The commentor's concern is noted. The PEIS assesses the potential environmental impacts of alternative plans for the long-term management of the depleted UF_6. These impacts include ecological, health, safety, and socioeconomic impacts, including employment. Following the PEIS, the selection of a plan will partially satisfy the requirements of the Ohio EPA Director's Final Findings and Orders — that the DOE reconsider its original plan to begin conversion in 2020, and that DOE make a good-faith effort to identify uses for the material. The DOE is also required to provide to the Ohio EPA an annual report documenting the work that has been done on identifying uses for the material.

Comment 19

In the presentation, it wasn't clear to me, is new material coming into these facilities on a daily basis, and will it continue during the processing or during your plan of action to be coming in?

Response 19

The Draft PEIS considered the management of a fixed inventory of 46,422 full cylinders containing depleted UF_6 that were the responsibility of DOE. Since the issuance of the Draft PEIS, the scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). In addition, the management of several hundred heel and small cylinders has been clarified in the Final PEIS.

4.2 PADUCAH PUBLIC HEARING ORAL COMMENTS AND RESPONSES

All public comments with the exception of comments from one individual, Mr. Eugene Hoffman, provided at the Paducah hearing and DOE's responses to these comments are given below. Mr. Hoffman attended and provided comments at the Paducah, Oak Ridge, and Washington, D.C. hearings. The comments he made at the Paducah and Oak Ridge hearings were essentially the same,

except he added a few more remarks in Oak Ridge. Therefore, his comments are addressed in whole in Section 4.3 under the Oak Ridge hearing. His comments at the Washington, D.C. hearing were somewhat different from his prior comments. Therefore, they are also included in Section 4.4.

Comment 1

My name is Christie Henson. And I live approximately 50 miles, as the crow flies, from the plant. I oppose proceeding to a decision on this Draft PEIS because it neglects to discuss the actual method of conversion. How can the public or DOE make a decision on how to convert the depleted uranium if there's no information on what kind of conversion facility will do the work?

Response 1

Descriptions of conversion methods and preconceptual conversion facility designs are provided in Appendix F of the PEIS. As described in Appendix F, seven different methods of conversion were considered in the PEIS, including two technologies for conversion to U_3O_8, three for conversion to UO_2, and two for conversion to uranium metal. Additional detailed descriptions of the conversion methods and facility designs used in the PEIS are provided in the engineering analysis report prepared by Lawrence Livermore National Laboratory (LLNL 1997; the full citation is provided in Appendix F of the PEIS), available for review at the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), or by contacting the DOE program manager identified on the cover sheet of the PEIS. Although the PEIS considered seven different conversion technologies, the selection of a specific conversion technology (if required by the management strategy ultimately selected) is beyond the scope of the PEIS which addresses broad program strategies. Future planning and environmental analysis will address issues related to selection of sites and technologies for depleted UF_6 management strategies.

Comment 2

The PEIS also neglects to divulge other important studies done by the National Academy of Science, the Navy and DOE's own assessment team.

Response 2

The report Disposition of the DUF_6 (Chapter 7 of the 1996 National Research Council's "Affordable Cleanup? Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities") is a valuable background reference on the depleted UF_6 in general and its management options. This report as well as some other general reports on the subject were reviewed and used in preparation of the PEIS and supporting documents, for example, the engineering analysis report. A brief discussion of these general reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided.

Comment 3

I also want to comment on DOE's lack of responsibility of ignoring this problem for so long. We are faced with a critical health, environmental and economical crisis that could have been avoided. DOE's piling of 28,351 cylinders out in the open on gravel since the 1950's is not much different than dumping out on the back forty. And to make matters worse, DOE is still continuing to make the waste and putting it on the pile. Please do the right thing and make the right decision, to protect our community and the workers who have to deal with this mess.

Response 3

DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading of cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion and regular inspection and surveillance of the cylinder and storage yard conditions. The depleted uranium being produced today is by the United States Enrichment Corporation rather than by DOE, and is a product of the enrichment process. Since the gaseous diffusion process began, there have been justifications for keeping the depleted UF_6 in its present form. These justifications may or may not be valid for today's needs, and therefore the need for new decisions regarding the material. This Programmatic Environmental Impact Statement is the first step in that decision-making process. Its purpose is to assess the potential environmental impacts of alternative management strategies. The potential impacts on the community and the workers are considered in this assessment.

Comment 4

I think the draft is insufficient under NEPA. The biggest flaw of the Draft EIS is that it chops off the scope of the analysis at the conversion. And that violates the requirement to do an adequate cumulative effect analysis. And as the NEPA people who are doing this should know, cumulative effects must be analyzed in EIS if there are reasonably foreseeable actions or if there are connected actions. And any way you look at this, the whole process of conversion would have to be looked at as a connected action because you have to empty the cylinders in order to convert the material. When you empty the cylinders, you have to deal with the empty cylinders. And then if you defluorinate, you have to bring in cylinders to put the fluorine in, and those have to be dealt with, and you have the environmental effects of the facilities. All that has to be done in order to convert. It's clearly a connected action. So, therefore, it's arbitrary to just chop off the analysis like this EIS does.

Response 4

The PEIS does not "chop off" the analysis at conversion. Rather, for each of the alternatives, the PEIS considered all of the activities that would be required during implementation, as shown in Figure S.2 and Figure 2.1. It should be noted that conversion itself is not one of the alternatives evaluated in the PEIS, but only one step required by several of the alternatives. The

types of activities considered in the PEIS included continued storage of the cylinders for some period of time (Appendix D); preparation of cylinders for shipment (Appendix E); conversion (including defluorination activities) and treatment of emptied cylinders (Appendix F); long-term storage (Appendix G); manufacture and use (Appendix H); disposal (Appendix I); and transportation (Appendix J). The evaluation of potential environmental impacts for these activities included both the construction and operation of facilities during normal and accident conditions. The evaluation of conversion, presented in Appendix F, considered all the materials required to build and operate a conversion facility, including hydrogen fluoride production and a treatment facility for empty cylinders, and evaluated the potential environmental impacts of operating such a facility. The overall environmental impacts for each PEIS alternative were found by combining the impacts from each of the required activities, as appropriate, as described in Section 2.1. Consequently, the analysis in the PEIS addresses all of the events that would be triggered by the selection of a specific management strategy. The conversion step is not a "connected action" but rather an integral component of several of the alternatives that is addressed accordingly. The cumulative impacts of each alternative are addressed in Section 5.8 for those activities that would occur at the three current storage sites. At this time, the only activities that are reasonably certain to occur at the three current storage sites are continued storage of cylinders (for some period of time) and preparation of cylinders for shipment.

Comment 5

But that's not the only NEPA problem that DOE has here at Paducah. And it has been my position now for a couple of years that what is needed at this facility is a site-wide environmental impact statement so that we can try to get our hands around the big picture. Under the cumulative effects requirement, under the reasonably foreseeable future actions, the major Supreme Court ruling is a case called Kleppe versus Sierra Club. And that ruling found that if there were proposals that were on the table at the time, in front of the agency, that they have to be looked at in a single EIS, the cumulative effects. That sends — I was involved in a recent court case in Southern Illinois where cumulative effects was defined as all of the proposed actions, the effects of those actions had to be looked at in combination. So, we have here at the facility — not only do we have these cylinders going on, but we have waste management activities. For instance, just as an example, we have 50,000 barrels of legacy waste that there's planning going on — there's a proposal to bring in a radioactive waste incinerator slash vitrification machine to deal with some of that. There's a NEPA going on for that right now. It's an illegal segmentation to segment that analysis from these cylinders. There's also environmental restoration activities — very significant restoration activities at WAG 6, the C-400 Building, which has very massive trichloroethylene and technetium 99 spills, burial grounds, contaminated ditches and creeks, serious groundwater contamination. All of those activities have cumulative effects, not just on — not just direct, but indirect, and not just on the specific location where the direct effects are occurring, but in an area around. And I think the public deserves, I think the regulations require, and I think the statute requires that this be looked at as a major federal action, and that we be given the opportunity to look at the effects of all of these actions together.

Response 5

The issue of the need for a site-wide EIS for the Paducah site is beyond the scope of this PEIS. Section 5.8.2.1 of the PEIS explicitly considers cumulative impacts at the Paducah site of existing operations at and near the site (if close enough to affect it), the two activities proposed in the PEIS that would occur at the site, and other reasonably foreseeable future actions at and near the site. Included in the cumulative impact calculations are the impacts of the proposed Vortec Vitrification Process and the impacts of waste management activities at the Paducah site, both mentioned in the comment (see Table 5.12). The topic of environmental restoration activities has been reexamined for all three current depleted UF_6 storage sites, including the Paducah site, and pertinent past and current restoration activities have been added to the cumulative impact calculations (see Table 5.12). As noted in Section 5.8.1, the impacts of future environmental restoration activities were not included in the cumulative impact calculations because of insufficient characterization of the contamination and because proposals for particular actions are not yet final; impacts of environmental restoration activities at these sites would be analyzed and documented as appropriate under the relevant environmental regulations. The geographic breadth of cumulative impacts depends on the nature of each, with some associated with the site itself (e.g., radiological impacts to worker population) and others (most) associated with the area around the site (e.g., off-site radiological and air quality impacts).

Comment 6

Another thing I'm concerned about is, there are statements of little or no impact based on what I would call in-house studies, where the methodology isn't explained, there's no independent verification of where this data came from, just a reference to some of DOE's own studies. I believe that would be — that that's nothing more than a conclusory statement of no impact. Conclusory statements of no impact are insufficient to support an EIS. There's tons of case law on that.

Response 6

The assessment methods used in the PEIS are described in Chapter 4 and in Appendix C for each technical discipline. Chapter 4 also provides a detailed table that describes the general criteria used to summarize and describe the magnitude of environmental impacts for each area of impact considered in the PEIS. The main body of the PEIS provides a discussion of the types and magnitude of potential environmental impacts for each alternative, with additional supporting technical information provided in the appendices. Detailed assessment results and further discussion is provided in a series of backup reports that are cited throughout the PEIS. Specifically, supporting information for the various technical disciplines is presented in: Cheng et al. (1997) for the assessment of human health impacts during normal operations; Policastro et al. (1997) for the assessment of accident impacts; Tschanz (1997) for the assessment of air impacts; Tomasko (1997a, 1997b) for the assessment of water impacts; Biwer et al. (1997) for the assessment of transportation impacts; and Allison (1997) for the assessment of socioeconomic impacts. (See PEIS Appendix C for complete citations.) The computer models, and exposure and risk assessment methods used in the PEIS are in wide use in the scientific community and are referenced as appropriate in

Appendix C and the backup reports. The intent of this presentation was to provide sufficient information in the PEIS to establish the applicability of the methods and assumptions, with detailed information provided in the supporting reports. The supporting reports are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 7

Also, I think that while there are equity issues, you know; i.e., we shouldn't be wanting to dump our problems on other communities, the seismic concerns here are really legitimate. I don't think that we should be bringing any cylinders in here. And I sort of reluctantly think that there needs to be strong consideration given to converting the cylinders elsewhere because of the length of time that it's going to take to convert all these cylinders and the seismic risk and the possibility of breaches to the cylinders if there is a seismic event.

Response 7

The commentor's preference for not siting any facilities for long-term storage or conversion of depleted UF_6 at the Paducah site is noted by DOE. With respect to seismic concerns at the Paducah site, the analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 8

Total in long-term storage, 55,000. 21,000, inaccessible end plugs. Oak Ridge is really bad, and the others are not a whole lot better. But these are stacked so tightly together that it's very difficult to do much of an inspection. I'm sure the workers have done the best they can. But the fact that they're stacked so close is a real, real problem.

Response 8

As part of the cylinder program management plan, cylinders with insufficient spacing to allow for complete inspection are scheduled for relocation. The management program calls for

relocating these cylinders to improve stacking and storage conditions, and also includes upgraded inspection procedures and training to improve the capability of the inspectors to make a complete inspection. New stacking requirements which require a four foot aisle between cylinder rows have been implemented through use of by improved procedures and new cylinder stacking equipment. Cylinder relocations have been ongoing in conjunction with the construction and reconstruction of storage yards. In FY 1998 approximately 14,000 cylinders were relocated; 9,900 cylinder relocations are planned for FY 1999, and 8,600 are planned for FY 2000.

Note: *This commentor was also a speaker at the Oak Ridge, Tennessee and Washington, D.C. public hearings. With the exception of this comment, he made essentially the same comments at both the Pacucah and Oak Ridge hearings. Although there was considerable overlap, his Washington, D.C. public hearing comments were somewhat different from his Paducah and Oak Ridge comments. Therefore, detailed responses to his hearing comments are provided in Oak Ridge public hearing comments and responses 29-41 and in D.C. public hearing comments and responses 24-48.*

Comment 9

My name is Al Puckett. And I live within a mile of the plant. I'm an atomic veteran. I was one of the first people that went into Nagasaki after the bomb was dropped. And the thing that irritates me now is the statement that I hear — they say, well, we dropped the bomb, we killed over 2 million women and children because we wanted to spare the people that would be in an invasion of Japan. Which is totally not true. When the war was over with in Germany, they brought all the B-29 bombers over there and they were bombing Japan. And in one night, they burned 15 square miles of Tokyo. And Japan was trying to surrender before they dropped the atomic bombs. So, they killed mostly 2 million women and children for nothing. And this is what irritates me, when they come out with this party line, oh, we done that to protect the veterans or the servicemen so that they wouldn't be killed. There was no need to invade Japan. There was no need to drop the bomb. Japan was trying to surrender at the time that they were dropping bombs.

Response 9

The comment is outside the scope of the PEIS.

Comment 10

I was appointed as the chairperson of the first Earthquake Hazards Commission in Kentucky. And Dr. Otto Nuttli was a very dear friend until the day he died. This gentleman has given you a very conservative statement of what you're going to be faced with. And I can tell you this truthfully; the best geologists, the best earthquake specialists in Golden, Colorado, in Western Virginia will never stay overnight in Paducah, because I've invited them to. For the past 20 years, they have declined. One of the prime reasons, of course, is that they fear being below all of the dams on the Tennessee River when the seismic event occurs. With respect to where the epicenter might be, before Dr. Nuttli died, he told me that he believed that the next epicenter for the New Madrid

earthquake action will be in the vicinity, maybe a little north, of Evansville. But don't think we will be spared, because the plans are extended out as far as Dallas, Texas, Chicago, Denver, all the way to the East Coast and on. So, this gentleman has given you the gospel. Please accept it.

Response 10

Seismic risks for Paducah are addressed in Section 3.1.4.1 of the PEIS. Additional text has been added (See Comment 27 from the Washington, DC Oral Comments) and the Paducah site safety analysis report has been referenced to provide more information to the reader.

4.3 OAK RIDGE PUBLIC HEARING ORAL COMMENTS AND RESPONSES

Comment 1

And fundamentally what I am trying to get across to them is that if you're going to write a book like this and tell people about how it's going to affect the environment, you got to tell the people what UF_6 is in more detail than Ched just did.

You need to know — talk about the face, characteristics of it, and things of that nature, not the least of which is this stuff is all in the bottom of the cylinder. It's only sixty percent full.

So these guys that go around worrying about earthquakes and claim the cylinders are going to roll end over end, well, that – it won't do it. It's centric loaded. It won't roll. So things like that need to be pointed out. I think it's important.

Another thing that I did not see in the book is to tell people something about the characteristics of the cylinders themselves. Most of them have been made to an ANSI standard; some of them, older ones, were not, but at least we ought to tell people what the cylinder characteristic is

Response 1

More detailed descriptions of the characteristics of both the storage cylinders and depleted UF_6 have been added to Section S.1.1 of the PEIS Summary and Section 1.1 of Chapter 1. Detailed information has been added which addresses the physical characteristics of the cylinders which are used for storage, as well as the physical and chemical characteristics of the depleted UF_6. Photographs have also been included which detail the cylinder and its associated parts which are referenced in the document, such as the cylinder skirt and stiffening rings.

Both the ORO-651 series of documents (DOE's own standard for handling UF_6) and the ANSI N14.1 Standard were reviewed during preparation of the PEIS. The ANSI standard is incorporated under Title 49, Code of Federal Regulations, Section 173.420, the federal regulations

governing transport of depleted UF_6. Reference to the 49CFR173 has been added to Section 1.1 of the PEIS.

Comment 2

In the book I notice they talk about cylinders with skirts on them. Well, to someone that all they got is a book to read, they don't know what that means. So I have volunteered to give people some of my documents for inclusion. I can't get a rise out of them.

Response 2

A definition of "skirted ends" has been added to Section C.2.1 of the PEIS.

Comment 3

But then in addition to telling people what UF_6 is and what the cylinders are like, you need to tell them how much is in the cylinder. The darn things are only sixty percent full. I think it's important that people know that, and we don't say so in the book.

Response 3

Text has been added to Section 1.1 of the PEIS which indicates that the cylinders are approximately 60% full.

Comment 4

So the plan, the proposed alternative, to convert and use the billion pounds is a proposed decision sort of made by amiable sleepwalking agency which doesn't have its eyes wide open because it's sort of blind to all the data. It's an unrealistic — as I see it, it's an unrealistic decision.

Response 4

In response to comments received on the Draft PEIS, DOE has revised its preferred alternative. The revised preferred alternative consists of the following elements: continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use (see Section 2.5.1 of the PEIS). The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 5

I believe there's no prospect that uses, which would be desirable if they were invented, can keep up with the increasing amount of UF_6 the country has. It may be in different ownership, the new stuff, but it's still UF_6, in Kentucky and Ohio probably.

Response 5

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as necessary, to continue the safe management of its depleted UF_6 cylinder inventory. The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). The management of any additional depleted UF_6 generated by USEC's privatized successor would be addressed in future agreements as appropriate.

Comment 6

The storage method, while safe in the short run — we haven't hurt many people — is not a good long-term method for dealing with an unstable industrial end product.

Response 6

The commentor's view regarding storage of depleted UF_6 is noted.

Comment 7

If I'm wrong, the demonstration that the uses could be as large as the increasing amount we have, that's more important than other things we're discussing, and that should be given a big — a big, positive push.

Response 7

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products.

Comment 8

There are good efforts to try to increase the uses, but I don't believe they keep up with the increase in the amounts we have before us. If I'm right, we need a combined option. One, convert to oxide and use what we can make use of, as suggested by Mr. Bradley; and, second, the other half of the option, is to have a program for converting and disposing of the remainder.

Response 8

It is possible that DOE will select as a management strategy a combination of two or more of the six PEIS alternatives, such as converting and using some portion of the inventory and converting and storing of the remainder. The parametric analysis presented in Appendix K of the PEIS was included to allow the environmental impacts of such combinations to be estimated. Several examples of how the impacts for combinations of alternatives can be calculated are provided in Section K.7 of Appendix K. The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 9

Now, what we're going to do. I would think first one would take care of the increase. We shouldn't be — we should have a policy that whoever is making depleted UF_6 now no longer leaves it in storage yards, goes on and puts it in a stable oxide form. And then, of course, suspect cylinders need to be treated first.

Response 9

DOE is no longer producing depleted UF_6. However, new material is being produced by the United States Enrichment Corporation (USEC). USEC is responsible for decisions regarding the disposition of the depleted UF_6 that it produces. Two disposition options for USEC-generated depleted UF_6 are to convert the material themselves, or to contract with DOE for the service. Any conversion activities undertaken by USEC would be licensed by NRC. The depleted UF_6 produced by USEC prior to privatization and a limited amount produced by the privatized corporation will be conveyed to DOE. This material has been included in the inventory analyzed in the PEIS. Any additional depleted UF_6 that may be transferred to DOE for management will be addressed in future agreements.

Comment 10

UF_6 has a wide variety of future uses for high technology materials. I'll just throw out a few of them that we've already considered. These won't be the specific compounds, but will give you some idea of some of the uses we envision. New non-ozone depleting halon, or fire extinguishing agent. New high tech polymer in computer processors. Currently this polymer is being made by another method. New medicinal agents, especially in surgery. New fluorination technology. One that's a little bit speculative, new depolymerization or polymer recycle technology, and these are just a few of them. Now, one of — a single one of these, the high tech polymer and computer processors, represents a potential use of eighteen million pounds of UF_6.

Response 10

Comment noted. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products.

Comment 11

My concern with the document is primarily the assumptions. The assumptions that were made really make all the options look very much alike.

Response 11

The six management strategies considered in the PEIS were developed to cover the reasonable range of possible alternatives. The alternatives considered and the assessment assumptions, methods and supporting data were carefully selected to provide a meaningful and relevant evaluation and comparison of potential environmental impacts. Similarities exist among the alternatives because they would require very similar activities during implementation. For instance, the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives would all require storage of cylinders for some period of time, conversion of depleted UF_6 to another chemical form, and possibly transportation of cylinders and associated materials (as well as preparation of cylinders for shipment, if required).

Comment 12

And the timeliness is one of my concerns. There's no action before the year 2009 and it goes through 2028. Well, not all of these cylinders are in perfect condition. In fact, the document recognizes this. However, in the appendix D on page D-3, they were assumed that the breaches would cease from corrosion because they were going to paint them. But, indeed, they're not painting enough of them per year to keep that up. Assume the paint — you have to paint them every ten years, but they're not painting enough per year to keep that up.

Response 12

The assumptions used in the PEIS for the No Action Alternative and other alternatives were made based on the current UF_6 cylinder project management plan in effect at that time (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS), and on the cylinder painting program (Pawel 1997 — see references in Appendix D of the PEIS for full citation). The management plan covers a five-year period. The cylinder painting program document states that the estimated life of the paint system would be 12 years, meaning that during this time the painting process arrests corrosion and no further reduction in cylinder wall thickness occurs. Based on this information, the PEIS assumed that each cylinder would be painted once every 10 years in its analyses of impacts from continued cylinder storage (see Appendix D, Section D.2 of the PEIS). In order to address uncertainties in both the effectiveness of the painting in controlling further corrosion and uncertainties in the future painting schedule, a conservative assessment of the impacts was also made assuming that painting would have no effect on corrosion (i.e., historical corrosion rates from

past poor storage conditions were assumed to continue into the future, although many improvements in storage conditions have actually been implemented). The outcome of this supplemental analysis is described in Appendix D, Section D.3 of the PEIS. Project personnel continue to develop more information regarding the physical condition of cylinders, the corrosion rate of the steel, the methods and equipment used for handling cylinders, and storage conditions. Changes to this plan, which include decisions regarding the rate of recoating the cylinders, are made through technical and risk evaluation. Although the rates for construction and recoating may change somewhat, DOE remains committed to the safe management of the inventory. Construction and recoating rate changes or changes in cylinder and storage conditions will be evaluated and accounted for as part of the ongoing cylinder management program.

Comment 13

Because of the nature of the corrosion and the condition of the cylinders, the oldest ones happen to be here at Oak Ridge. There is no strategy given that says in what order do you process them. And do you do the worst ones first, or do you do the best ones first because they're the easiest and can make — you know. It's not given.

Response 13

The actual schedule or order in which the cylinders would be included in any storage, conversion, or disposal action would be best decided when site- and technology-specific environmental reviews are conducted in follow-on phases of the program. Under all alternatives, DOE is committed to continuing for as long as necessary the safe management of its depleted UF_6 cylinder inventory. The actual decisions of which cylinders are the first to be processed under any of the alternatives would be based on environmental, safety, engineering and economic considerations.

Comment 14

They recognize a potential hazard at Oak Ridge in the future from breaches and excess hydrogen fluoride being released. We do have a very wet environment here and so there's always water vapor around. Hydrogen fluoride is very nasty stuff. The other products are soluble and go into the water, which is not good for the environment.

Response 14

As the commentor states, the PEIS indicates that if cylinder maintenance and painting activities do not reduce cylinder corrosion rates, it is possible that the HF air concentration could be greater than the regulatory standard level at the K-25 storage site around the year 2020, and also that concentrations of uranium in groundwater could exceed the guideline level of 20 µg/L at all three sites at some time after the year 2100. (These analyses are discussed in Section D.3 of Appendix D.) It should also be noted; however, that if continued cylinder maintenance and painting are effective in controlling corrosion, as expected, air concentrations of HF would be kept within

regulatory standards, and groundwater concentrations would be well below the 20 µg/L level (see Sections D.2.3 and D.2.4 of the PEIS for a more detailed discussion of these results).

Comment 15

Now, we've been fortunate that we haven't had more breaches of the seven that the document speaks of. Four of them, you know, were here at Oak Ridge, and that is primarily because we have the oldest cylinders probably.

Response 15

The oldest cylinders containing depleted uranium hexafluoride are actually located at the Paducah Site, however, they are the thick wall design and no thick wall cylinders have breached. The oldest thin wall cylinder containing depleted UF_6 is at the Portsmouth Site. Mechanical damage to the cylinder wall sustained during handling of cylinders and excessive corrosion due to poor storage conditions are actually the root causes of the cylinders breaching. These root causes have been mitigated by a cylinder restacking program, construction of new cylinder yards, new procedures for handling cylinders and a cylinder recoating project.

Comment 16

Anyway, I'd like to see things go a little faster. I'd like to see options that can move quicker or priorities set for certain conditions. I mean, it recognizes the poor conditions, and it's just not acceptable to wait until 2028 to have all of this taken care of.

Response 16

The commentor's preference for action to begin quickly is noted. DOE is committed to implementing the selected alternative as early as practicable. The preferred alternative in the PEIS has been modified to clarify this point. (See Section 2.5.1 of the PEIS and the response to the following comment)

Comment 17

And I don't mind it being used, if it's really truly feasible, but I'd like to see it converted to U_3O_8, which is the most inactive form, and then you can store it as long as you want and you can wait until these uses get proven. If you're not going to convert it until you can use it and until you can market it, I think we have some big problems because I don't think it will be done by 2028 either. And I'd like to see it move faster.

Response 17

The preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventor; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted

uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products.

Comment 18

I'd like some real differences in the alternatives. I'd like to see, okay, you know, how many plants do you have to process? You had a thousand mile transportation thing that was — you know, that's kind of a make-believe number. I'd like to see some strategy.

Response 18

The six management strategies considered in the PEIS were selected to cover the reasonable range of alternatives. The six alternatives are fundamentally different from one another, although many of the alternatives share common elements. For instance, the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives would all require storage of cylinders for some period of time, conversion of depleted UF_6 to another chemical form, and possibly transportation of cylinders and associated materials (as well as preparation of cylinders for shipment, if required). Because the PEIS addresses broad program strategies, a number of assumptions were made to allow for a reasonable estimation of potential impacts and a meaningful comparison among the alternatives. For example, because the selection of sites for depleted UF_6 management strategies will be addressed in future planning and environmental analyses, the PEIS evaluated transportation impacts for distances ranging from 155 to 3,100 miles (250 - 5,000 km) (see Appendix J). However, for the purposes of comparing the potential impacts among alternatives, shipment distances of 620 miles (1,000 km) were assumed for all alternatives. The results presented in Appendix J can be used to evaluate how the impacts would differ for either shorter or longer shipment distances. Selection of a different shipment distance would not effect the comparison between the alternatives.

Comment 19

I realize this is a programmatic — PEIS, but you're putting a lot of work into a document that isn't of a great value because there is no strategy in it, and the assumptions are just — some of them, I think, are very poor, others are reasonable. And I'd like to see something done quicker.

Response 19

The purpose of the PEIS is to provide a meaningful evaluation and comparison of broad alternative management strategies. In selecting the broad programmatic alternatives, the DOE considered information obtained from all interested parties through a Request for Recommendations which was issued on November 10, 1994 (59 FR 56324). The alternatives considered were based on input from the Request for Recommendations, as well as a technology assessment report and an engineering analysis report (see Section 1.4 of the PEIS for a more detailed discussion). The assessment assumptions, methods, and supporting data were carefully selected to provide a meaningful and relevant evaluation of potential environmental impacts. The ultimate decision on

a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 20

HF is not a good compound to work with, but it certainly isn't the worse. I came into this industry from another industry which most people considered far worse, fuming sulfuric acid, nitric acid. TNT, those kinds of things. This is a technology which has been in existence and use for fifty years and it's had a good record. We understand the chemistry pretty well. We understand the technology. We need to get on with it. The cylinders can't last forever. Eventually they'll have to be faced, and it will be embarrassing if they do start to fail.

Response 20

In the PEIS, the alternatives which involve handling of HF are those which include conversion of the depleted UF_6 to another chemical form for long-term storage, use or disposal. The commentor's preference for timely implementation of one of these alternatives is noted by DOE.

Comment 21

You have a maintenance program, which I understand is quite expensive, and that is an added cost. The uses that are hypothetical I think are pretty far out. It isn't as if we were destroying the material. It will be available for uses in the future. But I think the public is getting tired of the procrastination in these processes, and I would urge DOE to get on with conversion either to the oxide or to the metal, place this in the form it can be stored safely in the truly long term and will not require the maintenance cost forever and ever that the present storage requires.

Response 21

The commentor's preference for conversion to begin promptly is noted. In fact, the preferred alternative in the Final PEIS has been modified to clarify that it would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory and plans to continue its support for the development of government applications for depleted uranium products.

Comment 22

There have been a lot of warnings lately about the New Madrid fault and Paducah is very close to that. We're close enough. So if the 1812 earthquake was 8.5 on the Richter scale, it was probably six and a half here so --

Response 22

The text in Section 3.3.4.1 of the PEIS has been modified to be consistent with material presented in the Safety Analysis Report for K-25 (LMES 1997a; the full citation is provided in Appendix C of the PEIS). That is, for the K-25 site, an earthquake that has a 1,000 year return period would have a horizontal top-of-soil acceleration of 0.2 times that of gravity. Such an earthquake could occur with equal probability any time within the 1,000 year period. For these conditions, slope stability and soil liquefaction (loss of shear strength) would not be problems, and rocking and rolling-out of cylinders would not occur for single or multiple stacked-cylinders (LMES 1997a).

Comment 23

Time to completion is definitely too long. I can't wait until 2028, and I don't think anybody else can either. I think that we, as Al Brooks has pointed out, that we know this material, we know the process, we know the chemistry, we understand it.

Response 23

The commentor's preference for completing the dispositioning of the DOE's depleted UF_6 inventory before 2028 is noted.

Comment 24

The ideas that you mentioned earlier about — from the scoping meeting was safety and handling, employment, resource value of the material. Those are not my concerns. I mean, I was there. I don't remember hearing any of that. They're relevant, but I don't think that they're relevant in this particular situation.

Response 24

Under the National Environmental Policy Act, an environmental impact statement (EIS) analyzing the impacts of a proposed action and all reasonable alternatives must be prepared for any major federal action. An EIS generally addresses areas such as health and safety, employment impacts, and resource materials required by the various alternatives, along with other major impact areas (for example, air quality, water and soil, ecology, waste management, land use). These areas are addressed in an EIS because they have been found to be of general concern to the populations which would be affected by the proposed action. The above-listed areas have therefore been included in the depleted UF_6 PEIS.

Comment 25

And how much the material is worth is of some value to me too. How much are the storage casks worth? You could sell those too for scrap.

Response 25

In the context of the comment, it was assumed that "storage casks" refers to depleted UF_6 cylinders, as opposed to spent nuclear fuel casks that could potentially use depleted uranium as shielding material. The empty cylinders were addressed in the PEIS in association with the conversion options (Appendix F), and in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). The report by Nieves is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), or by contacting the DOE program manager identified on the cover sheet of the PEIS. The report analyzed the potential health and cost impacts associated with various options for the cylinders after treatment, including recycle, reuse, burial, and free release.

Comment 26

There is, I think — maybe to point out one thing that I find a little strange in this preliminary report. They have here what I assume means a complete collapse of a cylinder happening once in ten years under dry conditions. On the next page they estimate that it comes once in a hundred thousand years in wet conditions. With the rainfall here in Tennessee — I guess maybe the big document explains all this, but it doesn't seem to match common sense, even a hundred year flood in connection with it. Now, the question of how likely is this sort of thing to happen I really can't say, but you do have these figured correctly, the area of them, and something like a ten PSI differential between the atmosphere and what's inside the things. They are under 250,000 pounds, I think, each cylinder, something of that sort. And they are — I'm reasonably sure that if all of the wall is in good condition all the way through, this is probably nothing to worry about. They will support this very easily probably. Many, many factors of safety. But they are getting old. There are corrosion pits and things like this, and they are sitting some — they are stacked too deep so you have not only the pressure of the atmosphere from the outside, you also have it stacked on top of them, plus the possibility of events like earthquakes and other things of this sort, of maybe dropping when they 're picked up, moved for maintenance, or something like this. So it seems to me like there's a fair possibility of a rather bad accident occurring over this long — rather long period of time we're talking about before we get on with this business. And if you do it under wet conditions, you can get a HF plume, I would imagine, that would give the people that have been bad mouthing TSCA something really to complain about.

Response 26

The accident scenarios considered for continued cylinder storage are given in Table D.6 of Appendix D. The cylinder spill accidents discussed in the comment involve corroded cylinders containing solid depleted UF_6 which hypothetically rupture during their handling. The accident frequency (once per 100 years) for the case where the corroded cylinder ruptures during dry conditions (no rain) was estimated taking into account the estimated number of corroded cylinders and the number of cylinder movements per year. In general, cylinder handling does not occur when it is raining. The lower accident frequency for the hypothetical accident where the corroded cylinder

ruptures during heavy rainfall takes into account the low probability that a rainstorm would appear during cylinder handling. The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 27

So I think myself we're going to have to do it sooner or later, get on with it. If the — I know that this is easy to say with the budgetary limits and this sort of thing, but at least I think there should be some estimate. I think this is kind of out of the waste management business. It's not considered comparative risk when you're setting priorities between this and, say, digging up Bear Creek Valley and putting it somewhere else. I think it should — DOE should consider considering it in this context. I know there are a lot of things I wouldn't want to interrupt. I wouldn't want to interrupt them from cleaning out the GUNNI tanks. I don't want them to interrupt them cleaning out the mold and salt reactor for something like this. But I think there are probably a lot of things they're talking about doing that could be put off easier than this, and we could get on with maybe doing something about the tanks.

Response 27

The commentor's preference for moving forward on a strategy for managing depleted UF_6 and for appropriate prioritization of that strategy within the context of risk management is noted. DOE will seek appropriate funding to implement the depleted UF_6 management strategy announced in the Record of Decision for the PEIS.

Comment 28

One of the concerns I have about the report is the overall conclusions. I didn't see any discussion in there about how other people that are in the enrichment business are handling this problem. And you know for truth that France has been converting theirs for a number of years. So I was wondering what's different about the situation we have versus what they have? Is it just in the methodology, or is it some real factor that's different between the two?

Response 28

The various sections in Appendix F (e.g., Section F.2.1 for conversion to U_3O_8) indicate which processes are commercially available. An example is the conversion of UF_6 to UO_2 which is used by the nuclear fuel fabrication industry. The conversion of UF_6 to U_3O_8 through the introduction of steam is called defluorination and is practiced on a large scale industrial basis by COGEMA in France.Text has been added to Section F.2.1 to clarify that this process is practiced on a large scale industrial basis by COGEMA in France. There are a number of established and innovative technologies for UF_6 conversion. The PEIS is examining the possible benefits of these innovative technologies, in addition to commercially-available technologies, to establish the most appropriate strategy for depleted UF_6 management.

Comment 29

I think the document is a flawed document, and I think some of you may agree with me when I get through. And I am encouraged that Ched has — in conversations we've had he has said that there needs to be some modifications and I couldn't agree more.

Response 29

The December 1997 version of the PEIS was a draft. All public comments have been carefully reviewed and responded to. In addition, the PEIS has been revised as appropriate in response to the comments.

Comment 30

So there's three independent documents that were not (cited: the ORNL Report; the DNFSB Report, and NAS Report)-- I think they have very pertinent information because if you don't have a good feel for the condition of the cylinders, this has a lot to do with determining the use and the schedule and the painting and the cleaning and so forth.

Response 30

The reports referenced in the comment are valuable background references on the depleted UF_6 in general and its management options. Except for the ORNL report (titled Draft Preliminary Report-DOE Independent UF_6 Cylinder Assessment Team; 25 March 1992), the reports referenced in the comment were reviewed and used in preparation of the PEIS and supporting documents (for example, the engineering analysis report). A brief discussion of these reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided. The draft preliminary report was never finalized, so it is not cited in the PEIS.

Comment 31

Now, the seismic concerns. Even though Paducah is in much worse shape than this area, as been mentioned already, that doesn't make the problem go away as far as Oak Ridge is concerned. And there were three sentences in the Draft PEIS on this subject, and I'll read them because I know you can't read this in the back. And throughout this I'll just try to point out highlights because I don't

want anybody to try to read all this. But here's what was indicated by PEIS. It says: The largest recorded earthquake in the region occurred in 1912 and was centered in New Madrid. The earthquake had a magnitude of 7.3 on the Richter, sixty miles from the plant. The estimated 1,000-year return period peak ground acceleration is 0.45 and so forth. Technically, I'm not a seismologist, and I don't take exception to this sentence. It could be technically correct. But it's extremely misleading. I think the average person that would look at this might think this is a 1,000-year event. His (Dr. Nuttli) studies, based on the stresses in the strata at this time, he said were sufficient to produce a 7.6. But, more importantly, this is a tremor worth fearing and it has the potential to strike this very day. I mean, it could happen tonight, you know. And my comments here are: Severe earthquakes will create multiple cylinder failures at Paducah, Oak Ridge, and Portsmouth storage areas. Yes. What's the definition of severe? But seven or eight certainly could happen in New Madrid.

Response 31

The seismic risk text in Section 3.3.4.1 of the PEIS has been modified to be consistent with material presented in the safety analysis report (SAR) for K-25 (LMES 1997h; the full citation is provided in Chapter 8 of the PEIS). The SAR does recognize and discuss the potential for multiple cylinder failures in association with an earthquake.

Comment 32

These were the numbers that we were given in our investigation in 1992, total 55,649, total thin wall cylinders. This was given to us by Lockheed-Martin and K-25 folks. Another report that we got was there was 54,000. The DNFSB report says 55,649 in '95; again, information supplied by Lockheed-Martin. But the Draft PEIS says 46,000.

Response 32

The PEIS addresses the cylinders which contain depleted uranium, that is, uranium with an assay less than 0.7110% U-235. Additional cylinders present at the sites contain normal UF_6 (assay equal to 0.7110% U-235) or enriched UF_6 (assay greater than 0.7110% U-235). Depleted, normal, and enriched UF_6 are very different materials in their end use. Disposition plans for the normal and enriched UF_6 would be quite different from those proposed for the depleted UF_6 and therefore would not be appropriately addressed under the current scope for this PEIS. If the number of cylinders containing normal and enriched uranium were added to the number containing depleted UF_6, they would total in excess of 55,000 cylinders.

Most of the cylinders at the three storage sites are large diameter cylinders (i.e., 48") that are filled to their capacity with depleted UF_6. Some smaller cylinders also contain depleted UF_6 and are included in the scope of the PEIS. Additionally, approximately 200 cylinders contain a small amount (commonly called a "heel amount" in the UF_6 industry) of depleted UF_6. Text has been added to the PEIS stating that these "heels" cylinders are a part of the inventory included in the scope of the PEIS. (See Sections 1.5.2 and 4.2.1 of the PEIS.)

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). In order to accommodate these new cylinders, the PEIS has been revised. Rather than increasing the amount of cylinders assumed to be processed annually, the revised PEIS assumes that the work-off period (the period over which the processes assumed in the PEIS, for example, cylinder preparation, transportation, conversion, manufacturing, would take place) has increased by approximately 6 years (i.e., from 20 to 26 years).

Comment 33

This is a work agreement signed by — or to Link Hall and Parks and so forth. FY '96. And it said: Complete annual inspection of 17,475 cylinders exhibiting accelerated corrosion. Anywhere there's moisture, that rate of corrosion is five to ten times that level, which greatly shortens the lives. And the corrosion is in the forms of pits, which makes it a little more difficult to determine how much wall is left and so forth. But that's just an idea of the numbers we're talking about that are in degraded condition.

Response 33

Prior to the current inspection program and database, it was necessary to estimate the number of cylinders requiring an annual inspection, i.e., those experiencing accelerated corrosion, severe pitting, and those in very poor storage conditions. Since that time, the number of cylinders requiring an annual inspection has decreased significantly from the number quoted in the comment due to the relocation of cylinders from previously poor storage conditions, improved inspection procedures, and the recoating of cylinder bodies.

Comment 34

This is an early report. This was reported by the Defense and the Safety Board in their report of '95, and this is the results that were provided to them by the Lockheed-Martin folks. They were looking at the early analysis of what might be going out in the cylinder yard. And they concluded that there might be twelve additional breaches that hadn't been detected, and the number could be as high as 200. I don't believe it's anything like — as high as that, but I sure wouldn't want to bet there's no leakers out there now. And the process, as maybe described earlier, is so slow that the big leak — the scientists at K-25 did some very, very good work, determined that that cylinder had been leaking for thirteen years, reacting and drooling on the ground and so forth.

Response 34

Since that early analysis, the study has been refined with additional data. Currently, the predicted number of breaches reported in the report entitled, "Prediction of External Corrosion for Steel Cylinders - 1998 Report," ORNL/TM-13568, February 1998, is one in 1998 (ETTP, K-yard) and one in 2000 (ETTP, K-yard). The values in this report were based on the assumption that the

historical trends would continue, and thus represent all baseline projections. Many of the yards are being improved, in which case the corrosion rates will probably be reduced. Additionally, all the cylinders have been inspected, with some cylinders being inspected annually. Prior to 1998, seven cylinders (one at Paducah, two at Portsmouth, and four at K-25) had been identified that had developed breaches, generally around spots previously damaged by handling activities.

In 1998, one additional breached cylinder was identified at the K-25 site during the course of cylinder maintenance operations (i.e., cylinder painting); previous corrosion modeling had predicted that some additional cylinder breaches would be detected during such activities. The breach was detected during steel grit blasting of the cylinder surface in preparation for painting. An as-fabricated weld defect was opened by the blast process. The cylinder management program includes provisions for patching newly-identified breached cylinders to eliminate releases of material.

Comment 35

That's the biggie. This is the one that was leaking for an estimated thirteen years. The way they detect this, they were looking — checking this valve. And the people who were working on the valve happened to bend over and look down under the cylinder and here was this pile of green stuff. And so they made two attempts to patch it. I think on the third try they succeeded. This is what happens if you get close to — this is the cylinder that was near — I think maybe the leak was over in this area. But this lifting lug used to go out to about here like so. And the HF has completely eaten it up, and that's why the area all around here, the HF fumes are pretty devastating to the steel in the area.

Response 35

The commentor is describing one of two breached cylinders discovered at the Portsmouth site in 1990. The discovery of these breached cylinders lead to inspection of all the cylinders, the identification of 5 more breached cylinders before 1998 , and the development of an extensive cylinder project management plan (described in the Introduction to Appendix D of the PEIS). The conditions which allowed the breached cylinder to go unidentified for such a long period of time have been eliminated. As described in Appendix D, all cylinders are now inspected at least every four years (those with more extensive corrosion or pitting are inspected annually). Runoff from the new and reconstructed storage yards is also monitored, so that the presence of uranium compounds in the runoff would lead to prompt investigation of the source and identification of any breached cylinder. Of the seven breached cylinders discovered before 1998 (2 at Portsmouth, 1 at Paducah, and 4 at K-25) all have either been patched by welding a steel patch to the cylinder body, or have had their contents transferred to new cylinders. The four cylinders discovered at the K-25 Site were originally patched with temporary steel patches that were strapped on with steel and nylon bands. All of these patches have been replaced with welded steel patches, while the remaining breached cylinders have had the contents transferred by refeeding into the cascade at the gaseous diffusion plants. In 1998 one additional breached cylinder was identified at the K-25 site during the course

of cylinder maintenance operations (see response to Oak Ridge Public Hearing Comment 31 for further details). The cylinder management program includes provisions for patching newly-identified breached cylinders.

Comment 36

So my question is, what is being done to protect these painters who are in blasting off the rust and painting in very close proximity to the cylinders? It may not be a problem. They only cite surface smears in the report on the lessons learned on the painting. It don't mention what kind of gamma protection, but I assume they had some, but it's not obvious in the report.

Response 36

Workers involved in cylinder maintenance are protected through a combination of planning, training, monitoring, environmental controls, and the use of personal protective equipment, as appropriate. For the specific recoating of cylinders, radiological control personnel at the sites perform pre- and post-work contamination surveys for detecting possible contamination and directing decontamination if necessary. In addition, workers are provided with radiation dosimeters to monitor external doses. All workers in radiological areas receive training (Radiological Worker II) prior to performing work on-site to ensure that they understand and are aware of the hazards associated with radiation and proper procedures to ensure safety. Workers must review and understand the applicable area-specific requirements prior to entry into specific radiological controlled areas. Cylinder refurbishing activities will be performed inside a containment building that is operated under negative pressure. Ventilation is used to control the dust concentration within the containment building. Air exhausted from the containment building will be filtered to prevent excessive dust emissions and control potential contaminants. Potentially contaminated dust will be controlled to the degree feasible. The selection of personal protective equipment for the painting is based on the physical, chemical, and radiological hazards and is determined by the Health & Safety Officer for the project. All personnel will utilize "as low as reasonably achievable" methods to reduce exposure and hazardous situations and all activities will be performed in accordance with the radiological requirements found in 10 CFR 835.

Comment 37

So they (the French) — since 1977 they have been converting their UF_6 to U_3O_8. And they have — and not only that, the containers, the three cubic meter metal containers, the powder is pressed to condensify it, and then these containers are stored in a metal frame seismically resistant modular shed. And they can accommodate — I think it's 288,000 metric tons in this facility.

Response 37

The PEIS considers in Appendix F an option similar to that suggested in the comment, which incorporates the conversion of UF_6 to U_3O_8 practiced on a large scale industrial basis by COGEMA in France. In the PEIS, the U_3O_8 product from the conversion step is then compacted

and stored in readily-available 55-gallon drums in a seismically-qualified building, prior to being transported for storage or disposal.

Comment 38

Okay. Again, these are the — this is as reported in the PEIS, and these are some of my comments, quite obvious. Transportation of degraded cylinders is a problem on-site and a much more challenging, expensive off-site transportation problem. Conversion of the Paducah cylinders on-site would eliminate a very large part of the transportation problems as they've got the bulk of the cylinders. And my thought is that the Oak Ridge and Portsmouth cylinders — the conversion to start at a second facility if you expedite more timely conversion and to provide a technical and cost competitive situation which would benefit the taxpayer.

Response 38

The commentor's preference for conversion to occur at the Paducah site (and possibly also at the Portsmouth and K-25 sites) in order to reduce transportation risks, is noted by DOE. It should also be noted; however, that the PEIS did look at two cylinder preparation options which would allow transportation of substandard cylinders if necessary under the management alternative chosen. The two substandard cylinder preparation options looked at were the use of overcontainers for substandard cylinders, and the construction and operation of a cylinder transfer facility to transfer substandard cylinder contents to new cylinders prior to transportation (see Appendix E of the PEIS for details). Differences in cost of the various options was beyond the scope of the PEIS, but cost estimates have been provided in the cost analysis report (LLNL 1997b; the full citation is provided in Chapter 8 of the PEIS). To provide a conservative estimate of potential impacts, it was assumed for the PEIS that a conversion facility would be located at a separate site, requiring transportation of cylinders from the current storage sites. The potential impacts of transportation of cylinders are discussed in detail in Appendix J of the PEIS. Site-specific issues will be addressed in future planning and analysis documents when the site selection occurs.

Comment 39

This is one I had a little problem with. There's a statement in the EIS that in nearly forty years of handling, no accidents involving releases from cylinders containing uranium hexafluoride have occurred that has caused diagnosed irreversible adverse effect. The translation of that is death, plus serious injury. And this is what is in the NUREG report on the accident that happened at Gore, Oklahoma, at Sequoyah Fuels. On January 4th at 11:30 a.m. a Model 48 cylinder with uranium ruptured while it was being heated in a steam chest. The incident resulted in the death of one plant worker and injuries to several others.

Response 39

The PEIS text referred to is in Sections S.4.2.2 and 2.4.2.2, Facility Accidents Involving Releases of Radiation or Chemicals, as follows: "In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing solid uranium hexafluoride have occurred

that have caused diagnosed irreversible adverse effects among workers." The word solid is significant, because all the depleted UF_6 cylinders addressed in the PEIS contain solid UF_6 that is in storage at ambient temperatures. If a breach occurred during handling of a cylinder containing solid UF_6, the rate of UF_6 release would be significantly less than that which occurred in the Gore, Oklahoma accident. However, cylinders containing liquid UF_6 (which may be present if conversion is required under the management strategy selected), or cylinders engulfed in flame for a sufficient amount of time to cause hydraulic cylinder rupture will release their contents to the atmosphere quickly in the form of HF gas and particulate uranyl fluoride. Accidents of this nature have been assessed for all alternatives in the PEIS. The greatest initial hazard after such a release would be the HF, which can cause death if inhaled concentrations are high enough. The acute danger from exposure to HF gas is stated in Sections 4.3.1.2.1 and in Appendix C, Section C.5.2.1. The text in Sections S.4.2.2 and 2.4.2.2 was not intended to minimize the danger of exposure to HF gas; text has been added to the referenced paragraph to clarify that such exposure is life-threatening.

Comment 40

This isn't an Oak Ridge problem, but one of the problems that we had in our investigation.--I think Bob would agree with this, is these three plants were operating like independent entities. The problems were the same, but everybody had a different method. Oak Ridge has asphalt yards, gravel yards. Portsmouth had concrete, which was the best. Paducah insisted that gravel was the best. And they finally — they've come around. They're putting concrete there.

Response 40

On May 5, 1995, the Defense Nuclear Facilities Safety Board (DNFSB) issued to the Department of Energy (DOE) a recommendation regarding the storage of depleted UF_6 in cylinders. In their response and acceptance of this recommendation, the Department committed to managing the UF_6 cylinder project using a systems engineering approach. This approach has been implemented through a 3-Site Management Project with project control to be accomplished through the institutionalization and maintenance of systems engineering for the project. As a part of this approach, a 3-Site Technical Manager has been appointed to provide recommendations and guidance to the project to ensure that technical consistency is achieved. Additionally, all procedures have been converted to three-site procedures and guidelines as necessary to ensure work is performed safely and consistently. Prior to this approach and implementation of systems engineering, each storage location was under the technical and programmatic direction of the managing site which did result in inconsistencies.

Comment 41

AVLIS. If AVLIS isn't dead, it's sure not too healthy. And many people feel that even if we have AVLIS, uranium is cheap, natural uranium with 0.7235, so why would you mess around with these cylinders and the problem handling it when you can get that 0.2 to 0.4235. Economically, it would seem to me that they prefer to use the natural uranium. And then blending down from the

enriched material we're getting from the Russians and so forth and for weapons, said, would have little effect on the conversion to U_3O_8.

Response 41

The possible use of atomic vapor laser isotope separation (AVLIS) to re-enrich uranium is mentioned in Section S.1.1 and Section 1.1 of the PEIS as one of several reasons explaining why depleted UF_6 was stored at the current storage sites. Re-enrichment of depleted uranium using AVLIS technology is not considered in detail as a future use in the PEIS. However, as discussed in Section 2.3.2, if a more efficient enrichment technology, such as AVLIS, becomes commercially available in the future, using depleted UF_6 to make reactor fuel might become more advantageous than using natural uranium. The advantages and disadvantages of using depleted UF_6 for re-enrichment are discussed in the reports by White ("Environmental and Energy Analysis of the Refeed Option of Depleted Uranium Hexafluoride") and Gillette ("Cost Analysis for Refeed Option, Depleted Uranium Management Program") referenced in the PEIS and available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability). These reports can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

4.4 WASHINGTON, D.C., PUBLIC HEARING ORAL COMMENTS AND RESPONSES

Comment 1

Thank you very much and good afternoon. There's no secrecy. I'm Andrew Lorimer from British Nuclear Fuels, BNFL. We share the problem with the United States in that we have tails material of our own in Europe. Our quantities are 30,000 metric tons rather than the 500,000 metric tons that you've got, but the problem remains the same. In the UK we currently have the same policy which we welcome in this report. We look at this material as a strategic material. We should be continuing to store the material and looking at ways in which it can be done safely whilst we find uses for that material. Again from the UK's point of view, we have the luxury, if not the handicap, of not having anywhere to put this material if we did want to decide to put it away now. We have a pecking order for disposal. Our repository is probably slightly more remote than your Yucca Mountain, but at the best will of the world, because of other materials, this material would not be available for disposal, ultimate disposal, until 2050 which, if you think about the economics of processing it now, discounting makes the cost of conversion into alternative forms relatively significant compared to the ultimate disposal process.

Response 1

Comment noted.

Comment 2

In terms of finding uses for this material, it's important that we recognize that the material does not disappear. You can convert it hopefully into forms for which there is a use. This is both an economic and an environmental advantage. But at the end of the day, some of this material is going to exist and certainly in terms of material which has nuclear connotations, i.e., the uranium, it remains significant and, therefore, if we convert it into an alternative form for use or for storage, we have ultimately to take account of the environmental and economic effects of disposition including the end disposal.

Response 2

The DOE recognizes the long half-life of uranium and the associated concerns. However, the PEIS did not address in detail the ultimate disposition of uranium after use because actions to be taken beyond the 40 year period considered in the PEIS (with the exception of long-term disposal impacts) are considered highly uncertain and speculative at this time. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Comment 3

On that basis, we see that there is an omission in the current PEIS which is the use of metal or the implications for metal of disposal. Metal is identified in the report for its potential uses. We see that on the argument that even if you use it, you've got to dispose of it at the end of the day, but also in its own right, metal has potentially certain advantages for long-term storage and ultimate disposal and we would invite the DOE to add that long-term storage and the disposal issues associated with metal along with those of oxide and other forms.

Response 3

The reasons why elemental uranium metal was considered but not analyzed in detail for long-term storage and disposal are provided in Sections 2.3.3 (Long-Term Storage) and 2.3.4 (Disposal) of the PEIS. Disadvantages associated with long-term storage of uranium metal include higher conversion cost, lower chemical stability than uranium oxides, and uncertainty about the suitability of the metal form for eventual disposal in large quantities. The reasons for considering but not analyzing in detail the options for long-term storage and disposal of depleted uranium metal are also explained in Sections 4.4 and 4.5 of the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). Sections 2.3.3 and 2.3.4 of the PEIS have been expanded to add more detail from the engineering analysis report.

The engineering analysis report is available for review at DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 4

Transport has been mentioned. Again, we concur with the general conclusions of the transport. We've looked at the transportation of the tails from a European perspective, both from BNFL and also from Urenco, as an enricher. And the integrity of the container is an important thing, that there is no problem, there is a lot of experience, a lot of very good safety record of moving sound containers containing UF_6. So if the containers are sound, the transportation is not a difficulty.

Response 4

The comment is noted. Prior to transportation, the cylinders would have to meet DOT transportation requirements for UF_6 (as given in 49 CFR 173). Any cylinders not meeting these standards would either have the contents transferred to new cylinders, or be placed in overpacks which would also meet DOT transportation requirements. Details on the overcontainer and cylinder transfer facility options are given in the Appendix E, Section E.2 of the PEIS, and in the engineering analysis report (LLNL 1997a; the full citation is provided in Chapter 8 of the PEIS). All other materials requiring shipment under the management strategy selected would also be transported in certified containers conforming to all applicable shipping regulations.

Comment 5

The problem occurs when the containers are of dubious quality. And we would caution against assumptions that these can be moved simply in an overpack. The overpack itself has to act as the containment of the material in the event of a rupture of the original container and our practice would be to gas off the cylinders and put them in sound cylinders before they're moved, so that has cost implications to the program.

Response 5

Many of the depleted UF_6 cylinders in storage would not meet DOT transportation requirements because they are either overpressured, overfilled, or of substandard quality. In the PEIS, the options assessed for transporting these "problem" cylinders were to transport them in overcontainers, or to transfer the cylinder contents to new cylinders. Any overcontainer selected for use would have to meet requirements such that, when loaded with a damaged, deteriorated, or breached UF_6 cylinder, it could safely be subjected to the same handling, storage, transportation, pressure, temperature, and operational requirements as new Model 48G cylinders (see the engineering analysis report, Chapter 6 for more details). The human health and environmental impacts of using overcontainers to prepare problem cylinders were found to be lower than those of transferring the contents of problem cylinders to new cylinders. However, the impacts of the two options were not significantly different from one another.

Comment 6

In terms of the risk analysis of transportation, we found from a risk analysis basis the dangers of actually moving heavy material from A to B — and Ched mentioned the question of people being run over or so forth — these greatly exceed any chemical or radiological hazard resulting from an accident. So it's actual physical transportation of the quantities that are important. I think that's all I need to say.

Response 6

Comment noted. As summarized in Section J.1 of Appendix J, the transportation analysis for the PEIS shows that the vehicle-related risks exceed the chemical and radiological risks for transportation of the depleted uranium and related materials.

Comment 7

In its report, the DOE examined six alternatives but its analysis is incomplete and deficient. The DOE's effort to address the long-term management of the country's depleted uranium hexafluoride, specifically the realization of the importance to convert this material into a stable form, is long overdue. The Draft PEIS is seriously deficient because it doesn't address the most environmentally appropriate option. Specifically, the DOE did not include the alternative of disposing of depleted uranium according to the rules of 40 CFR 191 which governs the disposal of transuranic waste. IEER (Institute for Energy & Environmental Research) in its comment on DOE's notice of intent has already noted that their proposed list of alternatives was incomplete since it did not include the option of disposal under 40 CFR 191.

And I will summarize with IEER's recommendation which are depleted uranium should be classified as a waste equivalent of transuranic waste for management purposes. UF_6 should be converted to an oxide form and declared a waste to be handled on a par with repository designated TRU waste with the possible exception of a relatively small quantity to be used for the blending down of highly enriched uranium. This should be the preferred option in the Final PEIS.

Response 7

The commentors preference for depleted uranium to be considered as transuranic waste that would be disposed of in accordance with 40 CFR 191 is noted. Depleted UF_6 is a source material. For purposes of evaluating disposal options in the PEIS, it has been assumed that depleted UF_6 would be converted into an oxide. This oxide form would be considered to be a LLW. Only waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, is classified as TRU waste. Waste containing depleted uranium with no or little TRU radionuclides does not fall within this definition. Therefore, disposal of depleted uranium oxides resulting from the conversion of DOE's depleted UF_6 inventory would not be subject to the regulations specified in 40 CFR 191. The material would be classified as LLW and the disposal alternative evaluated in the PEIS considered it to be LLW.

Comment 8

The DOE has rejected our comments without providing any technical or environmental explanation. Our comments are attached. If you're interested, I can give you these comments. DOE should include this option in the Final PEIS.

Response 8

All comments received during the scoping process were considered in defining the scope of the PEIS. Appendix L of the PEIS contains a summary of the responses to comments received during the scoping process.

Comment 9

IEER agrees with DOE that no action alternative is inappropriate and should be rejected because of the dangers of UF_6 storage. For the same reason, long-term UF_6 storage in new containers should also be rejected. Overall conversion to oxide would reduce risks. While conversion poses risk to workers and the outside population, continued storage also poses serious risks. However, the various alternatives that DOE has considered have not been properly assessed in this PEIS

Response 9

The purpose of the PEIS is to present and compare the potential environmental impacts from alternative strategies for the long-term management of depleted UF_6, including evaluation of the no action alternative. The alternatives considered and the assessment assumptions, methods, and supporting data were carefully selected to provide a meaningful and relevant evaluation of potential environmental impacts. Although some differences exist, the results of the PEIS indicate that the potential impacts to human health and the environment are generally similar among the alternatives considered. The ultimate decision on a management strategy will be announced in a Record of Decision. The Record of Decision will consider the results of the PEIS, along with other information, such as cost and engineering data, to select a management strategy. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 10

Now I will address the conversion of uranium hexafluoride. Most of the alternatives considered involve the conversion of uranium hexafluoride, but DOE's analysis is incomplete or deficient in regard to several points. The first one is the fate of the empty cylinders. In its PEIS the DOE doesn't say what will happen to the empty cylinders and that means that the ultimate disposition of the empty cylinders was not analyzed in detail as part of the alternative management strategy, and we don't think this is acceptable.

Response 10

The management of empty cylinders was addressed in the PEIS in association with the conversion options (Appendix F), as well as in a support document entitled "Analysis of Options for Disposition of Empty Depleted Uranium Hexafluoride Cylinders" (Nieves et al. 1997). In the PEIS, for each alternative requiring conversion, the impacts of constructing and operating a cylinder treatment facility were included in the impact analysis. This analysis assumed an initial storage period of 3 months after UF_6 removal from the cylinders to allow the level of radioactivity associated with the decay products of uranium to decrease to acceptable levels. The cylinders would then be washed with water to remove the heels; finally the cylinders would become part of the DOE scrap metal inventory. As a part of the waste management analyses in the PEIS, the impact of disposal (i.e., burial) of the empty cylinders as low-level waste was also examined (Section F.3.7.4). It was found that the empty cylinders would represent only approximately 3% of the projected DOE complex-wide volume of LLW expected to be generated during the time period examined (i.e., through about 2030). The above-cited report by Nieves et al. analyzed the potential health and cost impacts associated with various options for the empty cylinders after treatment, including recycle, reuse, disposal (i.e., burial), and free release. Health endpoints assessed included chemical risks, radiation risks, and trauma risks. Total inventory health risks over 20 years of processing ranged from 0.1 to 0.8 total fatalities for the various options. The potential health impacts were similar for each of the options; however, the disposal option would have the greatest adverse environmental impacts due to land-allocations required and removal of the metal mass from any further usefulness. Text has been added to Sections 2.3.6 and F.2 of Appendix F of the PEIS to summarize the results of the Nieves et al. analyses. The Nieves et al. report and other PEIS supporting documents are available to the public through the DOE public reading rooms near the three current storage sites and in Washington, DC (listed in the Notice of Availability), and can also be obtained by contacting the DOE program manager identified on the cover sheet of the PEIS.

Comment 11

The second point is the commercial use of contaminated hydrogen fluoride which is produced during conversion. The DOE has not properly assessed the management of both hydrofluoric acid which is a byproduct of the conversion process and calcium fluoride, a product of the neutralization of hydrogen hydrofluoric acid. The DOE in its Draft PEIS assumed that these products could be commercially sold for unrestricted use which is quite a problem and it admits that public acceptance will be rather difficult.

Response 11

The PEIS evaluates several options for the fluorine-containing products of conversion, as follows: (1) that hydrogen fluoride (HF) produced during conversion could potentially be sold for use; (2) that the HF could be neutralized by the addition of lime to form calcium fluoride, which could also be sold for use; or (3) that the HF could be neutralized to form calcium fluoride, which would be disposed of either as nonhazardous solid waste in a commercial landfill or as low-level waste (LLW), depending on the uranium concentration and applicable disposal regulations at the

time of disposal. These various use and disposal options for HF and calcium fluoride are described in Sections 2.2.3, 2.2.4, 2.2.5, 2.2.6, and Section F.2 of Appendix F; the potential waste management impacts of the various options are described in Sections 2.4.8, 5.3.7, 5.4.7, 5.5.7, 5.7.8, and Section F.3.7 of Appendix F. Additionally, the risks from storage and transportation of HF if HF production were part of a conversion option chosen for implementation are presented in Sections 2.4.2.2 and 2.4.3. The ultimate decision concerning HF or calcium fluoride production will depend on the conversion process selected, the residual uranium concentrations, market demand, and both public acceptance and regulatory considerations. In response to this uncertainty, the potential environmental impacts of options for both production and sale of HF, and production and sale or disposal of calcium fluoride, are considered throughout the PEIS.

Comment 12

Also, the DOE has not addressed the fact that part of the UF_6 inventory is recycled UF_6 which is contaminated by radionuclides although the uranium-238 such as technicum-99 and uranium-236 which both have a long half life and, as far as I know, there are three sides of this problem of technicum-99 at least.

Response 12

Between 1953 and 1975, some recycled uranium was fed to the Paducah gaseous diffusion plant and to the gaseous diffusion plant at Oak Ridge. The recycled uranium does contain the isotopes mentioned in the comment. However, these isotopes are lighter than U-238, and consequently tend to preferentially end up in the enriched product when they leave the enrichment cascades. The amount of Tc-99 and U-236 in the depleted UF_6 inventory is too small to make a significant difference in the health and safety analyses results presented in the PEIS.

Comment 13

The third point is the radiological effects on workers during the conversion process. In their calculation of radioactivity dose assessment, DOE doesn't take into account internal radiation doses that would be received by involved workers during the conversion process and that certainly needs to be addressed.

Response 13

Radiological impacts were evaluated in the PEIS for both involved workers (those involved in hands-on activities) and non-involved workers (workers at the site not directly involved in hands-on activities) during conversion operations. The assessment of the radiation dose to non-involved workers considered internal radiation from the inhalation of radioactive material released through exhaust stacks. The evaluation of the dose to involved workers was limited to external radiation exposure. Internal radiation doses would be expected to be much smaller than external doses because (1) processes would be enclosed, (2) ventilation controls would be in place to inhibit airborne emissions within facilities, (3) indoor air would be monitored to ensure concentrations were below applicable standards, and (4) workers would be provided with

appropriate personal protective equipment (e.g., respirators) if internal exposures were possible. In addition, dose monitoring is required for all radiation workers. Radiation workers are routinely monitored for external exposure and, in cases where workers are likely to be exposed to free contamination, for internal exposures by use of bioassay or whole-body counting. The worker doses are kept below approved administrative and regulatory limits. They are also kept as low as reasonably achievable (ALARA). Furthermore, the conceptual nature of the conversion, storage, manufacturing, and disposal facility designs does not allow for an accurate estimate of potential indoor air concentrations at this time.

Comment 14

Now I will address the uses of depleted uranium. In its PEIS, DOE's preferred alternative is to use the entire inventory of depleted uranium after its conversion to metal or oxide form for radiation shielding in storage casks for spent fuel. However, since these casks would have to be licensed by the NRC, this choice is premature. Even if the license is approved, cast fabrication creates more problems than solutions. It is not a final solution since the cask conversions do not meet the criteria for deep repository disposal, and DOE doesn't say what will happen to the depleted uranium in these casks.

Response 14

As described in Section 2.2 of the PEIS and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. The PEIS does not state a preference for the end-use products. Consequently, discussion of issues related to specific uses, such as NRC licensing of spent fuel casks, is considered beyond the scope of the PEIS. Such issues would be considered and evaluated in more detail in future planning and environmental analyses. A discussion of issues related to the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9. This section acknowledges the uncertainties associated with the ultimate disposition of the material and notes that at the end of their useful lives products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level radioactive waste.

Comment 15

Then DOE addresses some other uses, not in depth, but which could have very serious consequences if they are being implemented. With the long-term storage options, DOE preserves the possibility to pursue the use of depleted uranium in light water reactor fuel cycle, advanced reactor fuel cycles and advanced material applications. The light water reactor option has two sub-options, the re-enrichment of depleted uranium and the use of depleted UF_6. Among these options, the fact that the use of depleted uranium in advanced reactors, which is another name for breeder reactors, is at all considered is particularly disturbing. Depleted uranium being the raw

material for plutonium production when converting it into material not only much more radioactive but also weapons usable would not only defeat the purpose of the PEIS which is, in quotes, "Achieve the safe and effective long-term management of depleted UF_6" and it would also have serious proliferation consequences.

Response 15

As described in Section 2.2 and Appendix H, the two use options evaluated in the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, are representative and were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end-use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. Careful consideration would be given to whether the benefits of any proposed use outweigh the potential risks. Regarding the use of depleted uranium in advanced reactors, the United States has no active breeder reactor program at this time. Implementation of an advanced reactor fuel cycle would require a change in national policy.

Comment 16

We think that the PEIS has some uses which are not analyzed and specifically the feasibility of using depleted uranium hexafluoride for the blending down of surplus highly enriched uranium was not considered in this PEIS. Although it would utilize only a small portion of the stock, this use would have several advantages, among them the contribution to nonproliferation, a minimum of handling, and incorporation of depleted uranium into spent fuel. This use option could be made part of any of the alternatives except UF_6 storage.

Response 16

The two use alternatives evaluated in detail in the PEIS, use as uranium oxide and uranium metal as radiation shielding, were selected as representative options for the purposes of comparing the potential environmental impacts of broad alternative management strategies. These options were intended to be representative only, and were not intended to preclude other potential uses in the future. Specific uses, such as use for blending down highly enriched uranium, would be considered and evaluated in the implementation phase (Phase II) of the program as appropriate. Several alternatives for managing highly enriched uranium were evaluated in the Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement, issued in June 1996, as summarized in Section 1.6 of the PEIS. It is expected that such uses would require only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy. A reference to the potential use of depleted uranium for blending has been added to Section 2.3.2 of the PEIS.

Comment 17

But nevertheless, to recycle this material the first gentleman pointed out the one unequivocal thing one must recognize is that it's still radioactive at the end of its functional life. No matter what that is, its half life being over five billion years, is going to outlast most of us and, as a consequence, any recycled, reused storage or whatever needs to contemplate the long-term outcome.

Response 17

The DOE recognizes the long half-life of uranium and the associated concerns. However, the PEIS did not address in detail the ultimate disposition of uranium after use because actions to be taken beyond the 40 year period considered in the PEIS (with the exception of long-term disposal impacts) are considered highly uncertain and speculative at this time. For instance, products containing depleted uranium potentially could be stored, recycled for other uses, or treated and disposed of as low-level waste. In addition, future regulatory requirements concerning disposal may differ significantly from current requirements. To address such issues, a discussion related to potential life-cycle impacts and the final disposition of products containing depleted uranium has been added to the PEIS in Section 5.9.

Comment 18

And the long-term outcome, as I see it, should be chosen on the basis of the minimum cost path to an acceptable long-term or essentially geologically equivalent management strategy. There's a lot of simple and very expensive ways we can get to a safe long-term outcome. There are much fewer economic ways.

Response 18

The ultimate decision on a management strategy, which will be announced in a Record of Decision, will consider cost information along with the results of the PEIS, engineering data, and other pertinent information. The Record of Decision will document the strategy selected and describe how it was selected from among the different alternatives.

Comment 19

When we talk of depleted uranium as a resource, we have to talk out of two sides of our brain. On one hand, the fluorine material, if properly extracted and mined, can in fact have an economic resource recovery value. The depleted uranium, until there's a lot more people in line wanting to use it, does not have an economic recovery value, and I think the strategy that needs to be chosen is one that will minimize the cost on getting to the geological repository disposal and, more importantly, minimizing it in a context of all of the other nuclear waste management issues under the responsibility of the Department of Energy.

Response 19

The commentor's preference is noted.

Comment 20

To wit, I would like to mention spent fuel, one that most of you are relatively familiar with. The spent fuel storage issue, be it geologic or the interim storage facility, there is no solution today and I offer DUCRETE which, for those of you not familiar with it, is simply to take the depleted uranium hexafluoride, extract the fluorine value from it as best as you can and as economically as you can. You now will have converted it into an oxide, just as the last couple of speakers mentioned. In an oxide form you have a chemically stable, inherently relatively benign material. If you keep it out of your lungs, it ain't going to hurt you. That's health physics for depleted uranium. And then the next step after that that I advocate is the conversion to a ceramic aggregate which the work we did at INEL has formed an extremely stable ceramic aggregate that's comparable in leach resistance to some of the high level waste glasses that have been developed. That ceramic aggregate can now be mixed with traditional concrete materials and made into concrete. With a density of about 400 pounds a cubic foot, you have a uniquely different shielding material than ever before contemplated by mankind because in a technical context you have both the high density associated with uranium which other materials have high density, but you also have hydrogen embedded in the matrix for the attenuation of neutrons. So you have a uniquely capable material to use for high level waste and spent fuel storage applications. In the means of processing this thing, you have now incorporated the uranium into an extremely stable geologically safe repository waste form that at the end of the useful life of the containers can then be disposed of either with the containers in a repository — and for some of you, you've seen I have many papers on how I would redesign the repository which I won't get into today. But there are many safe and very practical things that, if the Department takes the context of uranium management in the system context of its other management issues, you will come up with a different solution than by separating these things into what has become popular the last two years called the stovepipes where you separate the solutions and ignore the fact that there's the functional equivalent of 11,000 containers of depleted uranium concrete casks could be made and supplied and use up this entire inventory including the generous contributions yet to come from the U.S. Enrichment Corporation.

There's an interesting system match between the amount of material that we've mined, converted into fissile material, used in reactors and the tails left over such that in the studies I've done under the INEL work in the past years and most of which are public documents, you'll find that there's enough inventory now for about 8,700 casks and with the USEC generating about 300 cask equivalents per year, we won't run out of DU before we encapsulate all of the spent fuel in a DUCRETE system which leaves the entire management in an environmentally responsible final physical form that is stable for very, very long periods of time.

Response 20

The commentor's preference for use of depleted uranium in DUCRETE is noted. The PEIS considers the potential use of DUCRETE in depleted uranium shielding. As noted in Appendix H of the PEIS, the PEIS evaluates two options for the manufacture and use of depleted uranium shielding, one of which is the uranium oxide option, which is based on the use of dense uranium oxide (UO_2).

This option uses dense uranium oxide in the manufacture of depleted uranium concrete for shielding in spent nuclear fuel storage casks, to produce an uranium concrete material known as DUCRETE.

Comment 21

So with that, I think I will mention one other important thing is that all of that which looks good on paper doesn't mean a damn thing unless we get on with it today. This has been talked about futilely myself for over four years in my efforts at INEL and since I've left INEL a year and a half ago with the company I'm now employed by. The spent fuel storage system is evolving. It is being designed. It can't be retrofitted easily with DUCRETE without causing large financial perturbations on those companies that are active in it. If this option is to be available to the Department, it must be implemented on a timely basis and from the system consideration I'm talking about so that all the departments who have some role in these various disposal issues will focus on it as a combined problem and develop the synergy that can be brought to it. So the action is required now, not 10 years from now when the commitments and fuel storage, fuel transportation for Yucca Mountain are all well established and you can't walk backwards without incurring billion dollar type of cost liabilities.

Response 21

The commentor's preference for prompt implementation of the uranium oxide concrete (DUCRETE) spent fuel storage cask option is noted.

Comment 22

Related to what I said at the outcome and the British gentleman said, this stuff is a low level waste under any stretch of the imagination and there needs to be a final disposition planned in advance. It's not called a resource when somebody has to take the liability potentially — Barnwell, for example-- of $300 a cubic foot and then some and God only knows what it might be 20 or 50 years hence.

Response 22

An evaluation of impacts of any specific plan for disposal would be included in a project-specific NEPA document following strategy selection. The analysis in the PEIS is at a more general level appropriate for the selection of a strategy. Once the strategy is selected, and should that strategy involve disposal, the project-specific disposal plan analysis would be done. However, for purposes of evaluating strategies involving disposal, it was assumed that depleted UF_6 would be converted into an oxide form and thereafter disposed of as a low level radioactive waste. The PEIS evaluates the impacts of such disposal on human health and the environment (section 5.6 of the PEIS). The potential disposal impacts are evaluated for two different uranium oxides — U_3O_8 and UO_2. For each disposal form, several disposal options were considered, including disposal in engineered shallow earthen structures, below-ground vaults, and a deep mine.

Comment 23

I think to support and encourage the deployment of resource applications of the uranium material, be it an oxide or in any other form that makes economic sense, that there needs to be a policy issue addressed and probably Congress has to get in the act that at the end of the day when the sun sets that there will be a facility owned and operated by the DOE to ultimately receive the material. Without that, no commercial company is going to take on the liability of owning an inventory of material even if the regulators would allow it — and in most states that wouldn't happen — and taking on this liability that's going to essentially put their stockholders in bankruptcy. So recycle is a wonderful word but only if all the parts fit together. It's got to be the economics. It's got to be the final disposition and the action has to be taken now or those few, very, very few applications will disappear as the evolution of spent fuel storage issues move forward in the country. Thank you.

Response 23

Use of products made from either depleted uranium oxide or metal is possible today in non-commercial environments such as DOE or the Department of Defense, consistent with government policy, procedures, and regulations. To be used outside of those environments, the planned uses would have to be consistent with policies and regulations of the Nuclear Regulatory Commission. DOE believes that the private sector, rather than the Government, may be better able to provide solutions for the management of the depleted UF_6 inventory. On March 4, 1999, DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations. (This is referred to on page 13 of the March 8 issue of the Commerce Business Daily *published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory.*

Comment 24

As I said down here, unfortunately, this report six years is still considered draft, preliminary draft. It's never been issued for public dissemination which was contrary to every investigating team that I worked on while I was at the Department of Energy. Needless to say, this report, even though not formally issued, has received wide dissemination by me.

Response 24

The comment regarding the "Draft Preliminary Report — DOE Independent UF_6 Cylinder Assessment Team" is noted.

Comment 25

More disturbing are the next two. As a result of my concerns and others' concerns, DNFSB–everybody, I think, knows that hieroglyphic–but the Defense Nuclear Facility Safety Board, looked at the cylinders of K-25 and they decided investigation would be appropriate and they spent about six or seven months with a high quality team of former nuclear Navy types under Doctor Woody Cunningham and they issued a report on May 5, 1995. Here's the number. DNFSB TECH-4.

Not only was the preliminary draft report not cited in the EIS which is not maybe too surprising, but this report is not cited either.

Response 25

The preliminary draft report referred to in the comment is the March 25, 1992, Draft Preliminary Report by the DOE Independent UF_6 Cylinder Assessment Team. Because this report was never finalized it is not cited in the PEIS. The referenced DNFSB Tech-4 report was followed by DNFSB Recommendation 95-1, which made specific recommendations to DOE to address the problems identified in Tech-4. DNFSB Recommendation 95-1 has been addressed by DOE and was used in the preparation of the PEIS to the extent practicable. DNFSB Recommendation 95-1 was listed in the reference section of the Draft PEIS, but on review of the text it was decided that further details on the recommendation and its relationship to this PEIS would be informative. A summary of the DNFSB report and DOE's actions in response to the DNFSB recommendations has been added to the PEIS (see new Section 1.7).

Comment 26

And third, even more disturbing is the fact that an investigation or examination by the National Academy of Sciences and National Research Council did a very extensive study. This is the preliminary ORO report. This is the DNFSB report and this tome is the National Research Council report. "The Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities" and there's one or two chapters in here that are devoted specifically to the subject of this meeting and that's the depleted UF_6. That again is not cited in the environmental impact statement. And I'm glad to hear there's an emphasis on this. A draft is a draft and it's going to be revised and I talked with Ched a little bit and he told me that he thought it would be appropriate to maybe mention these reports which are specific to this problem. The National Research Council team, and they spent about 18 months, I believe, investigating this. This laundry list of names here are outstanding engineers and scientists in this nation that did this study and there were several of these. Doctor May and Doctor Schneider, Georgia Tech and University of Illinois, that headed a sub-task that looked at depleted uranium. And when I talked to Doctor Zuccheeto, who is the study director, recently he was quite surprised, disappointed, shocked, however you want to characterize it, that none of the information that they generated was used in the PEIS.

Response 26

Much of the information provided in the report Disposition of the DUF_6 (Chapter 7 of the 1996 National Research Council's "Affordable Cleanup? Opportunities for Cost Reduction in the Decontamination and Decommissioning of the Nation's Uranium Enrichment Facilities" consists of preliminary estimates of costs associated with various options for disposition of the depleted UF_6 inventory. Cost analyses are not within the scope of the PEIS. However, the report is a valuable background reference on the depleted UF_6 in general and its management options. This report as well as some other general reports on the subject were reviewed and used in preparation of the PEIS

and supporting documents, for example, the engineering analysis report. A brief discussion of these general reports has been added to the PEIS (see new Section 1.7) and references to the reports have been provided.

Comment 27

I'll switch gears now to my seismic concerns. I'd be waiting to see a copy of this for nine months. It was originally planned to be issued in March of last year and then June and September and then finally Christmas Eve I got a package. I told my wife that was the nicest Christmas present I could get. She always thought I was a little weird but that confirmed it. I told my wife the first thing I'm going to do is a sanity check. I'll read you what's said in the EIS. "The largest recorded earthquake in the region occurred in 1812 and was centered in New Madrid Fault Zone. This earthquake had a magnitude of 7.3 on the Richter scale and the epicenter was 60 miles southwest of the site. Paducah, of course. The estimated 1,000 year return period peak ground acceleration was 0.45 of the acceleration to gravity." I'm no seismologist, but I think that the general public, with their lack of detailed knowledge of seismology, might interpret this as 1,000 year return period or reoccurrence frequency. And, as I've said before, my 95 year old mother and my 12 year old grandson know more about the New Madrid earthquake than was displayed in this document. This is one of many, many references to that subject and I have a file about two or three inches thick in New Madrid in my home in western Kentucky. But in The Coming Quake by Heppenheimer 1988, references the New Madrid earthquake. Without reading all the details, there were four major earthquakes. The smallest was 8.3 and the largest was 8.8 over a three month period. Greater than any earthquakes ever hit the United States. Three or four times higher than anything California has ever seen and some people think maybe it was the largest earthquake in the history of the earth. Doctor Otto Nuttli, who is the guru of this subject and several other people have confirmed to me that he is quite a knowledgeable expert, in a paper issued in the Journal of Seismology in 1973 said there was enough stress built up in the faults in New Madrid to generate a 7.6 earthquake. Remember the EIS said 7.3. And this is a tremor worth fearing. It has the potential to strike tomorrow, not 1,000 years from now or not 500 years from now. That doesn't mean it's going to happen, but the potential is there. This shows kind of the bull's eye. The selectors of the Paducah site must have used this map to pick the site. Paducah is right about here and this is the New Madrid quake and this is Doctor Nuttli's prediction based on a 7.6 Richter and, as you can see, Knoxville and Oak Ridge is a little bit out of the range there but the characteristic of New Madrid is quite — for those of you, I don't want to talk down to anyone on this subject — but the earthquakes in the New Madrid area were a hell of a lot more severe than anything in California. I mean they extend for hundreds and hundreds and hundreds of miles without much dissipation of force, quite in contrast to the California quakes. I'm sure you've all heard about that 1812 ringing the church bells in Boston which it did.

Response 27

The PEIS addresses the potential for seismic activity at each of the three storage sites in Sections 3.1.4.1, 3.2.4.1, and 3.3.4.1. Of the three storage sites, an earthquake which could cause

more than slight damage is considered credible (though highly unlikely) only for the Paducah site. The text of Section 3.1.4.1 of the PEIS has been revised to be consistent with information presented in the safety analysis report for the Paducah Gaseous Diffusion Plant.

The analysis of accident scenarios for continued cylinder storage (Section D.2.2 of the PEIS) was based on the range of potential accident scenarios considered in the safety analysis reports recently prepared for each of the three storage sites (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS). The SARs considered a range of potential accident scenarios that could be associated with current storage activities, including natural phenomena events such as earthquakes. The accidents considered in the PEIS for current depleted UF_6 cylinder storage were extracted from those evaluated in the SARs. The accidents selected for the PEIS analysis were those accident scenarios in the SARs that resulted in the greatest potential consequences at each of the three storage sites. These accidents did not include earthquake scenarios, which were found in the SAR analyses to have lesser consequences than the accident scenarios discussed in the PEIS. The text in Section D.2.2 of the PEIS has been modified to clarify this point. If the safety analysis reports are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

Comment 28

There's a little concern about — or at least I have a little concern about how many cylinders we're talking about. Again, without going into all the details, in our investigating team we were told there were 55,649 thin wall cylinders of various models. The DNFSB team was told in '95 55,000 and the direct EIS is 46,400. Now there may be a very good explanation for this, but I'm not sure what it is but, as Ched pointed out, the number is going to go up about 10,000 if the privatization occurs so it's such a big number I guess it doesn't matter whether it's off five or ten thousand.

Response 28

The PEIS addresses the cylinders which contain depleted uranium, that is, uranium with an assay less than 0.7110% U-235. Additional cylinders present at the sites contain normal UF_6 (assay equal to 0.7110% U-235) or enriched UF_6 (assay greater than 0.7110% U-235). Depleted, normal, and enriched UF_6 are very different materials in their end use. Disposition plans for the normal and enriched UF_6 would be quite different from those proposed for the depleted UF_6 and therefore would not be appropriately addressed under the current scope for this PEIS. If the number of cylinders containing normal and enriched uranium were added to the number containing depleted UF_6, they would total in excess of 55,000 cylinders.

Most of the cylinders at the three storage sites are large diameter cylinders (i.e., 48") that are filled to their capacity with depleted UF_6. Some smaller cylinders also contain depleted UF_6 and are included in the scope of the PEIS. Additionally, approximately 200 cylinders contain a small amount (commonly called a "heel amount" in the UF_6 industry) of depleted UF_6. Text has

been added to the PEIS stating that these "heels" cylinders are a part of the inventory included in the scope of the PEIS. (See Sections 1.5.2 and 4.2.1 of the PEIS.)

The scope of the PEIS has been expanded to include up to 15,000 cylinders produced by USEC after July 1, 1993 that became or will become the responsibility of the DOE by the signing of two Memoranda of Agreement between DOE and USEC after publication of the Draft PEIS (DOE & USEC 1998a-b; the full citations are provided in Chapter 8 of the PEIS). In order to accommodate these new cylinders, the PEIS has been revised. Rather than increasing the amount of cylinders assumed to be processed annually, the revised PEIS assumes that the work-off period (the period over which the processes assumed in the PEIS, for example, cylinder preparation, transportation, conversion, manufacturing, would take place) has increased by approximately 6 years (i.e., from 20 to 26 years).

Comment 29

This is what I call a swamp picture. This is Oak Ridge. The cylinder is too high. You can barely see the ties here that they're resting on and they were on a very soft storage yard and they sunk into the earth and this is weeds and so forth and the importance of this is that the moisture accelerates the local corrosion by a factor of five to 10, so a lot of times you might see that the corrosion rate is like 1/10th of a mil per year or a fraction of a mil per year and that may be true on the upper portions of the cylinders where it's fairly dry, but the lower part is complicated by a lot of factors. If it's close to the ground, it's a moist area, if it's got rust on it, moisture collects in the rust, the water runs around the cylinders and the cylinders cool off at night and in the day time they pick up moisture. Moisture condenses. So you've got a prime condition for getting the moisture in contact with the steel which accelerates the corrosion.

Response 29

Because substandard conditions such as ground contact and poor drainage in cylinder storage yards have been identified as the cause of external cylinder corrosion, the UF_6 cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS) was developed to eliminate these substandard conditions. (The plan is discussed and referenced in the Introduction to Appendix D of the PEIS.) Under this management plan, all cylinders must be stored out of ground-contact with enough space to allow for periodic complete inspections. These requirements have necessitated some yard reconstruction and cylinder relocations; most of this work has already been completed at the three sites or is planned for completion by the year 2002. The DOE is confident that the activities required under the cylinder project management plan will maintain adequate safety of the depleted UF_6 cylinder inventory.

Comment 30

This was the biggie. There's a reinforcing ring right here. The scientists at Oak Ridge did a wonderful job of analyzing these leaks and the scenario of how the corrosion started, when the leaks initially occurred and the material doesn't drool out on the ground by any stretch of the

imagination. They estimated that this leak from their studies was 13 years old. When you get all the crud off, there was a hole 4" wide and about 18" long and the only reason this was discovered was there'd been a lot of trouble with the valves on these cylinders in the past and when the workers were looking at the valve, somebody happened to glance around the corner and saw this pile of reaction debris laying underneath the cylinder. I may mention it later but these reaction products are soluble in water so if you have a small leak and a lot of rain and you start checking for uranium, you're not going to find much.

Response 30

The commentor is describing one of two breached cylinders discovered at the Portsmouth site in 1990. The discovery of these breached cylinders lead to inspection of all the cylinders, the identification of five more breached cylinders before 1998 , and the development of an extensive cylinder project management plan (described in the Introduction to Appendix D of the PEIS). The conditions which allowed the breached cylinder to go unidentified for such a long period of time have been eliminated. All cylinders are now inspected at least every four years (those with more extensive corrosion or pitting are inspected annually). This inspection schedule has been designed to detect breaches in the early stages so that the environmental impact can be greatly minimized. During early stages of hole growth, the exposed area of UF_6 is separated and protected from the environment by a relatively insoluble UF_4 layer. It is estimated that it takes 4-5 years for a 2-inch hole to develop. Visual inspections geared to detection of holes within this period (1 to 4 years) are designed to limit the potential uranium loss. The size of the hole in the cylinder the commentor is referencing indicates that the reaction had been occurring for an estimated 13 years. The comment is correct in stating that uranyl fluoride would react further upon contact with water. The second paragraph of section C.2.1 in Appendix C of the PEIS indicates that the estimation of potential impacts to water resources from cylinder breaches assumed reaction of the uranyl fluoride laying on the ground with water to form hydrogen fluoride and various uranium compounds which could dissolve and infiltrate surface and shallow groundwater resources.

In 1998 one additional breached cylinder was identified at the K-25 site; see response to Oak Ridge Public Hearing Oral Comment 31 for further details on this breached cylinder.

Comment 31

This is what I call a 6:00 leak. Initially when it was in another storage yard before it was transported and restacked, this was in the ground or close to the ground and the corrosion on the bottom of the cylinder excessive and generated this leak. I'm not going to say much about mechanical damage, but that is another real problem and, even though Portsmouth cylinders are probably in better shape than anywhere else, they have a lot of cylinders that have dents in them and where the lugs, depending on how accurately they stack them, if they aren't very careful, these lugs can hit the adjacent cylinder and these cylinders are 0.312, 5/16th of an inch thick and I have more to say about that later on.

Response 31

Cylinder stacking anomalies such as contact of lifting lugs with neighboring cylinder bodies are noted and recorded in the periodic cylinder inspections so that cylinder management personnel can be made aware of incorrect stacking conditions. Under the current cylinder project management plan (LMES 1997i; the full citation is provided in Chapter 8 of the PEIS) discussed in the introduction to Appendix D of the PEIS, restacking of many cylinders and construction of new storage yards has been accomplished to correct stacking anomalies and to remove cylinders from ground contact. Annual cylinder inspections are required for cylinders previously stored in ground contact or cylinder damaged due to incorrect stacking. Improved procedures now used during stacking activities have greatly decreased the number of cylinders damaged during restacking.

Comment 32

Ched showed a picture of this earlier. Unfortunately, it's glorified with a nice border and so forth and detracted a little bit, I think, from the detail. I think in this shot there's something like 33,000, but you can see a few rusters here, rust, all these are rusted, all these, these, these, these. They're pretty heavily rusted. No semblance of paint remaining on these cylinders.

Response 32

The commentor is referring to an aerial view of the Paducah Cylinder Storage Yards. The remarks are noted.

Comment 33

When we were doing our investigation, this is the numbers that were given to us by Martin-Marietta, the contractor operating the K-25. I won't go through all this but number in long-time storage, 55,000. Number in near ground contact, 37,000. Inaccessible end plugs. Anybody that happens to be in Oak Ridge and is interested in this subject should take a mechanized tour around the fence to look at these cylinders as far as being inaccessible. Some of them you couldn't put a piece of paper between the ends of them. Twenty one thousand of those. Shell to lug contact, 44,000. Poor drainage yard, 12,253. Paducah and Oak Ridge are the worst offenders in this regard. Portsmouth did a much, much better job with their concrete yards. This is out of a work agreement to Linc Hall, Lockheed Martin from Joe Parks of DOE Operations Office, October '95 and it says, this particular line, "Complete annual inspection of 17,475 cylinders exhibiting accelerated corrosion and other problems." So we're talking about a lot of cylinders that are in varying degrees of degradation.

Response 33

Subsequent to the identification of 7 breached cylinders in 1990 through 1992, the cylinder project management plan was initiated to remediate the inadequate storage conditions listed above by the commentor. Under this management plan, all cylinders are now inspected at least every four years (those with more extensive corrosion or pitting are inspected annually). All cylinders must be stored out of ground-contact with enough space to allow for the periodic complete inspections.

These requirements have necessitated some yard reconstruction and cylinder relocations; most of this work has already been completed at the three sites. The DOE is confident that the activities required under the cylinder project management plan will maintain adequate safety of the depleted UF_6 cylinder inventory.

Comment 34

This is a K-25 report in '92 which again corroded cylinders, visible pitting and so forth, 15,000. Full limit consideration fill limit and I'm not going to get into that too much but that's a real problem if you have a cylinder that has more in it than you thought it might have and when it's melted, it can cause rupture. So there are some cylinders that may be okay, but there's a question mark involved in some of them. Inaccessible cylinders, 22,000.

Response 34

In regard to the overfilled cylinders, this issue is discussed in the Introduction to Appendix E of the PEIS, and in the engineering analysis report, Section 6.1.4.2. Both the overcontainer and the cylinder transfer options considered under Cylinder Preparation would address the problem of overfilled cylinders and allow for safe transportation and handling of these cylinders. Additionally, the amount of material in each cylinder is a known quantity and can be evaluated when the cylinder is handled, whether for transportation or for transfer of material. The problem of inaccessible cylinders is being addressed under the cylinder project management plan through restacking in configurations that allow for complete cylinder inspection. Corroded cylinders with visible pitting are required to be inspected annually so that if a breach were to develop, it would be identified and patched before significant quantities of UF_6 were released. (During the early stages when a cylinder is breached, the exposed area of UF_6 is separated and protected from the environment by a relatively insoluble UF_4 layer.)

Comment 35

And a few words about conversion. To me, the most important one is what have the French been doing for the last 22 years? They chose in 1977 to convert all their UF_6 to U_3O_8 and they packed the U_3O_8. They compressed it to get it as dense as they can in steel three cubic meter containers and they store those containers in metal reinforced seismic resistant buildings. And I think they have something like 280,000 metric tons stored and additional capacity. But the reason they did that was because they felt there was a problem of storing UF_6 for a long period of time.

Response 35

Comment noted. Conversion to U_3O_8 followed by placement into long-term storage is one of the alternatives analyzed in the PEIS.

Comment 36

Some of the safety thoughts. There's a statement made in the PEIS that says, "In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing

uranium hexafluoride have occurred that have caused diagnosed irreversible, adverse effects among workers." I think it's an interesting term that must be used quite a bit, this irreversible adverse effects, but I think it includes death and serious accidents. This is a report in an NRC NUREG report June of 1986 and many of you who are in this business know of this accident. This happened at Gore, Oklahoma in the Sequoyah Fuels Corporation where a cylinder ruptured when they were making the transfer. It was liquid form. Thirteen tons. Lots of HF. One worker was killed and several others were injured and an HF cloud rolled across I-40 and the Oklahoma state police had to close the interstate for a number of hours. One lady who lived nearby in a home ran vigorously and escaped, thank goodness.

Response 36

The referenced text from the PEIS is from Sections S.4.2.2 and 2.4.2.2, Facility Accidents Involving Releases of Radiation or Chemicals. However, the text is slightly but significantly misquoted; the word "solid" was omitted in the comment. The actual text of the PEIS reads as follows: "In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing solid uranium hexafluoride have occurred that have caused diagnosed irreversible adverse effects among workers." The omission of the word solid is significant, because all the depleted UF_6 cylinders addressed in the PEIS contain solid UF_6 that has been in storage at ambient temperatures. If a breach occurred during handling of a cylinder containing solid UF_6, the rate of UF_6 release would be significantly less than that which occurred in the Gore, Oklahoma accident. However, cylinders containing liquid UF_6 (which may be present if conversion is required under the management strategy selected), or cylinders engulfed in flame for a sufficient amount of time to cause hydraulic cylinder rupture will release their contents to the atmosphere quickly in the form of HF gas and particulate uranyl fluoride. The potential for adverse effects and irreversible adverse effects, including death, from accidents of this nature have been assessed for all alternatives in the PEIS. The definition of these terms is found in Section 4.3.2.1 of the PEIS. As the commentor stated, the greatest hazard initially is the HF, which can cause death if inhaled concentrations are high enough. The acute danger from exposure to HF gas is stated in Sections 4.3.1.2.1 and in Appendix C, Section C.5.2.1. The referenced text in Sections S.4.2.2 and 2.4.2.2 was not intended to minimize the danger of exposure to HF gas; text has been added to the referenced paragraph to clarify that such exposure is life-threatening. The intent of the text was to clarify that the PEIS likely overestimates the health impacts which would be associated with exposure to uranium compounds if an exposed individual did not succumb to HF toxicity. For example, even in the Gore, Oklahoma accident, the 31 other exposed workers whose health status was investigated after the accident showed no signs of kidney toxicity from the uranium exposure; the intakes of these workers were estimated to range from 0.6 to 24 mg of uranium. Some workers did have short-term respiratory problems associated with the HF exposure; however, no evidence of long-term lung damage was observed based on comparison of pre- and post-accident pulmonary function tests.

Additionally, estimated intakes for 2 adult male workers exposed in a 1944 accidental release of UF_6 were 80-100 mg uranium (as summarized in McGuire 1991 and Fisher et al. 1990;

see references to Appendix C for full citations). These workers had some evidence of short-term kidney function impairment which was repaired by about 3 weeks post-exposure. In contrast to these findings, the PEIS conservatively assumed in the accident analyses that anyone with an intake of 10 mg or more of uranium could experience adverse effects (generally temporary in nature), and that anyone with an intake 30 mg or more could experience irreversible adverse health effects.

Comment 37

The fill limit problem. I'm not going to talk about that but it is a serious consideration. The 62 percent solid fill that was mentioned earlier by Ched is an extremely important consideration when you start melting these cylinders. You've got to be sure that you have room to expand. Incompressible liquids fracture things.

Response 37

The reference "Uranium Hexafluoride: A Manual of Good Handling Practices," ORO-651, provides information of UF_6 cylinder fill limits. UF_6 exhibits a significant expansion when undergoing the phase change from solid to liquid, with a 53% increase in volume from a solid at 70 °F to a liquid at 235 °F. As an example, a 140 cubic foot cylinder, with a shipping fill limit of 27,030 lb, could accept up to 31,340 lb UF_6 at 160 °F. When heated above 160 °F, the liquid UF_6 would completely fill the cylinder and would hydraulically deform and rupture the cylinder. To assure the safe transfer of the contents of the depleted UF_6 cylinders, the PEIS considers transferring by sublimination using air heating, instead of the current practice of transferring by liquefaction using steam heating. Further details of the method of cylinder transfer considered in the PEIS is provided in Appendix E of the PEIS.

Comment 38

This is an interesting memo I came across when we were doing our investigation. This is from Portsmouth and it's a 14 ton cylinder problem. It says, "It was reported that another cylinder was stepped on by a supervisor and he felt the wall give." I mean that may give you some indication of what this 0.312 and that's probably not due to corrosion. It's just the fact that just the weight of a foot on the top of these cylinders caused it to flex and it wasn't the first time. And I've got undocumented statements from other people that talk about the truck drivers when they tighten the tie-downs down have noticed the cylinder walls flexing a little bit but that's just to give you some idea of how rugged these cylinders are.

Response 38

The 0.312 the commentor is referring to is the wall thickness in inches. Most of the thin-wall cylinders are over 0.300 inches in wall thickness. Some of the older cylinders have wall thicknesses at some points below the 0.250 inches that the Department of Transportation requires for safe shipment and that the American National Standard Institute (ANSI) requires for safe transport. The cylinder project personnel have evaluated the structural integrity of these cylinders in the configuration that they are presently stored and in many handling configurations. It has been

determined that the cylinders may be safely stacked in two-tier rows without compromising the structural integrity. This allows one 14-ton cylinder to be stacked on top of two 14-ton cylinders with no deflection in the steel.

Comment 39

One thing I didn't mention is why are they 5/16th" thick? Somebody, probably a genius here at headquarters, back in the period of probably 30 years ago, 25 or 30 years ago, decided that they over-designed these cylinders and they could cut the thickness from 5/8", 0.625, down to 5/16. And in our investigation, we talked to the metallurgists at Portsmouth and Paducah in particular and they said they fought it but they were overruled on cost basis. So penny wise, pound foolish.

Response 39

The initial UF_6 processing utilized 30" cylinders and smaller cylinders for in plant processing and transportation. In the early 1950's 48" cylinders were designed for UF_6 use for a more efficient operation. These cylinders were designed very conservatively since the industry was young and operating conditions were being identified. The thicknesses of these initial cylinders were designed to be 5/8" which corresponded to 200 psig design pressure which turned out to be over-designed for the feed and withdrawal services actually experienced for normal operation. In the mid to late 1950's a 5/16" thick cylinder was designed corresponding to a 100 psig design pressure which was in line with actual process feed and withdrawal pressures. At this time these thinner cylinders were not used for any transportation. As the plants gained more experience with the thinner cylinders they were found to be acceptable for transport. Tests to demonstrate compliance to DOT requirements were initiated in the 1960's to be able to ship normal and depleted UF_6 in thin wall cylinders. The testing showed that the thin walled cylinders were better able to withstand the drop tests than the heavy wall cylinders. In the late 1980's ANSI N14.1 included the thin walled cylinders into the standard for shipment of normal and depleted UF_6. In the early 1990's IAEA accepted the thin wall design. When the thin walled cylinders were developed in the 1950's the design was accepted by all the sites. There were no technical objections to the design. The only significant advantage of the heavy wall cylinder over the thin is the additional thickness that is available for corrosion during storage.

Comment 40

The other thing I might mention in that regard is why the cylinders stack two high. Apparently about in the same time period appeals were made from the three plants to get more money for storage yards and somebody decided they didn't need the additional storage yard. They'd just stack them two high. And that was the second big mistake.

Response 40

The current practice for outside storage of depleted UF_6 cylinders is for the cylinders to be stacked two high. This stacking configuration has been evaluated by structural engineers and has been approved as sound. The bottom tier of cylinders is supported on saddles to distribute the

load and prevent contact with the storage surface. Depleted UF_6 cylinders have been safely stacked two high in outdoor yards since the 1950's without any significant radiological releases or other consequences to the general public.

Comment 41

These are taken from a DNFSB report. I'm not going to bother reading all this but they had safety concerns and one of them was — and this is something that was suggested by Martin-Marietta people many, many years ago — that there had never been a safety test run in which — let me back up. If you drill a hole in the bottom of the cylinder and you put it in a pond, no problem. It'll react slowly and so forth. Up in this vapor region you have fluff. This stuff decomposes, it condenses and so forth and it's a tremendous amount of surface area. The reaction of moisture with the UF_6 is exothermic and so the accident scenario that's been proposed is a small crack in the top of the cylinder like truck wrecks in a creek, whatever, and some limited amount of water gets into that upper area. You've got a tremendous surface area, exothermic reaction and limited amount of water for cooling and the scenario is that there will probably be a steam explosion of some type. It might just blow material back out. It might rupture the cylinder. I don't think we really have an answer to that.

Response 41

The accident scenario described in the comment is similar to the vehicle-induced fire accident considered in Appendix D of the PEIS, in that excessive heat (in the form of an exothermic reaction in the comment, and in the form of a fire in the PEIS accident) is postulated to result in hydraulic rupture of an affected cylinder, with resulting release of the cylinder contents. The PEIS considered the vehicle-induced fire accident scenario, because the PEIS accident was postulated to affect three cylinders (unlike a single cylinder in the comment) and thus would bound the consequences of the accident proposed in the comment.

Comment 42

This is one that came as kind of a shock to me. I was supplied with a memo of a 1964--this is to K-25 manager, John Murray from A.J. Mallett and it had been proposed that the quote "empty cylinders" which have about 50 pounds of heels — they don't get all the material out when they make a transfer — and this contains mostly daughter products of uranium and actually there's more radiation from an empty cylinder than a full one because of this material that's on the bottom and you don't have the shielding effect of the uranium when it's filled. But this is approval to clean 74 cylinders containing 33,000 grams of uranium, 435 U-235, various enrichment levels and so forth and what the safety person said is that the proposed cleaning in this pond appears safe. And so my question is how will cylinders be cleaned in the future and my other concern, and I've got it in my short list of major concerns is I don't think cleaning cylinders in this manner and then admitting the contaminated pond effluent to the Clinch River is going to be acceptable in the future.

Response 42

The commentor is correct that radiation exposure from empty cylinders is of special concern because the shielding effect of the depleted uranium hexafluoride is no longer present. In the PEIS and the engineering analysis report, the method proposed for protecting workers and the general public from exposure to the short-lived daughter products is to store the cylinders for three months after emptying to allow the daughter products to decay enough so that handling the cylinders is safe. Details on the design and operation of a cylinder treatment facility are provided in the engineering analysis report. The cylinders would be washed with an aqueous solution to remove the heels. The UF_6 from the heel would be converted to U_3O_8 which would be sent for either disposal or storage. Wastewater generation from a cylinder treatment facility is discussed in Section F.3.4.1 of the PEIS. Wastewater would be treated to meet the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and discharged to nearby surface waters, or to an appropriate wastewater sewer, depending on the location of the treatment facility. DOE has no plans for cleaning the cylinders in any pond at any site.

Comment 43

This is the last safety-related. Things keep happening on this activity that seem very timely. Here's the Paducah plant and the storage yards about 40 - 50 acres. The Barcley Regional Airport is about a mile and a half to two miles from the storage yard. The day before we had our meeting in Paducah — I'm sure all of you read about this — a B-1 bomber supersonic 200,000 pounds crew bailed out. Plane crashed into a farm. Dug a trench 4' deep and 40' long. It was 35 to 40 miles from this plant and I would say if somebody looked at what's the probability of a plane like that crashing on that farm, they'd say incredible, never happen, and so forth. But that's a consideration that we had back in our study and that the DNFSB had also. Can you imagine a plane like that hitting in the center of the cylinder yard? I mean you would be bound to rupture--I don't know--six dozen, I don't know how many cylinders. If it happened to be raining, you would have so much HF formed that you couldn't even get near it and the HF would start chewing up the cylinders around it. So you might call it a maximum credible accident, but I think it's not a ridiculous thing to be considered.

Response 43

Plane crashes were considered but only for small planes. Large planes have flight patterns that do not pass close to any of the three sites and as a result, impacts would be considered in the beyond incredible probability range ($<1 \times 10^{-7}$) for those large planes.

Comment 44

Uses. Most important. There's a lot been said about this already and here's just a couple of excerpts. This is from the PEIS and it talks about conversion half to UO_2 or metal but the thing that got me was safe management of the cylinder inventory would continue until 100 percent of the inventory had been converted for use. Now, the general reaction I've had from people that read that is that means, the translation is never because there's not going to be 100 percent use made of this material, as people have already said. And again, back to my earlier statement that if some

reasonable assessment could be made of an optimistic use scenario, start taking care of those cylinders and get serious about the conversion to U_3O_8.

Response 44

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products. The two representative use options described in Section 2.2 and Appendix H of the PEIS, use as uranium oxide and use as uranium metal as radiation shielding, were selected to provide a basis for comparing the potential environmental impacts of broad, programmatic management strategies. The selection of these use options for analysis in the PEIS was not intended to imply that the PEIS will be used to select a specific end use or preclude other potential uses in the future. If a use strategy is selected in the Record of Decision, specific uses would be considered and evaluated in more detail in future planning and environmental analyses as appropriate. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. This would be accomplished through continuing the safe, effective management of the cylinder inventory; beginning prompt conversion of the depleted UF_6 into uranium oxide and HF or CaF_2; interim storage of the uranium oxide pending use; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabrication of depleted uranium oxide and/or metal products for use. Prior to use or other disposition, DOE will continue the safe, responsible management of the cylinder inventory. Current cylinder management practices include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, cylinder coating maintenance, and cylinder yard maintenance. These practices will be modified and supplemented as necessary to meet any new or revised requirements or to incorporate new technologies as they become available for protecting workers, the public, and the environment. The commentor's preference for converting depleted UF_6 to U_3O_8 is noted.

Comment 45

And last, you'll be glad to hear. Again, I'm not going to go through this but in the National Research Council report they have a section on potential uses and not to take exception to the gentleman's experience with INEL and the DUCRETE studies, they had concerns about the use in DUCRETE. I'm not smart enough to know. It sounds to me like a good use for some of the material, but they also made a point that UO_2 is not totally stable. U_3O_8 is the form found in nature, extremely stable, doesn't react, so forth. And they sort of made a pitch like if you're going to use it in DUCRETE, you ought to use U_3O_8 and I know it's slightly less dense so that's a consideration.

Response 45

UO_2 is slightly less stable than U_3O_8, but is less susceptible to fracturing and to the formation of respirable fine particulates. U_3O_8 is less dense than UO_2 (density of 3 g/cm^3 versus between 6 to 9 g/cm^3 for UO_2), and is friable and not readily formed into hard microspheres that resist

fracture. Effective shielding of gamma radiation from spent nuclear fuel requires a relatively high density material, such as DUCRETE produced using dense UO_2 material. In addition, the friability of U_3O_8 may present operational problems during the high-shear mixing of uranium oxide and cement to produce DUCRETE.

Comment 46

And they talked about it as a fluorinating agent and their concern there is there's probably going to be some residual radioactivity in this fluorine and using, even at very low levels of radiation contamination, it's probably going to take NRC license and everything and a lot of commercial users are going to be a little hesitant to use fluorine in their products. There's people here that know more about that subject than I do. But these are three more uses, re-enrichment and dilution and so forth, and they sort of mostly discounted them as being a significant user of the inventory.

Response 46

DOE expects that in the future, uses will be available for some portion of the depleted UF_6 inventory. DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as necessary, to continue the safe management of its depleted UF_6 cylinder inventory. The use of depleted UF_6 as a fluorinating agent will depend on the conversion process selected, the residual uranium concentrations in the hydrogen fluoride produced, market demand, and both public acceptance and regulatory considerations.

Comment 47

In the PEIS DOE evaluated six alternative management strategies. However, an option to continue storage of a reasonable fraction of the DUF_6, only the best cylinders under shelter, for future use and begin conversion of the most degraded cylinders to a safe stable form of U_3O_8 was not considered in the PEIS and my question is why?

Response 47

The strategy the commentor describes would fall into the category of a "combination of alternatives," specifically, a combination of continued cylinder storage (a.k.a. No Action Alternative) and long-term storage as oxide. As discussed in Section 2.3.7 of the PEIS, the alternatives assessed in the PEIS were based on the assumption that all facilities would be designed to process 100% of the inventory; this approach was intended to provide a conservative estimate of the impacts that could result from each of the alternatives considered. However, DOE did recognize that it would be possible to select a management strategy that is a combination of the alternatives (e.g., 50% continued cylinder storage and 50% long-term storage as oxide). Therefore, the PEIS includes an analysis of potential environmental impacts for a range of facility sizes to allow for an evaluation of combinations of alternatives. Appendix K presents the potential environmental impacts for facilities designed to process between 25 and 100% of the depleted UF_6 inventory. Section K.7.1 presents an example of how to estimate the impacts for any combination of alternatives. The actual schedule or order in which the cylinders would be converted (if conversion is identified in the

Record of Decision) is beyond the scope of the PEIS. However, such considerations would be the subject of follow-on studies and reviews.

Comment 48

I mentioned before this work agreement by said there are--this is in the '92 statement by the DOE Oak Ridge. The current DOE schedule for cleaning, inspecting and repainting of the cylinders will require at least 30 years, especially when the fact is considered that many of the cylinders will have to be recleaned and repainted at least three times during that period. Now, the people that did the painting, Hartman Walsh of St. Louis, that painted 2,168 of these cylinders in the 1996-1997 period, the lessons report on that subject said that in their examination of the cylinders they didn't find much paint left on any cylinders that had been painted before 1990. Next. DNFSB, the accident concerns that they raised were not cited or addressed in the PEIS. Last of the last. And again, I don't have to repeat this I don't think too much because I just said it and this is the accident scenario involving a plane crash into the cylinder yards and what would happen in the event of that.

Response 48

The current UF_6 cylinder project management plan, dated March 1997, implements the analytical and risk studies conducted to determine the most effective means of recoating cylinder bodies. The worst case cylinders, that is, those that are determined to have exterior corrosion effects such that the wall thickness has been reduced below the 0.250" required for off-site transport, will be painted first. The rate of painting cylinders is determined by these studies as well as other factors. The assumptions for the No Action Alternative used in the PEIS were made to closely approximate the current management project, however, it is impossible to maintain those exact rates in a real-time situation. With respect to accident concerns raised by the DNFSB, their Recommendation 95-1 requested that the safety analysis reports for the three sites be updated. These reports (LMES 1997f-h; the full citations are provided in Chapter 8 of the PEIS) were updated and the results (including results for plane crash scenarios) were incorporated into the accident analyses conducted for the PEIS. See Appendix D, Section D.2.2, for a discussion of accident impacts under current storage conditions. If the SARs are revised in the future, DOE will modify its cylinder management program to ensure that the safety of the cylinders is maintained.

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