POLICY ISSUE
NOTATION VOTE

November 15, 2002 SECY-02-0204

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: UPDATE OF URANIUM RECOVERY GUIDANCE DOCUMENTS

PURPOSE:

To transmit the NUREG-1569, "Standard Review Plan for *In Situ* Leach Uranium Extraction License Applications," and NUREG-1620, Revision 1, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act," for Commission approval.

BACKGROUND:

SECY-01-0026 "Alternatives for Rulemaking: Domestic Licensing of Uranium and Thorium Recovery Facilities," dated February 15, 2001, proposed three alternatives to address incorporating new Commission guidance on several policy issues and to update the regulatory framework for the uranium recovery licensing program. The Commission approved alternative 3, which was to discontinue the development of a new Part 41, devoted to the regulation of uranium and thorium recovery facilities and disposal of 11e.(2) byproduct material, and instead, update guidance documents. In discussions with Commissioners' Assistants, it was agreed that the staff's primary efforts would be to update two standard review plans (SRPs); the first for the reclamation of mill tailings sites, which had been finalized as NUREG-1620 in June 2000, and the second for *in situ* Leach Uranium Extraction facilities, which had been published as a draft (NUREG-1569) in October 1997.

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DISCUSSION:

The staff has incorporated into the guidance documents the information from SECY-99-0011, SECY-99-0012, SECY-99-0013, SECY-01-0026, SECY-99-277, NRC Regulatory Issue Summary 2000-23 dated November 30, 2000, and other studies such as "Surety Estimation Methodology for Groundwater Corrective Action at Title II Conventional Mills" dated August 2001; NUREG-6733, "A Baseline Risk-Informed Performance-Based Approach for *In Situ* Leach Uranium Extraction Licensees" dated September 2001; and "Risk Informing Uranium Recovery" dated December 2001. Additionally, Chapter 4 of NUREG-1620, was completely revised to reflect the Commission's decision on exclusive jurisdiction of all radiological and non-radiological constituents from tailings impoundments.

The SRPs were issued for public comment in the Federal Register on February 5, 2002. The public comment period ended April 22, 2002. Comments were received from the following: State of New Mexico, Environmental Department State of Texas, Texas Department of Health, Nuclear Energy Institute (NEI), National Mining Association (NMA), Wyoming Mining Association, Kennecott Energy, and Rio Algom Mining LLC. A synopsis of the comments relating to each NUREG appears below. Detailed discussions of those comments appear in Attachments 1 (NUREG-1569) and 2 (NUREG-1620).

NUREG-1569 COMMENTS:

In preparing the final version of NUREG–1569, the NRC staff carefully reviewed and considered more than 750 written comments received by the close of the public comment period. To simplify the analysis, the NRC staff grouped all comments into the following major topic areas:

(1) Editorial and Organizational (322 comments)
(2) Policy Issues (including administrative, quality assurance, and surety/financial issues) (103 comments)
(3) Ground water (123 comments)
(4) Operational (47 comments)
(5) Health Physics (78 comments)
(6) Monitoring (55 comments)
(7) Environmental aspects related to NRC responsibilities under the National Environmental Policy Act (NEPA)(40 comments)

NUREG-1620 COMMENTS:

In preparing the final version of NUREG–1620, the NRC staff carefully reviewed and considered about 120 written comments received by the close of the public comment period. To simplify the analysis, the NRC staff grouped all comments into the following major topic areas:

(1) Editorial and Organizational (31 comments)
(2) Policy Issues (including administrative, quality assurance, and surety/financial issues) (51 comments)

(3) Geotechnical Stability (17 comments)
(4) Ground water (15 comments)
(5) Environmental aspects related to NRC responsibilities under NEPA (4 comments)

Related Action:

An additional parallel action is being conducted that may affect the content of NUREG-1569. As directed by the Commission in the SRM for SECY01-0026, the staff is conducting discussions with the Environmental Protection Agency (EPA) and affected states to determine the extent the NRC can rely on the EPA Underground Injection Control (UIC) program for groundwater protection issues at *In Situ* leach facilities. This will potentially eliminate NRC/State dual regulation of these aspects of In Situ leach facilities. Part of the discussions with EPA and the States includes appropriate methods to implement any agreements, including MOUs. Once agreement is reached with the EPA and the States, the staff will prepare a paper for Commission approval of this proposed policy change. If this action is approved, the appropriate sections of NUREG 1569 would be modified.

RECOMMENDATION

The staff recommends approval of the SRPs by the Commission for publication.

COORDINATION:

The Office of the General Counsel has no legal objection to the approval of the SRPs.

RESOURCES:

Minimal for publication of the SRPs.

/RA by William F. Kane Acting For/

William D. Travers
Executive Director
For Operations

Attachments:
1. Draft Notice of Availability of NUREG-1569
2. Draft Notice of Availability of NUREG-1620
3. NUREG-1569, "Standard Review Plan for *In Situ* Leach Uranium Extra License Applications"
4. NUREG-1620, Revision 1, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act"

ATTACHMENT 1

7590-01P

NUCLEAR REGULATORY COMMISSION

Notice of Availability of a Standard Review Plan (Nureg–1569) for Staff Reviews for *in Situ* Leach Uranium Extraction License Applications

AGENCY: U.S. Nuclear Regulatory Commission

ACTION: Notice of availability

SUMMARY: The U.S. Nuclear Regulatory Commission (NRC) has developed a Standard Review Plan (NUREG–1569) which provides guidance for staff reviews of applications to develop and operate uranium in situ leach facilities. Under the provisions of Title 10 of the Code of Federal Regulations, Part 40 (10 CFR Part 40), Domestic Licensing of Source Material, an NRC Materials License is required to conduct uranium recovery by *in situ* leach extraction techniques. Applicants for a new license and operators seeking an amendment or renewal of an existing license are required to provide detailed information on the facilities, equipment, and procedures used in the proposed activities. In addition, the applicant for a new license also provides an Environmental Report that discusses the effects of proposed operations on the health and safety of the public and assesses impacts to the environment. For amendment or renewal of an existing license, the original Environmental Report is supplemented, as necessary. This information is used by the NRC staff to determine whether the proposed activities will be protective of public health and safety and the environment and to fulfill NRC responsibilities under the National Environmental Policy Act (NEPA). The purpose of the Standard Review Plan (NUREG–1569) is to provide the NRC staff with guidance on performing reviews of information provided by the applicant, and to ensure a consistent quality and uniformity of staff reviews. Each section in the review plan

provides guidance on what is to be reviewed, the basis for the review, how the staff review is to be accomplished, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding the applicable sections in 10 CFR Part 40, Appendix A. NUREG–1569 is also intended to improve the understanding of the staff review process by interested members of the public and the uranium recovery industry. The review plan provides general guidance on acceptable methods for compliance with the existing regulatory framework. As described in an NRC white paper on risk-informed, performance-based regulation (SECY–98–144), however, the applicant has the flexibility to propose other methods as long as it demonstrates how it will meet regulatory requirements.

A draft of NUREG–1569 was issued in October 1997, and subsequently revised to reflect responses to public comments, and the results of Commission policy decisions affecting uranium recovery issues described in NRC Regulatory Issue Summary 2000–23, dated November 30, 2000. On February 5, 2002 (FR5347), the NRC made the revised second draft of NUREG–1569 available for a 75-day public comment.

In preparing the final version of NUREG–1569, the NRC staff carefully reviewed and considered more than 750 written comments received by the close of the public comment period on April 22, 2002. To simplify the analysis, the NRC staff grouped all comments into the following major topic areas:

(1) Editorial and Organizational Comments (322 comments)

(2) Policy Issues (including administrative, quality assurance, and surety/financial issues) (103 comments)

(3) Ground water (123 comments)

(4) Operational (47 comments)

(5) Health Physics (78 comments)

(6) Monitoring (55 comments)

(7) Environmental aspects related to NRC responsibilities under NEPA (40 comments)

ADDRESSES: Electronic copies of this document are available for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (The Public Electronic Reading Room). NUREGs 1569 and 1620 are under Adams Accession Number ML012990062. The documents are also available for inspection or copying for a fee at the NRC's Public Document Room, 11555 Rockville Pike, Room O1-F21, Rockville, Maryland, 20852. These guidance documents are not copyrighted, and Commission approval is not required to reproduce them.

FOR FURTHER INFORMATION CONTACT: John Lusher, Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle Safety and Safeguards, Mail Stop T-8 A33, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Telephone (301) 415-7694, or e-mail jhl@nrc.gov .

SUPPLEMENTARY INFORMATION: The following provides a more detailed discussion of the NRC evaluation of the major topic areas and the NRC responses to comments.

1. Editorial and Organizational Comments

Issue: The standard review plan has a number of redundancies and editorial errors.

Comment. Several commenters identified editorial concerns, text omissions, or areas where the organization of the standard review plan could be improved. Most of the organizational comments addressed perceived redundancies in the standard review plan or opportunities to streamline the style. Most editorial comments addressed inconsistent terminology, identified typographical and grammatical mistakes, or questioned the accuracy of reference documents.

Response. NUREG–1569 is structured consistent with NRC practice for standard review plan style and format. While this style and format may be considered complex or redundant by some commenters, no substantive changes have been made. This will preserve consistency with other NRC standard review plans. The commenters have provided numerous suggestions for improving the readability and clarity of the review plan. Editorial comments on inconsistent terminology, typographical and grammatical mistakes, or the accuracy of reference documents were accepted and incorporated in preparing the final standard review plan, as appropriate. The individual editorial comments are not addressed in this comment summary document.

An appendix (Effluent Disposal at Licensed *In Situ* Leach Uranium Extraction Facilities) was deleted since the guidance therein was superseded by SECY–99–013 which provided staff with direction on classification of liquid wastes at these facilities.

Issue: There is sometimes a lack of agreement between the topics to be reviewed and the corresponding acceptance criteria.

Comment: Commenters stated that in several review plan sections, the areas of review identified at the beginning of the section did not correspond well to the acceptance criteria that would be used to make the evaluation findings.

Response: The staff concurs with this comment. NUREG–1569 was edited to provide correspondence among areas of review, review methods, acceptance criteria, and evaluation findings in each section.

Issue: Chapter 5 (Operations) of the standard review plan has many editorial and technical discrepancies.

Comment: Several commenters identified editorial and technical concerns with Chapter 5 of the draft standard review plan. In some cases, the editorial problems may have made the regulatory guidance difficult to implement.

Resolution: The staff concurs with the commenters. Chapter 5 was rewritten to incorporate editorial and regulatory guidance improvements. The separate section on record keeping and reporting was combined with the section on the management control program to more closely match Regulatory Guide 3.46.1 (Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining). Editorial comments are not addressed individually in this comment summary document except where they have particular impact on the standard review plan.

Issue: Additional clarifying or background information should be included in NUREG–1569.

Comment: Several commenters suggested that specific additional information related to proceedings for a given site or that would provide general background information on *in situ* uranium extraction techniques and hazards be included.

Resolution: The NRC has elected not to include the suggested information in NUREG–1569 because the standard review plan is not written for application to a specific site, and general information is available in other references on *in situ* uranium extraction operations.

2. Policy Issues (Including Administrative, Quality Assurance, and Surety/Financial Issues)

Issue: NUREG–1569 attempts to apply a risk-informed, performance-based regulatory philosophy without a regulatory basis for doing so.

Comment: Commenters, while noting that risk-informed, performance-based regulatory philosophies could be applied to *in situ* leach uranium extraction facilities, argued that no regulatory basis exists for implementing such philosophies. The commenters stated that 10 CFR Part 40 should be modified to incorporate risk-informed, performance-based regulatory concepts before the associated standard review plan is modified in that way, because standard review plans are not to be used to promulgate regulatory policy. Commenters also stated that the NRC should not expect license applicants to conduct the accident analyses; consequence evaluations; and probability determinations associated with risk-informed, performance-based regulation. Finally, the commenters argued that the risk-informed, performance-based approach presented in NUREG–1569 was too cursory, contained undefined terms, assumed the existence of a facility change mechanism, and that the review plan contained highly prescriptive acceptance criteria.

Response: The NRC agrees that standard review plans cannot be used to promulgate regulatory requirements, and has no intent to do so using NUREG–1569. In related action, the Commission considered promulgating a new regulation (10 CFR Part 41) that would specifically address regulatory requirements for *in situ* leach uranium extraction facilities and that would formally incorporate risk-informed, performance-based regulatory philosophies. However, considering feedback from the uranium extraction industry and other stakeholders, and taking into account the economic status of the uranium extraction industry, the Commission determined that rulemaking was not an appropriate action at this time. Instead, in making this decision, the Commission directed the staff to update its regulatory guidance related to *in situ* leach uranium extraction facilities, and in so doing, to provide guidance on use of risk-informed, performance-based regulatory philosophies. NUREG - 1569 incorporates this direction from the Commission. It outlines risk-informed, performance-based approaches that staff reviewers may apply to *in situ* leach uranium extraction facilities that are also consistent with existing NRC regulations at 10 CFR Part 40.

In NUREG/CR–6733 (A Baseline Risk-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licensees) the staff presents analyses of *in situ* leach uranium extraction facility operations and accidents that consider both likelihood of occurrence and consequence (and therefore, risk). The analyses in NUREG–6733 are conservative and demonstrate that *in situ* leach uranium extraction facilities operated with properly trained workers and effective emergency response procedures generally pose low levels of radiologic risk. The staff considers analyses similar to, or based on, those in NUREG–6733 to be an appropriate basis for licensee safety analyses. NUREG–1569 is not intended to require applicants to prepare complex accident analyses, consequence evaluations, and probability determinations. However, site-specific conditions and circumstances must be addressed in any application.

For several years, the NRC staff has been approving *in situ* leach uranium extraction facility license renewals that incorporate a performance-based license condition that provides a facility change mechanism using a Safety and Environmental Review Panel. This accepted practice is continued in NUREG–1569.

Finally, the staff has not attempted to implement overly prescriptive acceptance criteria in NUREG–1569. Rather, standard practices that have been found acceptable in demonstrating compliance at *in situ* leach uranium extraction facilities have been placed in the standard review plan as one approach that the staff may use in determining compliance. Other approaches may be found acceptable as long as the staff can determine that such approaches comply with applicable regulations. In addition, the introduction to 10 CFR Part 40, Appendix A, allows applicants to propose alternative standards to the specific requirements in the Appendix A to demonstrate compliance, and the staff will review any such alternative standards that are submitted.

NUREG–1569 has been edited to remove inconsistent use of terms or undefined terms. Where useful, acceptance criteria have been modified to be less prescriptive. However, risk-informed, performance-based approaches to determining compliance have been incorporated in the standard review plan to the extent consistent with existing regulations.

Issue: Standard review plan guidance with respect to overlapping jurisdiction is not adequate.

Comment: Commenters were concerned that NUREG–1569 did not provide sufficiently clear guidance on coordinating license application reviews with federal and state agencies. Commenters also stated that NRC should accept state guidelines in conducting reviews.

Response: NUREG–1569 implements Commission direction in SECY–99–013 regarding ground-water issues at *in situ* leach uranium extraction facilities. While this direction requires the staff to determine the extent to which it can rely on the U.S. Environmental Protection Agency's (EPA) Underground Injection Control program and to work to implement agreements with appropriate states on these issues, it does not suggest that the NRC broadly accept state guidelines. As appropriate, minimizing dual regulation and implementing agreements with affected states remains an objective of the NRC, and interactions with the EPA and the states continue on these issues. The review plan has been revised to clarify this intent.

Issue: The standard review plan directs the staff to inappropriately seek disclosure of an applicant's primary corporate internal costs.

Comment: Commenters argued that corporate internal costs such as capital costs of land acquisition and improvement, capital costs of facility construction, and other operating and maintenance costs addressed in the draft standard review plan were not appropriate for staff review. The commenters suggested that only the forecast costs for plant decommissioning and site reclamation should be examined by the staff.

Resolution: The staff agrees with the commenters. The standard review plan has been revised to remove guidance that the staff examine costs outside of those associated with plant decommissioning and site reclamation.

Issue: NRC is exceeding its legal authority by requiring that a determination be made that a proposed licensing action is appropriate prior to allowing construction to proceed.

Comment: The Executive Summary to NUREG–1569 states that "beginning construction of process facilities, well fields, or other substantial actions that would adversely affect the environment of the site, before the staff has concluded that the appropriate action is to issue the proposed license, is grounds for denial of the application." The commenter disagrees with the "sweeping nature" of this statement and asserts that NRC has no jurisdiction over wells in an exempted aquifer until lixiviant injection begins.

Response: The NRC considers this statement to be consistent with the requirements of 10 CFR 40.32(e) and believes it to be appropriate for the agency's responsibilities to protect public health and safety and the environment. The license applicant should not conduct actions with a potential for adverse impacts prior to the NRC completing its safety evaluation and environmental assessment.

3. Ground Water

Issue: Some acceptance criteria for ground-water protection seem overly prescriptive or inconsistent with current practices at specific *In situ* leach uranium extraction facilities.

Comment: Several comments pertained to the use of examples of acceptable methods and approaches cited in the various acceptance criteria for ground-water protection. These comments expressed concern that the examples cited were not consistent with current practices at some *in situ* leach uranium extraction facilities. For example, several comments stated that the examples of acceptable methods for conducting mechanical integrity tests on injection wells are not consistent with methods currently employed or with state-approved practices.

Response: Examples of acceptable practices cited in the review plan acceptance criteria for ground-water protection were obtained from operations plans of currently operating *in situ* leach uranium extraction facilities. These examples refer to methods used to implement ground-water protection requirements that have been considered acceptable in past NRC licensing reviews. The NRC recognizes that an optimal approach to ground-water protection at one facility is not necessarily applicable or appropriate at all *in situ* leach uranium extraction facilities. As stated in the introduction to NUREG–1569, applicants may take approaches to demonstrating compliance that are different from the acceptance criteria in the standard review plan so long as the staff can make the requisite decisions concerning environmental acceptability and compliance with applicable regulations. Where appropriate, these comments were addressed by modifying text to clarify that the given examples are not prescriptive requirements.

Comment: Several comments recommended deletion of constituents from the list of typical baseline water quality indicators in Table 2.7.3-1 of NUREG–1569. In a specific example, a rationale was provided for eliminating radium-228 from the list of baseline water quality indicators to be sampled in each new well field.

Response: The rationales provided by the commenters for elimination of certain chemical constituents from the list of typical baseline water quality indicators are not necessarily applicable for all *in situ* leach uranium extraction facilities. A licensee may provide the rationale for the exclusion of water quality indicators in a license application or amendment request if operational experience or site-specific data demonstrate that concentrations of constituents such as radium-228 are not significantly affected by *in situ* leach operations. NRC reviewers will determine whether proposed exclusions are justified by the information provided. No changes to Table 2.7.3-1 were made for the final standard review plan.

Comment: Two commenters pointed out an apparently new policy that an excursion of lixiviant solutions will be deemed to have occurred if any single excursion indicator exceeds its upper control limit by 20 percent, where previous guidance considered an excursion to have occurred only when two or more excursion indicators exceed their upper control limits by any amount.

Response: Acceptance criterion (5) in Section 5.7.8.3 of NUREG–1569 was revised by deleting the statement regarding a single excursion indicator exceeding its upper control limit by 20 percent for determination of when an excursion has occurred. However, the same acceptance criterion retains the requirement that corrective action for an excursion is deemed complete when all excursion indicators are below their respective upper control limits, or when no single indicator exceeds its control limit by more than 20 percent. Ideally, corrective action for an excursion would be to restore all indicators to below their upper control limits. However, in the past, corrective action has been considered acceptable when a monitor well no longer meets the criteria for being on excursion status. Excursion status criteria allow one indicator to be above the respective upper control limit. However, once an excursion has occurred, the reduction in concentrations of indicator constituents by corrective action may not occur at the same rate. Therefore, corrective action may be terminated prematurely if one of two indicators are brought below upper control limits while another remains substantially above its control limit.

Issue: The NRC is unduly concerned with protection of ground water in aquifers where exemptions have been obtained from the requirements of the Safe Drinking Water Act.

Comment: Several commenters took exception to Acceptance Criterion (4) in Section 6.1.3 of the draft standard review plan, which states that the primary goal for restoration of well fields, following uranium extraction, is to return each well field to its pre-operational baseline water quality conditions. The commenters correctly pointed out that EPA requirements for the

Underground Injection Control program result in the uranium production zones being classified as "Exempted Aquifers." This means they are not considered a potential source of drinking water and, therefore, are not subject to requirements of the Safe Drinking Water Act.

Response: Acceptance Criterion (4) of Section 6.1.3 in the standard review plan was revised to clarify that the goal of ground-water restoration at *in situ* leach uranium extraction facilities is to protect present or potential future sources of drinking water outside of the exempted production zone. Generally, if water quality within the production zone is restored to the pre-operational baseline water quality, then protection of water resources outside the exempted zone is assured. Hence, restoration to pre-operational conditions is considered a primary goal whenever degradation of water outside of the exempted zone is a possibility. It is recognized, however, that restoration to pre-operational baseline conditions may not be practicable or feasible, owing to geochemical changes in the production zone during operations. Hence, applicants may propose secondary standards for monitored constituents that are protective of water resources outside of the exempted zone. This has also been clarified in the final standard review plan.

4. Operations

Issue: It is unclear which hazardous chemicals have the potential to impact safety at *in situ* leach uranium extraction facilities.

Comment: Some commenters expressed concern that the standard review plan addressed hazardous chemicals that were not realistic concerns at *in situ* leach uranium extraction facilities.

Response: In 10 CFR Part 40, Appendix A, regulations implement EPA Standards at 40 CFR Part 192, as required by law. Specifically, 10 CFR Part 40, Appendix A, Criterion 13 identifies those hazardous constituents for which standards must be set and complied with if the specific constituent is reasonably expected to be in, or derived from, the byproduct material, and has been detected in ground water. At the same time, the introduction to 10 CFR Part 40, Appendix A allows applicants to submit alternative proposals for meeting the requirements that take into account local or regional conditions. 10 CFR Part 40, Appendix A, Criterion 13 also notes that the Commission does not consider the subsequent list of hazardous constituents to be exhaustive. In summary, NUREG–1569 reflects the regulatory requirements but also allows the reviewer to consider any demonstration presented by an applicant that addresses the potential hazardous constituents at a specific site.

Issue: The responsibilities of the Safety and Environmental Review Panel are not well defined.

Comment: Various commenters stated that the responsibilities of the Safety and Environmental Review Panel, and their authority to authorize changes without a license amendment were either not clear or had no regulatory basis.

Resolution: The staff agrees that clarification of Safety and Environmental Review Panel responsibilities and authorities would facilitate use of the standard review plan. These portions of the plan were rewritten for clarity. However, consistent with a risk-informed, performance-based licensing approach, use of Safety and Environmental Review Panels has been accepted by NRC staff, and an evaluation of their use was left in NUREG–1569.

Issue: NRC is placing inappropriate restrictions on use of potentially hazardous process chemicals at *in situ* leach uranium extraction facilities.

Comment: The commenter refers to NUREG/CR–6733 (A Baseline Risk-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licensees) and states that the analyses in this document were conservative. The commenter concludes that chemical safety must be based on a realistic analysis of the hazards.

Resolution: The NRC staff interpreted the conclusions from the analyses presented in NUREG/CR–6733 differently from the commenter. NUREG–6733 conducted deliberately conservative analyses for the purpose of evaluating whether risks at *in situ* leach uranium extraction facilities were significant. The conclusion presented in NUREG/CR–6733 for chemical hazards was that licensees should follow design and operating practices published in accepted codes and standards that govern hazardous chemical systems. This recommendation leaves licensees flexibility to establish chemical safety measures appropriate for a specific facility and consistent with good engineering and safety practice. NUREG–1569 places no specific strictures on chemical safety practices at *in situ* leach uranium extraction facilities.

5. Health Physics

Issue: NRC is requesting information on radiation safety programs that is unnecessary, based on the operational record at *in situ* leach uranium extraction facilities, or is outside NRC licensing authority.

Comment: Some commenters expressed a concern that the NRC was requesting information that is not necessary to fulfill the agency mission of protecting the public health and safety and the environment from the effects of radiation. An example cited was information on radiation safety programs, such as the qualifications of those people proposed for the health physics staff.

Response: The NRC agreed with many of these commenters and revised Chapter 5 of NUREG–1569 to ensure that it is consistent with NRC regulations and regulatory guidance applicable to *in situ* leach uranium extraction facilities.

Issue: NUREG–1569 references regulatory guides that are outdated.

Comment: A number of commenters noted that the standard review plan referenced regulatory guides that have been revised or that are in the process of revision.

Response: The commenters correctly noted that some of the references in the draft standard review plan had been superseded or were in the process of revision. The standard review plan has been edited to reference current guidance. However, NRC has a number of regulatory guides that are being updated, and revised versions may only be referenced when they have been formally approved. This has necessitated retaining reference to some draft regulatory guides.

Issue: NUREG–1569 introduces a new and undefined concept in discussing “control systems relevant to safety.”

Comment: Several commenters objected to inconsistent use of terms and a lack of definition for terms related to control systems that may affect safety.

Response: NUREG–1569 was edited to incorporate consistent use of terms, and the term “controls” was defined consistent with other NRC regulatory guidance.

6. Monitoring

Issue: *In situ* leach uranium extraction facility licensees are not subject to long-term surveillance costs.

Comment: A commenter stated that including long-term surveillance costs in financial surety requirements, as addressed in the draft standard review plan is inappropriate.

Response: NRC staff agrees with the commenter. Reference to long-term surveillance costs has been removed from NUREG–1569.

7. Comments related to NRC Responsibilities under the National Environmental Policy Act

Issue: NRC is requesting non-radiological information that is outside its area of regulatory authority.

Comment: Many of commenters expressed concern that the NRC was requesting information that is not necessary to fulfill the agency mission of protecting the public health and safety and the environment from the effects of radiation. The areas of concern included information on water quality, air quality, and historical and cultural information.

Response: As a federal agency, the NRC is subject to the NEPA. NEPA requires the NRC to consider impacts to the human environment as a part of its decision making process for licensing actions. The regulations governing NRC implementation of NEPA requirements are in 10 CFR Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions. Guidance to the NRC staff on conducting environmental reviews is also provided in NUREG–1748 "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." In fulfilling its requirements under NEPA, the NRC routinely prepares an environmental impact assessment when evaluating applications for new materials licenses or amendments to such licenses. Areas of potential environmental impact that are investigated include water availability and quality, air quality, historical and cultural resources, ecology, aesthetic resources, socioeconomic effects, and environmental justice. In preparing its environmental impact assessment under NEPA, it is necessary for NRC to establish background conditions for the affected area. This may require collection of data over a larger geographic area than the licensed area, as well as collection of data in technical and sociological areas that are beyond the traditional scope of radiation safety assessments. The commenters noted that detailed environmental impact assessments may not be necessary for all licensing actions, such as license amendment requests that may be minor in scope or short in duration. The text of the review plan has been modified to clarify those situations where NRC has traditionally performed a detailed environmental impact assessment, but the NRC necessarily reserves the right to determine the nature of the assessment on a site-specific basis in accordance with the requirements of 10 CFR Part 51.

Issue: The standard review plan inappropriately examines corporate financial information in evaluating the socioeconomic effects in cost-benefit analyses.

Comment: A number of commenters noted that the standard review plan examines detailed internal corporate financial data as part the review of cost-benefit analyses for a licensing action. The commenters expressed concern that this information was proprietary and beyond the scope of information necessary for an evaluation of the socioeconomic impact of a facility.

Response: The commenters correctly noted that some of the information identified in the draft standard review plan was beyond the scope of information typically required for cost-benefit analyses. The text of the standard review plan has been revised to eliminate requests for proprietary corporate financial information and to clarify the purpose and use of the financial information that is addressed in the standard review plan.

Issue: Commenters questioned whether the standard review plan applies to facilities planned for private land as well as those on public land.

Comment: Several commenters expressed uncertainty as to whether the review methods and acceptance criteria developed in the standard review plan were also applicable to *in situ* leach facilities wholly located on private lands.

Response: The NRC must consider the environmental impacts of activities on both private and public lands to meet its responsibilities under NEPA, particularly with regard to assessment of direct, indirect, and cumulative impacts of proposed actions. The specific information to be provided by a licensee, and the level of the NRC staff review, will be determined on a site-specific basis considering the nature of the proposed action. The standard review plan is general guidance to the staff on the type of information that is commonly acceptable for evaluating the environmental impact of a proposed licensing action. Consistent with the NRC risk-informed, performance-based licensing philosophy, licensees may use compliance demonstration methods different from those presented in the standard review plan so long as the staff can determine whether public health and safety and the environment are protected. The standard review plan text has been revised for clarity, but it has not been changed to reflect different approaches for facilities operating on private and public lands.

Issue: Licensees should not be required to choose the alternative that has the least impact on the environment.

Comment: Several commenters expressed concern that the standard review plan requires a licensee or applicant to select the alternative that has the least impact on the environment, or requires that NRC use license conditions to mitigate adverse environmental impacts that are deemed outside the scope of NRC responsibilities.

Response: The NRC agrees that while NEPA requires the agency to identify a preferred alternative, it does not require that the alternative with the least impact on the environment be selected. However, if an environmental impact statement (EIS) is necessary for a proposed action, NEPA requires that all reasonable alternatives be evaluated and that the environmentally preferable alternative be identified in the final EIS. NUREG–1569 does not require the applicant or licensee to select the most environmentally benign alternative. As guidance to the NRC staff, the standard review plan asks the reviewers to determine whether the choice of a particular uranium recovery method has been adequately justified and whether different techniques and processes were evaluated as part of this justification. The standard review plan also directs the staff is to evaluate the bases and rationales used by an applicant in evaluating and ranking alternatives.

As stated in Council on Environmental Quality regulations (40 CFR 1502.16), in preparing an EIS, federal agencies are to identify all reasonable mitigation measures that can offset the environmental impacts of a proposed action, even if they are outside the jurisdiction of the lead agency. These mitigation measures are intended to avoid, minimize, rectify, reduce, or compensate for significant impacts of a proposed action. If an environmental assessment identifies potentially significant impacts that can be reduced to less-than-significant levels by mitigation, an agency may issue a mitigated finding of no significant impact (FONSI). In the case of a mitigated FONSI, the mitigation measures should be specific and tangible, such as may be stated as license conditions. The standard review plan states that NRC has responsibilities under NEPA to identify and implement measures to mitigate adverse environmental impacts of the proposed action.

Dated at Rockville, Maryland this   day of November, 2002.

For the Nuclear Regulatory Commission

Robert C. Pierson, Director
Division of Fuel Cycle Safety
and Safeguards,
Office of Nuclear Material Safety
and Safeguards

ATTACHMENT 2

7590-01-P

NUCLEAR REGULATORY COMMISSION

Notice of Availability of a Standard Review Plan (Nureg–1620)
for Staff Reviews of Reclamation Plans for Mill Tailings Sites
under Title II of the Uranium Mill Tailings Radiation Control Act

AGENCY: U.S. Nuclear Regulatory Commission

ACTION: Notice of availability.

SUMMARY: The U.S. Nuclear Regulatory Commission (NRC) has developed a Standard Review Plan (NUREG–1620) to provide guidance for staff reviews of reclamation plans for uranium mill tailings sites covered by Title II of the Uranium Mill Tailings Radiation Control Act. Under the provisions of Title 10 of the Code of Federal Regulations, Part 40 (10 CFR Part 40), Domestic Licensing of Source Material, an NRC Materials License is required in conjunction with uranium or thorium milling, or with byproduct material at sites formerly associated with such milling. The licensee's site Reclamation Plan documents how the proposed activities demonstrate compliance with the criteria in Appendix A of 10 CFR Part 40. This information, combined with the licensee's Environmental Report, is used by the NRC staff to determine whether the proposed activities will be protective of public health and safety and the environment. The purpose of the Standard Review Plan (NUREG–1620) is to provide the NRC staff with guidance on performing reviews of information provided by licensees. The use of the Standard Review Plan is also intended to ensure a consistent quality and uniformity of staff reviews. Each section in the review plan provides guidance on what is to be reviewed, the basis for the review, how the staff review is to be accomplished, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding

the applicable sections in 10 CFR Part 40, Appendix A. NUREG–1620 will also assist in improving the understanding of the staff review process by interested members of the public and the uranium recovery industry. The review plan provides general guidance on acceptable methods for compliance with the existing regulatory framework. As described in an NRC white paper on risk-informed, performance-based regulation (SECY–98–144), however, the licensee has the flexibility to propose other methods as long as it demonstrates how it will meet regulatory requirements.

A draft of NUREG–1620 was issued in January 1999 for public comment. A final NUREG–1620, which incorporated NRC staff responses to the comments received on the draft, was issued in June 2000. On February 5, 2002 (FR5348), the NRC made the revised second draft of NUREG–1620 available for a 75-day public comment.

In preparing the final version of NUREG–1620, the NRC staff carefully reviewed and considered about 120 written comments received by the close of the public comment period on April 22, 2002. To simplify the analysis, the NRC staff grouped all comments into the following major topic areas:

(1) Editorial and Organizational Comments (31 comments)

(2) Policy Issues (including administrative, quality assurance, and surety/financial issues) (51 comments)

(3) Geotechnical Stability (17 comments)

(4) Ground water (15 comments)

(5) Environmental aspects related to NRC responsibilities under NEPA (4 comments)

ADDRESSES: Electronic copies of this document are available for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (The Public Electronic Reading Room). NUREGs 1569 and 1620 are under ADAMS Accession Number ML012990062. The documents are also available for inspection or copying for a fee at the NRC's Public Document Room, 11555 Rockville Pike, Room O1-F21, Rockville, Maryland, 20852. These guidance documents are not copyrighted, and Commission approval is not required to reproduce them.

FOR FURTHER INFORMATION CONTACT: John Lusher, Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle Safety and Safeguards, Mail Stop T-8 A33, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Telephone (301) 415-7694, or e-mail jhl@nrc.gov .

The following provides a more detailed discussion of the NRC evaluation of the major topic areas and the NRC responses to comments.

1. Editorial and Organizational Comments

Issue: The standard review plan has a number of redundancies and editorial errors.

Comment: Several commenters identified editorial concerns, text omissions, or areas where the organization of the standard review plan could be improved. Most of the organizational comments addressed perceived redundancies in the standard review plan or opportunities to streamline the style. Most editorial comments addressed inconsistent terminology, identified typographical and grammatical mistakes, or questioned the accuracy of reference documents.

Response: NUREG–1620 is structured consistent with NRC practice for standard review plan style and format. While the style and format may be considered complex or redundant by some commenters, no substantive changes have been made. This will preserve consistency with other NRC standard review plans. The commenters have provided numerous suggestions for improving the readability and clarity of the review plan. Most editorial comments that addressed inconsistent terminology, typographical and grammatical mistakes, or the accuracy of reference documents were accepted and incorporated in preparing the final standard review plan. The individual editorial comments are not addressed in this comment summary document.

2. Policy Issues (Including Administrative, Quality Assurance, and Surety/Financial Issues)

Issue: NRC is inappropriately examining economic assessments that are the prerogative of the applicant.

Comment: The draft standard review plan asked the reviewer to examine the economic benefits when slopes steeper than 5h:1v are proposed by an applicant. The NRC staff should be concerned only with whether the slope design will be stable enough to protect the tailings.

Resolution: The NRC agrees with the commenter. The final standard review plan has been edited to remove consideration of economic factors in slope design.

Issue: Guidance provided on alternate feed materials and non-11e.(2) byproduct material is not informative.

Comment: Commenters stated that information presented in Appendix I [Guidance on Disposal of Alternate Feed Materials and Non-11e.(2) Byproduct Materials in Uranium Mill Tailings Impoundments] of the draft standard review plan was not useful. The commenter suggested that additional guidance was not needed and recommended that the appendix be deleted from the review plan.

Resolution: The NRC staff agrees with the commenters to some extent. Appendix I did not contain sufficient information to assist the reviewers in examining requests for disposal of these materials in mill tailings impoundments. However, recent guidance from the Commission on these subjects is relevant to such reviews. Accordingly, Regulatory Issue Summary 2000-23, which presents Commission guidance on these matters has been included in the appendix to facilitate staff reviews.

Issue: NUREG–1620 should present guidance on examining multi-site problems.

Comment: One commenter noted that guidance on review of multi-site problems should be included in the final standard review plan. The reviewer stated that if a group of licensees raise a common issue, it would be cost effective to address it generically.

Response: The NRC staff agrees that addressing multi-site problems in an integrated manner could be cost effective and potentially beneficial to public health and safety and the environment. Omitting this information from NUREG–1620 is not meant to reflect a lack of staff interest in multi-site problems. Rather, the standard review plan is meant to address licensing reviews that can be completed using well-accepted techniques. The staff believes that the technical and regulatory aspects of multi-site problems are such that it is best to examine them on a case-by-case basis.

Issue: The long-term custodian must accept transfer of property at termination of the specific license.

Comment: One commenter expressed concern regarding language in NUREG–1620 that there must be assurance that the long-term custodian will accept the property necessary to protect public health and safety. The commenter was concerned that the language in the standard review plan implied that the long-term custodian has the option to refuse transfer of the property.

Response: The language in the standard review plan is included to ensure that the reviewer verifies that the long-term custodian is aware of the full extent of required land transfer prior to termination of the specific license. The intent is to avoid delays in license termination because the licensee and the long-term custodian may not have a mutual understanding on the extent of land transfer, and the text has been clarified.

Issue: NUREG–1620 guidance on consideration of reasonably attainable corrective actions and economic constraints is unclear.

Comment: One commenter was concerned that standard review plan guidance to not eliminate potential corrective actions because of economic constraints is inconsistent with guidance to assess three reasonably attainable, practicable corrective actions. The commenter notes that in some cases there may not be three reasonably attainable, practicable corrective actions to assess.

Resolution: While the NRC understands the commenter's concern, the language in the standard review plan on this matter is appropriate to the intent of the guidance and needs no further detail. The guidance to evaluate three reasonably attainable, practicable corrective actions is not a regulatory requirement. The NRC expects that an applicant will present corrective action alternatives that are reasonable and practicable for a specific site and a specific set of circumstances.

Issue: Guidance that equipment owned by the licensee not be considered in reducing surety cost evaluations is inappropriate.

Comment: One commenter expressed concern that in estimating costs to complete reclamation by a third-party independent contractor, direction that the equipment owned by the licensee and the availability of licensee staff should not be considered in reducing costs was inappropriate. The commenter added that extreme interpretations of this approach could lead to extravagantly expensive or even unattainable surety requirements.

Resolution: It is appropriate not to consider equipment owned by the licensee and the availability of licensee staff in calculating costs for surety. The purpose of the surety to ensure that there will be adequate funds available to complete site reclamation in the event that the licensee is unable to do so. The most likely circumstance that would result in the licensee being unable to complete reclamation is bankruptcy by the licensee. Unless the licensee can show that the equipment and staff would be available during and after a bankruptcy, credit for such can not be taken. The text has been clarified to address this issue.

Issue: NUREG–1620 should be used as a tool for public education.

Comment: Several commenters suggested that discussions could be expanded in various sections of the standard review plan to improve public understanding of regulatory issues at Title II uranium mill tailings sites.

Response: Discussions in several sections of the standard review plan were revised to improve clarity and to correct editorial errors. Although it is made available to the public, the primary intent of the Standard Review Plan is to provide guidance to the NRC staff, not to serve as a tool for public education. The staff believes that the standard review plan contains the appropriate level of detail for its intended purpose as a guide for staff reviews of reclamation plans for Title II mill tailings sites.

3. Geotechnical Stability

Issue: NUREG–1620 requires additional flexibility in criteria for selection of rock erosion protection materials.

Comment: One commenter suggested that criteria in the standard review plan should provide more flexibility in selecting a less durable rock for erosion protection when obtaining more durable rock is not practical.

Response: Flexibility in selecting rock types for erosion protection is implicitly provided in several locations in NUREG–1620 (e.g., Section 3.5.3) as long as the applicant can demonstrate with reasonable assurance that the radon barrier will be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. Clarifying text has been added to indicate explicitly that this option is available.

Issue: Terminology for erosion protection covers needs to be clarified.

Comment: One commenter requested clarification in use of the terms “unprotected soil cover” and “vegetative soil cover.”

Response: The staff agrees with the commenter. Section 3.5 of the standard review plan has been retitled “Design of Erosion Protection,” and the review guidance in that section has been clarified to avoid confusion in the use of terms.

Issue: The NRC is requiring detailed seismic hazard analysis, even in zero seismic risk areas identified in the Uniform Building Code.

Comment: One commenter noted that for cases where a given site is located in a “zero” seismic risk area as identified in the Uniform Building Code, no further seismic characterization, explanation, or description should be needed for the licensee or applicant.

Response: Maps for the maximum considered earthquake ground motion for the United States in the most recent version of the building code (2000 International Building Code) are based on probabilistic seismic hazard maps with additional modifications incorporating deterministic ground motions in selected areas and the application of engineering judgement. These maps were prepared for the National Earthquake Hazards Reduction Program by the United States Geological Survey. Because it is based on probabilistic methods, within the new update, the “zero” seismic risk areas no longer exist.

The NRC is currently establishing risk-informed and performance-based regulations. One example of this philosophy is the application of a risk-graded approach in developing seismic design requirements for nuclear facilities. Under this approach for example, nuclear power plants have to meet the most stringent design requirements because they pose the greatest radiological risk to public health and safety. Other nuclear facilities like dry cask and canister storage facilities or uranium mining operations could be designed to less stringent design criteria because they pose substantially less radiological risk to public health and safety. This type of graded approach to radiological hazard is described in U.S. Department of Energy (DOE) Standard 1020–2002, “Natural Phenomena Hazards Design and Evaluation Criteria for Department of

Energy Facilities." In that guidance, the DOE developed five performance categories according to the relative risks posed by the potential failure of a structure, system, or components (SSCs) to perform its intended safety function. Performance Category (PC)–2 is intended for occupational safety and the design requirements for this category match those in the IBC–2000. PC–3 SSCs are for hazard confinement and the design requirements go beyond those within IBC–2000. Given the potential radiological hazards posed by Mill Tailing sites, evaluations of seismic hazards should therefore exceed those prescribed in the IBC–2000 for buildings. In addition, the National Earthquake Hazards Reduction Program maps do not take site effects into account. Local site effects, such as soil amplification, can greatly increase the level, spectral frequency content, and duration of vibratory ground motions at a site that is produced during an earthquake. Therefore, these effects need to be understood in order to accurately predict the seismic hazard at any site.

Based on these two considerations (graded risk approach and possible site amplification effects), staff conclude that site-specific seismic evaluations are necessary for all sites.

Issue: The NRC has not provided an adequate definition of the intent of using probabilistic seismic hazard analysis to satisfy the consideration of the maximum credible earthquake.

Comment: One commenter noted that the draft standard review plan indicates that licensees can use an alternative to the maximum credible earthquake, such as probabilistic seismic hazard analysis, but does not indicate whether the intent is to allow probabilistic analyses to satisfy 10 CFR Part 40, Appendix A, Criterion 4(e) or it is being considered as an alternative requirement.

Response: The application of a probabilistic seismic hazard analysis in place of a deterministic approach is not intended to be an alternative requirement to, as defined in the question, but another way of satisfying the existing move toward risk-informed and performance-based regulations. In addition, other NRC regulations clearly recommend the use a probabilistic approach as an acceptable way to account for uncertainties [e.g., 10 CFR 100.23(d)(1)].

Issue: The NRC has provided only general guidance to seismic hazard analysis, rather than guidance specific to certain geographic provinces.

Comment: One commenter noted that references cited in the standard review plan did not provide useful guidance with regard to site-specific seismicity issues, and suggested other references specific to Wyoming and the intermountain region of the western United States.

Response: The standard review plan is intended to provide general guidance to the NRC staff on reviewing license applications, license renewals, and amendment requests. The standard review plan does not preclude licensees from providing additional site-specific information as necessary in their license application or amendment requests, and identifying how this information supports a specific licensing action.

4. Ground Water

Issue: NUREG–1620 should be consistent in use of terminology related to ground water.

Comment: The term “constituent of concern” seems to be used interchangeably with the term “hazardous constituent.” Constituents of concern are not necessarily hazardous constituents unless they have migrated into “non-exempted” aquifers.

Response: Section 4.2.1 of the standard review plan was revised to delete a sentence equating constituents of concern with hazardous constituents. The term “hazardous constituent” is now used consistent with the definition in 10 CFR Part 40, Appendix A, Criterion 5B(2)

Issue: The difference in an As Low As Reasonably Achievable (ALARA) analysis for radiological and nonradiological parameters needs to be more clearly presented.

Comment: An ALARA analysis for a nonradiological parameter differs from that for a radiological parameter in that once the concentration of a nonradiological parameter falls below the maximum concentration limit, the licensee has no obligation to further reduce the parameter’s concentration. NRC should distinguish between the two types of ALARA studies.

Response: The NRC concurs with the commenter. A sentence was added to Section 4.3.3.3 of the standard review plan to indicate that, when a nonradiological hazardous constituent concentration is below its regulatory maximum concentration level, the licensee has no further obligation to reduce the constituent concentrations.

Issue: The benefits of ground-water corrective action requirements at remote sites are questionable.

Comment: Two commenters noted that NRC should provide further guidance on addressing instances where the benefits of ground-water correction action may not justify the cost. One comment referred to circumstances where restrictions on site access or site-specific physical characteristics may make it infeasible for members of the public to access ground water. Another comment suggested that the future value of the ground water removed and evaporated during corrective actions may exceed any risk posed by the contaminant.

Response: No changes to the standard review plan were made to address these comments. In such site-specific circumstances as described by the commenters, the burden is on the licensee to demonstrate that termination of ground-water corrective actions would pose no significant threat to human health and the environment. Licensees may propose alternate concentration limits that meet the requirements of 10 CFR Part 40, Appendix A, Criterion 5B(6). Consideration of the remoteness of a site, potential future water uses, and future value may be included in a licensee's basis for determining that alternate concentration limits are protective of human health and the environment, and that limits are as low as reasonably achievable. These and other factors for consideration by the Commission are specifically mentioned in 10 CFR, Part 40, Appendix A, Criterion 5B(6), which is appropriately cited in the standard review plan.

5. Comments related to NRC Responsibilities under the National Environmental Policy Act

Issue: The NRC is reviewing information that is outside its areas of regulatory authority.

Comment: Several commenters noted that NRC is asking for information that appears to be beyond its regulatory authority. This includes information on nonradiological hazardous constituents and review of restoration plans for borrow areas.

Response: As a federal agency, the NRC is subject to the National Environmental Policy Act (NEPA). This requires the NRC to consider impacts to the human environment as a part of its decision making process. The regulations governing NRC implementation of NEPA are described in 10 CFR Part 51. Guidance to the NRC staff on conducting environmental reviews is also provided in NUREG–1748 "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." With regard to NEPA, the NRC must consider the environmental impacts of both radiological and nonradiological aspects of a proposed action, particularly with regard to assessment of direct, indirect, and cumulative impacts of the proposed action. The exact nature of the information to be provided by a licensee, and the level of NRC staff review will be determined on a site-specific basis. The standard review plan is intended as general guidance to the staff on the type of information that is commonly acceptable for evaluating the environmental impact of a proposed licensing action. Under the risk-informed, performance-based licensing philosophy used by the NRC, the licensee is free to present alternative approaches for NRC consideration.

With regard to restoration plans for borrow areas, the intent of the section of the standard review plan identified by the commenter is to have staff review restoration plans for borrow areas as part of characterizing the stratigraphy and materials at a given site, and fulfilling NRC requirements under NEPA. The NRC also needs to consider the cumulative impacts of both radiological and nonradiological hazardous constituents to meet its obligations under NEPA. General guidance to NRC staff for the evaluation of cumulative impacts is provided in Section 4.2.5 of NUREG–1748 “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs.”

Dated at Rockville, Maryland this day of November, 2002.

For the Nuclear Regulatory Commission

Robert C. Pierson, Director
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

ATTACHMENT 3

NUREG–1569

STANDARD REVIEW PLAN
for *In Situ* Leach Uranium Extraction License Applications

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Fuel Cycle Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

NUREG–1569

STANDARD REVIEW PLAN
for *In Situ* Leach Uranium Extraction License Applications

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AVAILABILITY NOTICE

ABSTRACT

A U.S. Nuclear Regulatory Commission source and byproduct materials license is required to recover uranium by *in situ* leach extraction techniques, under the provisions of Title 10 U.S. Code of Federal Regulations, Part 40 (10 CFR Part 40), “Domestic Licensing of Source Material.” An applicant for a research and development or commercial-scale license, or for the renewal or amendment of an existing license, is required to provide detailed information on the facilities, equipment, and procedures used and an environmental report that discusses the effects of proposed operations on the health and safety of the public and on the environment.

The standard review plan is prepared for the guidance of staff reviewers, in the Office of Nuclear Material Safety and Safeguards, in performing safety and environmental reviews of applications to develop and operate uranium *in situ* leach facilities. It provides guidance for new license applications, renewals, and amendments. The principal purpose of the standard review plan is to assure the quality and uniformity of staff reviews and to present a well-defined base from which to evaluate changes in the scope and requirements of a review.

The standard review plan is written to cover a variety of site conditions and facility designs. Each section is written to provide a description of the areas of review, review procedures, acceptance criteria, and evaluation findings. However, for a given application, the staff reviewers may select and emphasize particular aspects of each standard review plan section, as appropriate for the application.

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FIGURES

TABLES

INTRODUCTION

A U.S. Nuclear Regulatory Commission (NRC) source and byproduct material license is required under the provisions of Title 10 of the U.S. Code of Federal Regulations, Part 40 (10 CFR Part 40), Domestic Licensing of Source Material, to recover uranium by *in situ* leach techniques. The licensing process for Part 40 licenses is pictured in Figure 1. NRC authority to regulate *in situ* leach facilities comes from the Atomic Energy Act of 1954, as amended, and the Uranium Mill Tailings Radiation Control Act of 1978, as amended. Specific requirements for *in situ* leach facilities are taken from 10 CFR Part 40, Appendix A criteria. The specific sections in this standard review plan that address these criteria are shown in Appendix B of the review plan. Although the National Environmental Policy Act of 1969 does not provide NRC with any additional authority, it does reinforce NRC authority found in the organic statutes by obligating NRC to evaluate both radiological and nonradiological environmental impacts for NRC-licensed sites. Also the National Environmental Policy Act , as interpreted by the courts, requires NRC to mitigate environmental impacts resulting from Agency actions, to the extent possible, through its licensing. Therefore, NRC can also condition commitments made by applicants to mitigate such environmental impacts.

An applicant for a new operating license, or for the renewal or amendment of an existing license, is required to provide detailed information on the facilities, equipment, and procedures to be used and to submit an environmental report that discusses the effect of proposed operations on public health and safety and the impact on the environment as required by 10 CFR 51.45, 51.60, and 51.66. This information is used by NRC staff to determine whether the proposed activities will be protective of public health and safety and will be environmentally acceptable. General provisions for issuance, amendment, transfer, and renewal of licenses are described in 10 CFR Part 2, Subpart A. General guidance for filing an application and for producing an environmental report is provided in 10 CFR 40.31, Application for Specific Licenses, and in 10 CFR Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, respectively.

The purpose of this standard review plan is to provide the NRC staff in the Office of Nuclear Material Safety and Safeguards with specific guidance on the review of applications for *in situ* leach facilities. The standard review plan complements Regulatory Guide 3.46, Standard Format and Content of License Applications, Including Environmental Reports for *In Situ* Uranium Solution Mining (NRC, 1982) which is guidance to applicants and licensees on an acceptable format and contents for a license application. Sections of this standard review plan are keyed to sections in Regulatory Guide 3.46 (NRC, 1982). Applicants should use Regulatory Guide 3.46 (NRC, 1982) as guidance in preparing their applications. Information in this standard review plan will be used by the Office of Nuclear Material Safety and Safeguards staff in the review of applications for new facilities, renewals, and amendments.

Throughout the remainder of this standard review plan, “application” is synonymous with license application, renewal, or amendment. The principal purpose of the standard review plan is to ensure a consistent quality and uniformity in NRC staff reviews. Each section in this standard review plan provides guidance on what is to be reviewed, the basis for the review, how the staff review is to be accomplished, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding the applicable sections in Title 10 of the U.S. Code of Federal Regulations. In general, *in situ* leach

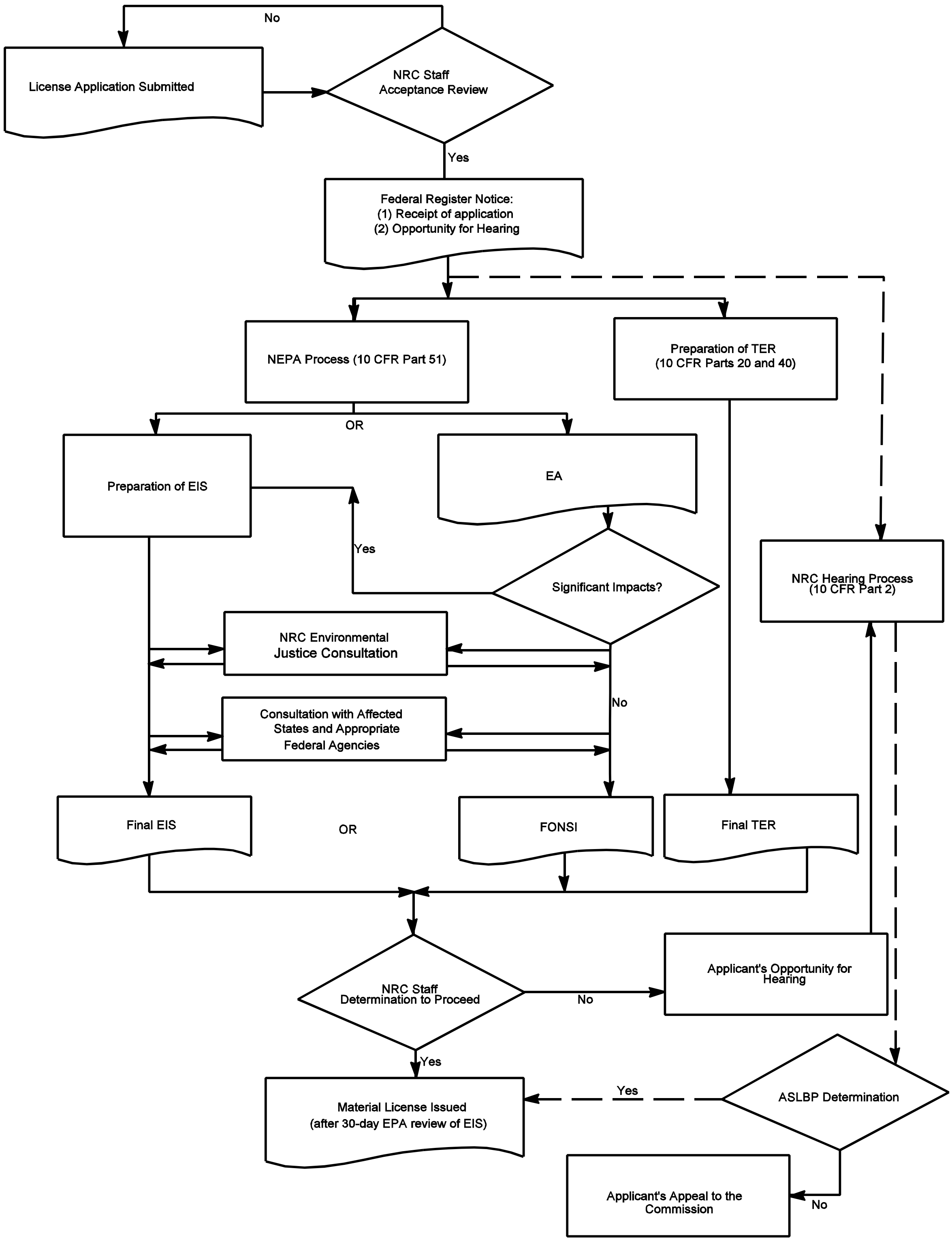

Figure 1. Licensing Process for 10 CFR Part 40 Licenses

operations are much more environmentally benign than conventional mining and milling and pose lower risk of occupational harm. Still, the NRC staff must determine if operations will be conducted in an environmentally acceptable manner and in compliance with applicable regulations. The detailed review procedures and acceptance criteria are intended to assist the Office of Nuclear Material Safety and Safeguards staff in making the necessary findings in an effective and efficient manner. General information regarding procedures for environmental reviews for licensing actions and guidance for the preparation of environmental assessments is available in NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs” (NRC, 2001).

This standard review plan is intended to cover only those aspects of the NRC regulatory mission related to the licensing of an *in situ* leach facility. As such, the standard review plan helps focus the staff review on determining if a facility can be constructed and operated in compliance with the applicable NRC regulations. The standard review plan is also intended to make information about regulatory matters widely available and to improve communications and understanding of the staff review process by interested members of the public and the uranium recovery industry.

For amendments, the focus of the review should be on the changes proposed in the amendment (see Appendix A for guidance for reviewing historical aspects of site performance). Reviewers should not review other previously accepted actions if they are not part of the amendment unless the review of the amendment package identifies problems with other aspects of facility operation.

For renewals, the licensee need only submit information containing changes from the currently accepted license. As for amendments, the staff reviews should focus on those aspects of facility operation that are different from what is in the current license. The licensee need not resubmit a complete application covering all aspects of facility operation. Reviewers should analyze the inspection history and operation of the site to see if any major problems have been identified over the course of the license term and should review changes to operations from those currently found acceptable (see Appendix A). If the changes are found to be acceptable, then the license is acceptable for renewal.

For license amendments and renewals, the operating history of the facility is often a valuable source of information concerning the adequacy of site characterization, the acceptability of radiation protection and monitoring programs, the success of and adherence to operating procedures and training programs, and other data that may influence the staff’s determination of compliance. Appendix A to the standard review plan provides guidance for review of these historical aspects of facility performance.

The products that will be prepared by the staff to document the review will be a technical evaluation report, and an environmental assessment with a finding of no significant impact to meet requirements under the National Environmental Policy Act. Preparation of an environmental assessment is required under the provisions of 10 CFR 51.20 unless (i) the staff finds, based on the environmental assessment, that NRC needs to prepare an environmental impact statement; (ii) an environmental impact statement is needed by another federal agency also involved in the action as a cooperating agency; (iii) an environmental impact statement would be needed because of controversy at the site, or (iv) the action is categorically excluded from the necessity to prepare an environmental assessment by 10 CFR 51.22. Different sections of this standard review plan refer either to a technical evaluation report, an environmental assessment, or both. Table 1 identifies which sections apply to a technical evaluation report and which to an environmental assessment. Details on the NRC National Environmental Policy Act process are contained in NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs” (NRC, 2001).

It is important to note that the acceptance criteria laid out in this standard review plan are for the guidance of NRC staff responsible for the review of applications to operate *in situ* leach facilities. Review plans are not substitutes for the Commission’s regulations, and compliance with a particular standard review plan is not required. This standard review plan provides descriptions of methodologies that have been found acceptable for demonstrating regulatory compliance. Methods and solutions different from those set out in the standard review plan will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a license by NRC.

General Review Procedure

A licensing review is not intended to be a detailed evaluation of all aspects of facility operations. Specific information about implementation of the program outlined in an application is obtained through NRC review of procedures and operations done as part of the inspection function. A definition of the differences between licensing reviews and inspections is provided in Figure 2.

The general licensing process is outlined in the flow diagram provided in Figure 1. An *in situ* leach source and byproduct material application may be denied or rejected under specific instances during the review process. Beginning construction of process facilities, well fields, or other substantial actions that would adversely affect the environment of the site, before the staff has concluded that the appropriate action is to issue the proposed license, is grounds for denial of the application [10 CFR 40.32(e)]. The applicant’s failure to demonstrate compliance with requirements [10 CFR 40.31(h)], or refusal or failure to supply information requested by the staff to complete the review (10 CFR 2.108) is also grounds for denial of the application.

Changes to existing licensed activities and conditions require the issuance of an appropriate license amendment. An application for such an amendment should describe the proposed changes in detail and should discuss the likely consequences of any environmental and health and safety impacts. Amendment requests should be reviewed using the appropriate sections of this document for guidance. Appendix A to this standard review plan provides guidance for examining the historical aspects of facility operations that may be useful for conducting such amendment reviews.

In conducting these evaluations, the reviewer shall consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. Ground-water compliance and protection reviews are the primary technical areas impacted by overlapping authorities. The desired outcome is to identify any areas where duplicative NRC reviews may be reduced or eliminated. The NRC staff must make the necessary evaluations of compliance with applicable regulations for licensing the facility. However, the reviewer may, as

Table 1. Identification of Sections Applicable to a Technical Evaluation Report or an Environmental Assessment

Section	Title	Applicable to Technical Evaluation Report	Applicable to Environmental Assessment
1.0	PROPOSED ACTIVITIES	X	X
2.0	SITE CHARACTERIZATION	X	X
2.1	Site Location and Layout	X	X
2.2	Uses of Adjacent Lands and Waters	X	X
2.3	Population Distribution	X	X
2.4	Historic, Scenic, and Cultural resources		X
2.5	Meteorology	X	X
2.6	Geology and Seismology	X	X
2.7	Hydrology	X	X
2.8	Ecology	X	X
2.9	Background Radiological Characteristics	X	X
2.10	Background Non-Radiological Characteristics	X	X
3.0	DESCRIPTION OF PROPOSED FACILITY	X	X
3.1	In Situ Leaching Process and Eqiupment	X	X
3.2	Recovery Plant Equipment	X	X
3.3	Instrumentation and Control	X	X
4.0	EFFLUENT CONTROL SYSTEMS	X	X
4.1	Gaseous and Airborne Particulates	X	X
4.2	Liquids and Solids	X	X
4.3	Contaminated Equipment	X	X
5.0	OPERATIONS	X	
5.1	Corporate Organization and Administrative Procedures	X	

Table 1. Identification of Sections Applicable to a Technical Evaluation Report or an Environmental Assessment (continued)

Section	Title	Applicable to Technical Evaluation Report	Applicable to Environmental Assessment
5.2	Management Control Program	X	
5.3	Management Audit, Inspection, and Record-keeping Program	X	
5.3.1	Management Audit, and Internal Inspection Program	X	
5.3.2	Recordkeeping and Record Retention	X	
5.4	Qualifications for Personnel	X	
5.5	Radiation Safety Training	X	
5.6	Security	X	X
5.7	Radiation Safety Controls and Monitoring	X	
5.7.1	Effluent Control Techniques	X	
5.7.2	External Radiation Exposure Monitoring Program	X	
5.7.3	Airborne Radiation Monitoring Program	X	
5.7.4	Exposure Calculations	X	
5.7.5	Bioassay Program	X	
5.7.6	Contamination Control Program	X	X
5.7.7	Airborne Effluent and Environmental Monitoring Program	X	X
5.7.8	Ground-Water and Surface-Water Monitoring Programs	X	X
5.7.9	Quality Assurance	X	X
6.0	GROUND-WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND PLANT DECOMMISSIONING	X	X
6.1	Plans and Schedules for Ground-Water Quality Restoration		X
6.2	Plans and Schedules for Reclaiming Disturbed Lands		X
6.3	Procedures for Removing and Disposing of Structures and Equipment	X	X

Table 1. Identification of Sections Applicable to a Technical Evaluation Report or an Environmental Assessment (continued)

Section	Title	Applicable to Technical Evaluation Report	Applicable to Environmental Assessment
6.4	Procedures for Conducting Post-Reclamation and Decommissioning Radiological Surveys	X	X
6.5	Financial Assessment for Ground-Water Restoration, Decommissioning, Reclamation, Waste Disposal, and Monitoring	X	X
7.0	ENVIRONMENTAL EFFECTS		X
7.1	Site Preparation and Construction		X
7.2	Effects of Operations	X	X
7.3	Radiological Effects	X	X
7.3.1	Exposure Pathways	X	X
7.3.1.1	Exposures from Water Pathways	X	X
7.3.1.2	Exposures from Air Pathways	X	X
7.3.1.3	Exposures from External Radiation	X	X
7.3.1.4	Total Human Exposures	X	X
7.3.1.5	Exposures to Flora and Fauna	X	X
7.4	Non-Radiological Effects		X
7.5	Effects of Accidents	X	X
7.6	Economic and Social Effects of Construction and Operation		X
7.6.1	Benefits		X
7.6.2	Socioeconomic Costs		X
8.0	ALTERNATIVES TO PROPOSED ACTION		X
9.0	COST-BENEFT ANALYSIS		X
10.0	ENVIRONMENTAL APPROVALS AND CONSULTATIONS		X

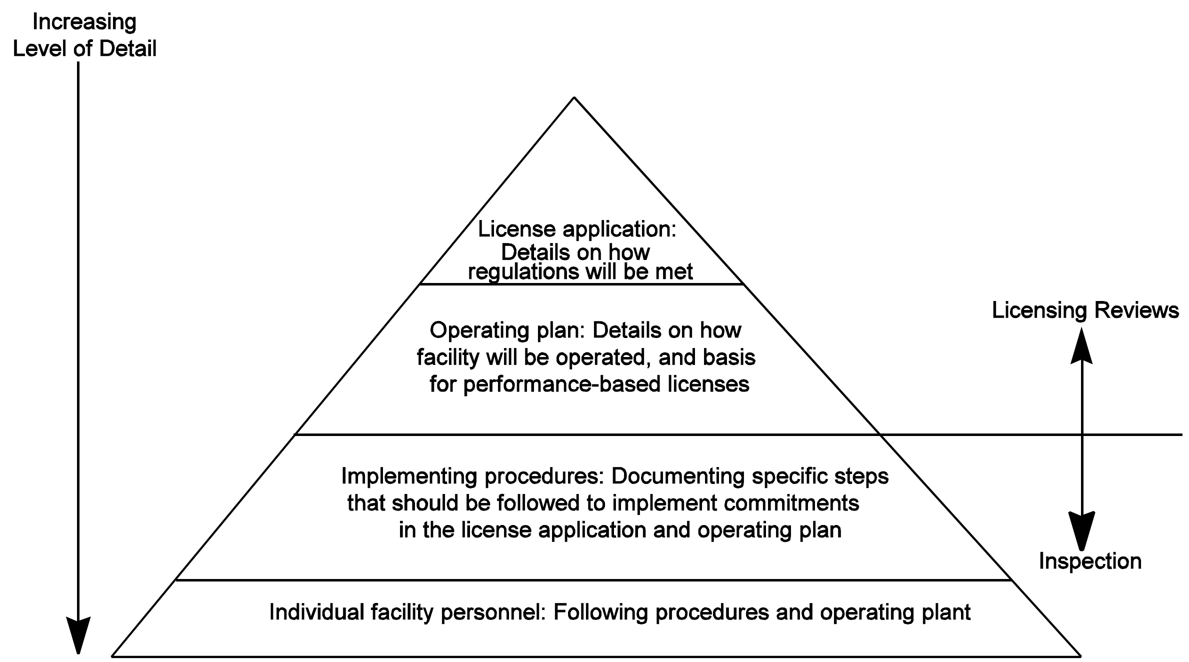

Figure 2. Schematic of NRC Licensing and Inspection Process and Applicability to Different License Documents

appropriate, rely on the applicant's responses to inquiries made by a state or another federal agency to support the NRC evaluation of compliance. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

The steps of the application review are described in the following paragraphs.

Acceptance (Administrative) Review Objectives

The staff should conduct an acceptance review of the application, which is an administrative review, to determine the completeness of the information submitted. This review requires a comparison of the submitted information to the information identified in the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982). The application will be considered complete for docketing if the information provided is complete, reflects an adequate reconnaissance and physical examination of the regional and site conditions, and provides appropriate analyses and design information to demonstrate that the applicable acceptance criteria will be met. Details for review of the environmental report are also contained in NUREG–1748 (NRC, 2001, Section 6). The staff should complete the acceptance review and transmit the results to the applicant within 30 days of the receipt of the application, along with a projected schedule for the remainder of the review as described in Section 1.1 of the standard review plan. In this transmittal, the staff should identify any additional information needed to make the application complete. Detailed technical questions, although not required, can be included if they are identified during the acceptance review. If the content of the application is acceptable for docketing, the staff should be able to make a finding that the applicable requirements in 10 CFR 40.31 have been met.

Detailed Review Objectives

Following completion of the acceptance review, the staff should conduct a detailed technical review of the application. The results of this review and the basis for acceptance or denial of the requested licensing action are documented by NRC in a technical evaluation report and either an environmental assessment (10 CFR 51.30) if there is a finding of no significant impact, or an environmental impact statement (10 CFR 50.31) if the review indicates that the licensed activity would have a significant impact on the health and safety of the public or on the environment. The detailed review should evaluate the environmental, economic, and technical evidence provided by the applicant to support the ability of the proposed facility to meet applicable regulatory requirements. Details on the NRC National Environmental Policy Act process are contained in NUREG–1748 (NRC, 2001).

Standard Review Plan Organization

The standard review plan is written to address a variety of site conditions and facility designs. Each section provides the complete review procedure and acceptance criteria for all the areas of review pertinent to that section. For any given application, the staff reviewer may select and emphasize particular aspects of each standard review plan section as appropriate for the application. Because of this, the staff may not carry out in detail all of the review steps listed in each standard review plan section in the review of every application.

Areas of Review Subsection

This subsection describes the scope of the review (i.e., what is being reviewed). It contains a brief description of the specific technical information and analyses in the application that should be reviewed by each technical reviewer.

Review Procedures Subsection

This subsection discusses the appropriate review technique. It is generally a step-by-step procedure that the reviewer uses to determine whether the acceptance criteria have been met.

Acceptance Criteria Subsection

This subsection delineates criteria that can be applied by the reviewer to determine the acceptability of the applicant compliance demonstration. Because the criteria are based on detailed technical approaches for determining compliance with applicable regulations, they do not routinely reference specific regulations. To include such reference would simply restate the requirements, and would not provide guidance on what is an acceptable method of compliance. The technical bases for these criteria have been derived from 10 CFR Parts 40 and 20, NRC regulatory guides, general design criteria, codes and standards, branch technical positions, standard testing methods (e.g., American Society for Testing and Materials standards), technical papers, and other similar sources. These sources typically include solutions and approaches previously determined to be acceptable by the staff for making compliance determinations for the specific area of review. These acceptance criteria have been defined so that staff reviewers can use consistent and well-documented approaches for review of all applications. Flexibility is provided to enable licensees to achieve the type of operation desired at their facilities. Applicants may take approaches to demonstrating compliance that are different from the acceptance criteria in this standard review plan as long as the staff can make the requisite decisions concerning environmental acceptability and compliance with applicable regulations. However, applicants should recognize that, as is the case for regulatory guides, substantial staff time and effort have gone into the development of these procedures and criteria, and a corresponding amount of time and effort may be required to review and accept new or different solutions and approaches. Thus, applicants proposing solutions and approaches to safety problems or safety-related design issues other than those described in this standard review plan may experience longer review times and NRC requests for more extensive supporting information. The staff is willing to consider proposals for other solutions and approaches on a generic basis, apart from a specific application, to avoid the impact of the additional review time for individual cases.

Evaluation Findings Subsection

This subsection presents general conclusions and findings of the staff that result from review of each area of the application as well as an identification of the applicable regulatory requirements. Conclusions and findings for a specific application and review area are dependent on the site and type of licensing action being considered. For each standard review plan section, a conclusion is included in the technical evaluation report or the environmental assessment/environmental impact statement in which results of the review are published. These documents contain a description of the review; the basis for the staff findings, including aspects of the review selected or emphasized; where the facility design or the applicant programs deviate from the criteria stated in the standard review plan; and the evaluation findings.

References Subsection

This subsection lists any applicable references.

Standard Review Plan Updates

This standard review plan will be revised and updated periodically as the need arises to clarify the content or correct errors and to incorporate modifications approved by NRC management. Corresponding changes to the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982) will be made as required.

References

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

———. Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining." Washington, DC: NRC, Office of Standards Development. 1982.

1.0 PROPOSED ACTIVITIES

1.1 Areas of Review

The reviewer should examine the summary of the proposed activities for which a license is requested to gain a basic understanding of those proposed activities and the likely consequences of any safety or environmental impact. The staff should review the corporate entities involved; the location of the proposed activities; land ownership; ore-body locations and estimated uranium (U_3O_8) content; proposed solution extraction method and recovery processes; operating plans, design throughput and anticipated annual U_3O_8 production; radiation safety protection estimated schedules for construction, startup, and duration of operations; plans for project waste management and disposal; source and byproduct material transportation plans; plans for ground-water quality restoration, decommissioning, and land reclamation; and surety arrangements covering eventual facility decommissioning, ground-water quality restoration, and site reclamation.

1.2 Review Procedures

The reviewer should determine whether the application provides a sufficiently comprehensive summary of the nature of the facilities, equipment, and procedures to be used in the proposed *in situ* leach activity including the name and location. Reviewers should keep in mind that the development and initial licensing of an *in situ* leach facility is not based on comprehensive information. This is because *in situ* leach facilities obtain enough information to generally locate the ore body and to understand the natural systems involved. More detailed information is developed as each area is brought into production. Therefore, reviewers should verify that sufficient information is presented to reach only the conclusion necessary for initial licensing. However, reviewers should not expect that information needed to fully describe each aspect of a full operation will be available in the initial application. For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

Applications for licenses authorizing commercial-scale operations should rely on results from research and development operations or other operational experience that can be used as a basis to support the proposed processes, operating plans (including plans for ground-water quality restoration), and assessment of the likely consequences of any environmental impact. This does not mean that the applicant needs to develop a research and development facility in order to license a full-scale production plant. Rather it is intended to allow the applicant to rely on available data from research and development facilities, other sites currently operated by the applicant, or sites with similar designs or natural features operated by other licensees. In performing the evaluation, the reviewer should use the data available from these other sources to assess how the proposed site compares with already licensed sites.

1.3 Acceptance Criteria

The proposed activities are acceptable if they meet the following criteria:

(1) The application summary of proposed activities includes descriptions of the following items that are sufficient to provide a basic understanding of the proposed activities and the likely consequences of any health, safety, and environmental impact. The content of the introduction is outlined in the "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining" [U.S. Nuclear Regulatory Commission (NRC), 1982].

(a) Corporate entities involved

(b) Location of the proposed facilities by county and state, including the facility name

(c) Land ownership

(d) Ore-body locations and estimated U_3O_8 content

(e) Proposed solution extraction method and recovery process

(f) Operating plans, design throughput, and annual U_3O_8 production

(g) Estimated schedules for construction, startup, and duration of operations

(h) Plans for project waste management and disposal

(i) Plans for ground-water quality restoration, decommissioning, and land reclamation

(j) Surety arrangements covering eventual facility decommissioning, ground-water quality restoration, and site reclamation

(k) For license renewals, a summary of proposed changes, a record of amendments since the last license issuance, and documentation of inspection results

(2) Applications for commercial-scale operations include results from research and development operations or previous operating experience as a basis for the proposed processes, operating plans, ground-water quality restoration, and assessment of the likely consequences of any environmental impact.

1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the summary of the proposed activities, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

The NRC has completed its review of the summary of the proposed activities at the _________________*in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate the proposed activities using the review procedures in standard review plan Section 1.2 and the acceptance criteria outlined in standard review plan Section 1.3.

The applicant has acceptably described the proposed activities at the ______________ *in situ* leach facility including (i) corporate entities involved; (ii) location of the proposed facility; (iii) land ownership; (iv) ore-body locations and estimated U_3O_8 content; (v) proposed solution extraction method and recovery process; (vi) operating plans, design throughput, and annual U_3O_8 production; (vii) schedules for construction, startup, and duration of operations; (viii) waste management and disposal plans; and (ix) ground-water quality restoration, decommissioning, and land reclamation plans; (x) surety arrangements covering facility decommissioning, ground-water quality restoration, and site reclamation. For license renewals, the applicant has provided a summary of proposed changes, a record of amendments since the last license issuance, and documentation of inspection results. Applicants for commercial-scale operations have included results from research and development operations or previous operating experience.

Based on the information provided in the application and the detailed review conducted of the summary of the proposed activities at the _______________ *in situ* leach facility, the staff concludes that the summary of the proposed activities is acceptable and is in compliance with 10 CFR 40.32, which describes the general requirements for the issuance of a specific license. The summary of proposed activities is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the proposed action sufficient to allow the staff to evaluate the impacts on the affected environment.

1.5 Reference

NRC. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

2.0 SITE CHARACTERIZATION

2.1 Site Location and Layout

2.1.1 Areas of Review

The staff should review geographic maps, topographic maps, and drawings that identify the site and its location relative to federal, state, county, and other political subdivisions. These should include maps provided to show the location and layout of the proposed facilities, well fields, and all principal structures such as surface impoundments, deep injection wells, recovery plant buildings, exclusion area boundaries and fences, applicant property and leases, and adjacent properties.

The regional location and site layout for the proposed *in situ* leach operations should be reviewed using maps that show the relationship of the site to local water bodies (lakes, streams); geographic features (highlands, forests); geologic features (faults, folds, outcrops); transportation links (roads, rails, airports, waterways); political subdivisions (counties, townships); population centers (cities, towns); historical and archeological features; key species habitat; and non-applicant property (farms, settlements). A contour map of the site showing a plan layout of constructions, significant topographic variations of the site environs, and drainage gradients, should be evaluated.

2.1.2 Review Procedures

The reviewer should establish the validity and completeness of the basic data, to determine that the site location and layout proposed in the application are complete and accurate, and that the site information is sufficient to evaluate the location of the proposed facilities relative to key features and activities. For new applications, the staff should conduct a site visit of the facility, after becoming familiar with the submitted materials, to develop an acceptable familiarization for the review and to verify the general aspects of the submitted materials.

The staff should examine maps and drawings provided in the application and associated environmental reports to determine whether they provide sufficient detail to locate the site regionally relative to local political subdivisions and natural and man-made features and that the maps allow the staff to determine the proposed layout within the existing topography at the site. On a regional scale, the reviewer should examine the location of the facility and all federal, state, county, and local political subdivisions that have a bearing on estimating the environmental impact of the proposed operations. The staff should verify that the total acreage that is owned or leased by the applicant and the portion of that real estate or any adjacent properties that could be affected by site activities have been identified. The reviewer should examine a contour map to determine that the contour intervals and information included on the map are sufficient to show any significant variations in site environs and important drainage gradients. The staff should also determine that the relationship between the site and surface drainage is readily apparent from the provided maps. Likewise, it should be possible to ascertain the likely areas of and effects of site activities on local flora and fauna from the location maps. The staff should determine that the scale and clarity of the maps are adequate to conduct the necessary environmental and safety reviews.

Site Characterization

Reviewers should keep in mind that the development and initial licensing of an *in situ* leach facility is not based on comprehensive information. This is because *in situ* leach facilities obtain enough information to generally locate the ore body and understand the natural systems involved. More detailed information is developed as each area is brought into production. Therefore, reviewers should ensure that sufficient information is presented to reach only the conclusion necessary for initial licensing. However, reviewers should not expect that information needed to fully describe each aspect of all the operations will be available in the initial application.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.1.3 Acceptance Criteria

The characterization of the site location and layout is acceptable if it meets the following criteria:

(1) Maps are provided that show geologic features, well fields, and all planned principal structures such as surface impoundments, diversion channels, monitoring wells, deep injection wells, and recovery plant buildings. If detailed information on actual well field design is not available at the time of the initial facility application, the maps show the expected well field locations with an indication that this information is preliminary.

(2) Any maps previously submitted (e.g., maps from the original application in the case of renewals) are legible, and actual or proposed changes are highlighted.

(3) Maps are provided that show exclusion area boundaries and fences.

(4) Maps are provided that show the applicant property and leases and current adjacent properties, including water bodies, forests, and farms, and all federal, state, county, and local political subdivisions.

(5) Maps are provided that show nearby population centers and transportation links such as railroads, highways, and waterways.

(6) A topographic map is provided with elevation contours that show the locations of drainage basins and variations in the drainage gradient in the vicinity of the proposed *in situ* leach facility. The specific locations of natural streams and proposed diversion channels, relative to principal structures, should also be provided.

(7) The proposed *in situ* leach facility is clearly labeled at a scale appropriate to the area being covered (regional and local) and with sufficient clarity and detail to allow identification and evaluation of the proposed *in situ* leach facility. Maps are at an appropriate scale and are clear and readable.

(8) Data sources are documented in reports such as U.S. Geological Survey open files or existing published maps. If data have been generated by the applicant, the data documentation should include a description of the investigation and data reduction techniques.

(9) Maps include designation of scale, orientation (e.g., north arrow), and geographic coordinates. In addition to maps, the applicant may provide tabular locations of facilities using universal transverse Mercator coordinates with appropriate Northing and cross-section in meters.

2.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the description of the site location and layout, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with site location and layout at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.1.2 and the acceptance criteria outlined in standard review plan Section 2.1.3.

The licensee has acceptably described the site location and layout with appropriately scaled and labeled maps showing site layout, principal facilities and structures, regional location, geology, boundaries, exclusion areas and fences, applicant property including leases and adjacent properties, nearby population centers and transportation links, and topography. References are cited acceptably. Any maps previously submitted (e.g., maps from the original application in the case of renewals) are legible, and actual or proposed changes are highlighted.

Based on the information provided in the application, and the detailed review conducted of the characterization of site location and layout for the _______________ *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.1.5 References

None.

2.2 Uses of Adjacent Lands and Waters

2.2.1 Areas of Review

The staff should review descriptions of the nature and extent of present and projected land use (e.g., agriculture, sanctuaries, hunting, mining, grazing, industry, recreation, roads), any recent trends or changes in population or industrial patterns, and any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site.

The staff should also review tables showing, for each of the 22½-degree sectors centered on each of the 16 compass points (i.e., north, north-northeast, etc.), the distances {to a distance of 3.3 km [2 mi]} from the center of the site to the nearest resident and to the nearest site boundary.

The staff review should include the location, nature, and amounts of present and projected surface-water and ground-water use (e.g., water supplies, irrigation, reservoirs, recreation, and transportation) within 3.3 km [2 mi] of the site boundary {0.8 km [0.5 mi] for research and development operations} and the present and projected population associated with each use point.

2.2.2 Review Procedures

The reviewer should determine whether the application provides sufficient information on the use of the lands and waters within a 3.3 km [2 mi] distance from the site boundary surrounding the proposed facilities {0.8 km [0.5 mi] for research and development operations} to assess the likely consequences of any impacts of *in situ* leach operations on adjacent properties.

The staff should determine that the application contains the location of residences, ground-water supply wells, surface-water reservoirs, and the estimated use of water in the lands surrounding the site of the proposed facility. Data sources should be referenced. This information should be evaluated to determine whether it is sufficient to delineate the likely impact(s) of the facility, under both normal operating conditions and accidents, on the ground water, surface-water, and population (both human and animal) near the site. The reviewer should determine that within 3.3 km [2 mi] from the site boundary, the nature and extent of present and projected water and land use and any other trends or changes in population or industrial patterns have been reported. Any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site should be identified.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining historical aspects of facility performance and the approach that should be used in evaluating amendments and renewal applications.

2.2.3 Acceptance Criteria

The characterization of the uses of adjacent lands and waters is acceptable if it meets the following criteria:

(1) Information is presented in detail sufficient to understand the surrounding land and water uses, such that the likely consequences imposed by *in situ* leach operations can be adequately assessed.

Although the specific requirements may vary from site to site, the general purpose for determining land and water use patterns is to provide supporting data for exposure calculations, cost-benefit analyses, and determinations of air emissions (e.g., dust). A 3.3-km [2-mi] distance from the site boundary is an acceptable area for which land and water use data should be collected. One acceptable method for presenting these data is for the applicant to provide the information requested in the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982), Section 2.2. The information presented should include:

(a) Maps showing the locations of nearest residences, ground-water supply wells, and abandoned wells

(b) Types of present and projected (life of facility) water use (e.g., municipal, domestic, agriculture, livestock) and descriptions of the methodology and sources used to develop projections

(c) Present and projected (life of facility) water use estimates, by type, for both ground-water and surface-water, including present and projected withdrawal, and descriptions of the methodology and sources used to develop projections

(d) For existing ground-water wells, well depth, ground-water elevations, flow rates, drawdown, and a description of the producing aquifer(s)

(e) The locations of abandoned wells and drill holes, including the depth, type of use, condition of closing, plugging procedure used, and date of completion for each well or drill hole within the site area and within 0.4 km [.25 mi] of the well field boundary

(f) Descriptions of the nature and extent of projected land use (e.g., agriculture, recreation, industry, grazing, and infrastructure) and descriptions of the methodology and sources used to develop projections

(g) The location of any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site

(2) For each of the 22½-degree sectors centered on the 16 cardinal compass points, the information identified in Section 2.2.3 of the Standard Format and Content of License Application, Including Environment Report (NRC, 1982) concerning human residences, nearest site boundary(ies) to residences, surface- and ground-water use, and projected water use, is provided. As described in Section 2.2 of the Standard Format and Content of License Application, Including Environment Report (NRC, 1982), appropriate presentation of the data should include mapped data as appropriate, a tabular summary for each of the 22½-degree sectors centered on the 16 cardinal compass points, and for each, the distance from the center of the site to the site boundary and the nearest residence.

(3) Data sources are documented in reports such as U.S. Geological Survey open files or existing published reports or maps. If data have been generated by the applicant, the data documentation should include a description of the investigations and data reduction techniques.

(4) Maps include designation of scale, orientation (e.g., north arrow), and geographic coordinates.

2.2.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the described uses of adjacent lands and waters, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with uses of adjacent lands and waters near the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.2.2 and acceptance criteria outlined in standard review plan Section 2.2.3.

The applicant has acceptably described the present and projected land use, including residential, commercial, agricultural, industrial, flora and fauna sanctuaries, arboreal, grazing, recreation (e.g., hunting, swimming, skiing), and infrastructure. Appropriate information on the location and extent of each use has been provided. In particular, the description and associated tabulated data of the location, nature, amounts, and population associated with each use point of present and projected (life of the facility) surface and ground-water adjacent to the site including water supplies, irrigation, reservoirs, recreation, and transportation within at least 3.3 km [2 mi] of the site boundary {0.8 km [0.5 mi] for research and development operations} are acceptable for determination of likely impacts of the proposed *in situ* leach facility. Tabulated data on present and projected water withdrawal rates, return rates, types of water use (e.g., municipal, domestic, agriculture, and livestock); source, water-use estimates, and abandoned well locations are acceptable. The applicant has identified and located (or has noted the absence of) other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site.

Based on the information provided in the application, and the detailed review conducted of the characterization of uses of adjacent lands and waters for the _______________ *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45 which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis, and 10 CFR Part 40, Appendix A, Criteria 5B(4) and 5G(3) which provide criteria for identification if underground sources of drinking water and exempted aquifers and the current uses of ground water.

2.2.5 Reference

NRC. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

2.3 Population Distribution

2.3.1 Areas of Review

The staff should review population data based on the most recent census, including maps that identify places of significant population grouping, such as cities and towns within an 80-km [50-mi] radius {3.2 km [2 mi] for research and development operations} from the approximate center of projected (life of facility) activities in the format specified in the Standard Format and Content of License Application, Including Environmental Reports (NRC, 1982). For the purposes of environmental justice (see Sections 7.6.1.3) and NUREG–1748 (NRC, 2001) the staff should also examine the distribution of low-income and minority populations based on the most recent census data available. The staff should review the basis for population projections.

In addition, for commercial-scale operations, the staff should review descriptive material giving significant population and visitor statistics of neighboring schools, plants, hospitals, sports facilities, residential areas, parks, *et cetera*, within 3.3 km [2 mi] of the *in situ* leach operations. The review should include appropriate available food production data in kg/yr for vegetables (by type and totals), meat (all types), and milk, and any available future predictions for this production by local governmental, industrial, or institutional organizations within 3.3 km [2 mi] of the site boundary.

2.3.2 Review Procedures

The reviewer should determine that data have been tabulated and presented in pie segments as described in Section 2.3 of the Standard Format and Content of License Application, Including Environmental Reports (NRC, 1982). The basis for population projections should be examined. Recent agricultural production data should be tabulated for vegetables, meat, milk, and other foodstuffs, in addition to predictions for future production by government, industry, or institutions for land within 3.3 km [2 mi] of the site. It is important to ascertain that the most recent census data have been used and that the data presented will support subsequent exposure and dose calculations and risk assessments.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.3.3 Acceptance Criteria

The characterization of the population distribution is acceptable if it meets the following criteria:

(1) Population data, including demographic information on minority and low-income populations, are provided based on generally accepted sources such as the U.S. Census Bureau, and other federal, state, and local agencies.

(2) A map of suitable scale is provided that identifies significant population centers within an 80-km radius [50 mi] {3.2 km [2 mi] for research and development operations} from the approximate center of the projected activities.

(3) A map of suitable scale is provided, centered on the proposed ISL facility, marked with concentric circles at 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km divided into 22½-degree sectors centered on one of the 16 compass points. A table keyed to this map showing separate and cumulative population totals for each sector and annular ring is provided. The distance to the nearest residence is noted for each sector.

(4) Descriptions of significant population and visitor statistics of neighboring schools, plants, hospitals, sports facilities, residential areas, parks, and forests within 3.2 km [2 mi] of the proposed *in situ* leach facility, based on generally accepted sources such as the U.S. Census Bureau, and state and local agencies, are provided, with identification of data sources.

(5) Projections are included of population, visitor, and food production data over the expected life of the *in situ* leach facility (typically tens of years).

(6) Descriptions of the methodology and sources used to develop projections are provided.

The food production data are acceptable if data (kg/yr) for vegetables, meat, and milk, based on generally accepted sources such as the U.S. Department of Agriculture, Farm Bureau, and state and local agriculture services, are provided, with identification of data sources.

2.3.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the population distribution and food production data, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with population distribution and food production near the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.3.2 and acceptance criteria outlined in standard review plan Section 2.3.3.

The applicant has acceptably described the population distribution using population data from generally accepted sources. A map showing the location of significant population centers, within an 80-km radius [50 mi] of the approximate center of proposed operations, is provided. A table and accompanying map providing population in pie-shaped wedges, centered on each of the 16 compass points, is included. Nearest residence distances are noted for each sector. The applicant has provided acceptable information on minority and low-income populations, schools, industrial facilities, sports facilities, residential areas, parks, and forests within 3.2 km [2 mi] of the proposed *in situ* leach facility. Food production data (e.g., vegetables, meat, milk) have been described and keyed on a map. Based on a description of the methodology and sources, all the data have been appropriately projected for the proposed life of the *in situ* leach facility.

Based on the information provided in the application, and the detailed review conducted of the characterization of population distribution and food production for the _______________ *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.3.5 References

NRC. Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining." Washington, DC: NRC, Office of Standards Development. 1982.

———. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

2.4 Historic, Scenic, and Cultural Resources

2.4.1 Areas of Review

The staff shall review discussions of the historic, cultural, and scenic resources, if any, within the area of potential effect. Historic properties include districts, sites, buildings, structures, or objects of historical, archaeological, architectural, or traditional cultural significance. Specific attention should be directed to properties included in or eligible for inclusion in the National Register of Historic Places (the National Register) and properties registered as National Natural Landmarks.

The staff should review identifications of those properties included in, or eligible for, inclusion in the National Register of Historic Places, located within the area of the proposed project, and should review evidence of contact with the appropriate state historic preservation officer, including a copy of any state historic preservation officer comments concerning the effect of the facility on historic, scenic, and cultural resources.

The review should include information on whether new roads, pipelines, or utilities for the proposed activity will pass through or near any area or location of known historic, scenic, or cultural significance.

2.4.2 Review Procedures

The staff should determine that the applicant has used the appropriate databases and records to identify historic, scenic, and cultural resources that are found within the study region. The staff should determine that the locations and descriptions of the features are sufficient to allow an evaluation of the likely impacts of the proposed facilities on these resources. Of particular interest are features included in, or eligible for inclusion in, the National Register and National Natural Landmarks. Means to consider and treat such data are discussed in several National Park Service guidelines (e.g., National Park Service, 1973, 1990, 1995). The reviewer should verify that data presented support estimates of long-term costs in terms of the likely impacts on the aesthetic or recreational values of such landmarks. It is important that the application document evidence of contact with knowledgeable sources when no historic, scenic, or cultural resources are identified by the applicant within the study area. The reviewer should examine the likely impact of new roads, pipelines, or other utilities on areas and locations of known historic, scenic, or cultural significance [White House, 2000 (Executive Order 13175)].

The reviewer should also confer with the state historic preservation officer as required by 36 CFR Part 800. As specified in Part 800, the state historic preservation officer can enter into a memorandum of understanding to assume the function of the Advisory Council on Historic Preservation. In these situations, consistent with 36 CFR 800.7(b)(1), NRC can comply with the state review process in lieu of the Advisory Council on Historic Preservation regulations. If such a memorandum of understanding is not in place, the staff must consult with the state historic preservation officer and other interested parties. If adverse effects are found, and the Advisory Council on Historic Preservation does not participate, the NRC may enter into a memorandum of agreement with the State Historic Preservation Officer as specified in 36 CFR 800.6(b)(1). The NRC must submit a copy of the executed memorandum of agreement, along with the documentation specified in 36 CFR 800.11(f) to the Advisory Council on Historic Preservation prior to approving the undertaking in order to meet the requirements of Section 106 of the National Historic Preservation Act. If adverse effects are found, and the Advisory Council on Historic Preservation does not participate, the NRC should follow the requirements of 36 CFR 800.6(b)(2).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.4.3 Acceptance Criteria

The characterization of regional historic, scenic, and cultural resources is acceptable if it meets the following criteria:

(1) A listing for all properties included in, or eligible for inclusion in, the National Register including National Natural Landmarks is provided.

(2) A map is included showing all identified National Register Properties and National Natural Landmarks with respect to the location of facilities such as buildings, new roads, well fields, pipelines, surface impoundments, and utilities that might affect these areas.

A license condition will be placed in the license prohibiting work if any previously unknown cultural artifacts are found.

(3) Discussions are incorporated of the treatment of areas of historic, scenic, and cultural significance that follow guidance equivalent to that provided by the National Park Service Preparation of Environmental Statements: Guidelines for Discussion of Cultural (Historic, Archeological, Architectural) Resources (National Park Service, 1973). Where appropriate, tribal authorities have been consulted on the likely impacts on Native American cultural resources (White House, 2000). For a consideration of environmental justice, see Section 7.6.1.3, Acceptance Criterion (3) and NUREG–1748 (NRC, 2001).

(4) If delegated by NRC, the applicant provides evidence of contact with the appropriate state historic preservation officer and tribal authorities. This evidence includes a copy of comments of the state historic preservation officer and tribal authority concerning the effects of the proposed facility on historic, archeological, architectural, and cultural resources.

(5) If delegated by NRC, the applicant presents a memorandum of agreement among the state historic preservation officer, tribal authorities, and other interested parties regarding their satisfaction with regard to the protection of historic, archeological, architectural, and cultural resources during site construction and operations.

(6) A letter from the state historic preservation officer has been obtained that discusses any issues associated with sites in, or eligible for inclusion in, the National Register, National Natural Landmarks, or other cultural properties that may be affected by the *in situ* leach operations.

(7) The aesthetic and scenic quality of the site is rated in accordance with U.S. Bureau of Land Management 8400—Visual Resource Management (U.S. Bureau of Land Management, 2001).

If the rating is below 19 (scale of 0 to 33), no special management is required. If the rating is 19 or above, the application provides a management plan for minimizing the impact of the proposed facility.

2.4.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the characterization of the historic, scenic, and cultural resources the following conclusions may be presented in the environmental assessment.

Site Characterization

NRC has completed its review of the site characterization information concerned with regional historic, scenic, and cultural resources near the _____________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.4.2 and acceptance criteria outlined in standard review plan Section 2.4.3.

The licensee has acceptably described the historic, scenic, and cultural resources. A listing of all nearby areas and properties included or eligible for inclusion in the National Register or National Natural Landmarks is provided. A map showing all historic landmarks and places with respect to *in situ* leach facilities is included. A record of the investigation of places and properties with historic, scenic, and cultural significance, which follows guidance equivalent to that of the National Park Service, is provided. Contact with local tribal authorities, where appropriate, is acceptably documented. A letter from the state historic preservation officer addressing any issues related to the properties that might be affected by the *in situ* leach facilities is included. The applicant has acceptably demonstrated that the state historic preservation officer and tribal authorities agree with the planned protection from or determination of lack of conflict with *in situ* leach facilities and activities and with any places of importance to the state, federal, or tribal authorities. The applicant has acceptably rated the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management Visual Resource Inventory and Evaluation System.

Based on the information provided in the application, and the detailed review conducted of the characterization of regional historic, archeological, architectural, scenic, cultural, and natural landmarks near the ______________ *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.4.5 References

National Park Service. “How to Apply the National Register Criteria for Evaluation.” National Park Service Bulletin No. 15. Washington, DC: National Park Service, U.S. Department of the Interior. 1995.

———. “Guidelines for Evaluating and Documenting Traditional Cultural Properties. National Register Bulletin No. 38. Washington, DC: National Park Service, U.S. Department of the Interior. 1990.

———. “Preparation of Environmental Statements: Guidelines for Discussion of Cultural (Historic, Archeological, Architectural) Resources.” Washington, DC: National Park Service. 1973.

NRC. NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs.” Washington, DC: NRC. 2001.

U.S. Bureau of Land Management. “Visual Resource Management.” U.S. Bureau of Land Management Manual—8400. Washington, DC: U.S. Department of the Interior. http://lm0005.blm.gov/nstc/rrm/8400.html. 2000.

White House. “Consultation and Coordination with Indian Tribal Governments.” Executive Order 13175. *Federal Register.* Vol. 65. pp. 67249–67252. 2000.

2.5 Meteorology

2.5.1 Areas of Review

The staff should review descriptions of the atmospheric diffusion characteristics of the site and its surrounding area based on data collected onsite or at nearby meteorological stations. The data to be reviewed include

(1) National Weather Service station data, including locations of all National Weather Service stations within an 80-km [50-mi] radius; and available joint frequency distribution data by wind direction, wind speed, stability class, period of record, and height of data measurement

(2) On-site meteorological data, including locations and heights of instrumentation, descriptions of instrumentation, and joint frequency distribution data, if National Weather Service data representative of the site are not available

(3) Miscellaneous data, including annual average mixing layer heights, a description of the regional climatology, and total precipitation and evaporation, by month

The staff should also review a discussion of the general climatology including existing air quality, the relationship of the regional meteorological data to the local data, the meteorological impact of the local terrain and large lakes and other bodies of water, and the occurrence of severe weather in the area and its effects. This review should also include data on averages of temperature and humidity.

2.5.2 Review Procedures

The staff should determine whether the application includes sufficient local and regional-scale meteorological information to support estimates of airborne radionuclide transport from the proposed *in situ* leach facility to the surrounding area and for determination of airborne pathway inputs to risk assessment models. This information may include National Weather Service data, on-site monitoring data, or data from local meteorological stations, and any maps or tables that describe meteorological conditions at the site and surrounding area. Section 2.5 of the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982) contains a list of acceptable meteorological data requirements.

Site Characterization

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.5.3 Acceptance Criteria

The characterization of the site meteorology is acceptable if it meets the following criteria:

(1) A description of the general climate of the region and local meteorological conditions is provided, based on appropriate data from National Weather Service, military, or other stations recognized as standard installations.

These data include precipitation, evaporation, and joint-frequency distribution data by wind direction, wind speed, stability class, period of record, and height of data measurement. The average inversion height should also be identified. Data should also be provided on diurnal and monthly averages of temperature and humidity. The locations of all stations used in the data analysis and the height of the data measurement should be included. Data periods should be defined by month and year and cover a sufficient time period to constrain long-term trends and support atmospheric dispersion modeling.

Data from local meteorological weather stations supplemented, if necessary, by data from an on-site monitoring program, are provided.

A minimum of one full year of joint frequency data presented with a joint data recovery of 90 percent or more is provided.

The on-site program should be designed in accordance with Regulatory Guide 3.63, “Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting” (NRC, 1988).

(2) Consideration of relationships between regional weather patterns and local meteorological conditions based on weather station data and the on-site monitoring program, if necessary, is included. The impacts of terrain and nearby bodies of water on local meteorology are assessed, and the occurrence of locally severe weather is described and its impact considered.

Information on anticipated air quality impacts from non-radiological sources, such as vehicle emissions and dust from well field activities, is provided for assessing cumulative impacts.

(3) The meteorological data used for assessing impacts are substantiated as being representative of expected long-term conditions at and near the site.

(4) The application contains a description of existing air quality.

The applicant must demonstrate that the radiological and non-radiological air quality impacts caused by *in situ* leach facilities are virtually indistinguishable from background, or information on the likelihood of air pollution is based on U.S. Environmental Protection Agency (EPA) studies. Affected counties within 80 km [50 mi] of the facility are classified according to the National Ambient Air Quality Standards as being in attainment (below National Ambient Air Quality Standards) or nonattainment (above National Ambient Air Quality Standards status.

(5) The sources of all meteorological and air quality data are documented in open file reports or other published documents. If data have been generated by the applicant the data documentation should include a description of the investigations and data reduction techniques.

2.5.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the meteorology, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with meteorology at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.5.2 and acceptance criteria outlined in standard review plan Section 2.5.3.

The licensee has acceptably described the site meteorology by providing data from National Weather Service military, or other stations recognized as standard installations located within 80 km [50 mi] of the site, including available joint frequency distribution data on (i) wind direction and speed, (ii) stability class, (iii) period of record, (iv) height of data measurement, and (v) average inversion height. The data cover a sufficient time period to constrain long-term trends and support atmospheric dispersion modeling. The applicant has provided acceptable on-site meteorological data, if necessary, including (i) descriptions of instruments, (ii) locations and heights of instruments, and (iii) joint frequency distributions. The joint-frequency data presented are for a minimum of 1 year, with a joint data recovery of 90 percent or more. Additional data on (i) annual average mixing layer heights, (ii) a description of the regional climate, and (iii) total precipitation and evaporation by month have been provided. The applicant has noted any effect of nearby water bodies or terrain on meteorologic measurements. The applicant has acceptably demonstrated that meteorologic data used for assessing environmental impacts are representative of long-term meteorologic conditions at the site. The applicant report on the existing air quality at the site and nearby is acceptable.

Based on the information provided in the application, and the detailed review conducted of the characterization of meteorology at the ______________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the spread of airborne contamination at the site and development of conceptual and numerical models, and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis. The characterization also meets the requirements of 10 CFR Part 40, Appendix A, Criterion 7, which requires pre-operational and operational monitoring programs.

2.5.5 References

NRC. Regulatory Guide 3.63, “Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting.” Washington, DC: NRC, Office of Standards Development. 1988.

———. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

2.6 Geology and Seismology

2.6.1 Areas of Review

The reviewer should examine information on the geologic aspects of the site acquired through standard geologic analyses, including a survey of pertinent literature and field investigations. This information should include regional seismicity and seismic history, local stratigraphy, petrology or lithology of rock units, tectonic features (faulting, folding, fracturing), and the continuity of the geologic strata at the site and in nearby regions.

Geologic, structural, and stratigraphic maps and cross sections, including representative core and geophysical well-log data of the site and its environs, should be reviewed. An isopach map of the intended zone of injection or production and associated confining beds should be evaluated. All conclusions regarding the lateral continuity and vertical thickness of the mineralized zone(s), surrounding lithologic units, and confining zones, as based on lithologic logs from core and drill cuttings, geophysical data, remote-sensing measurements, and the results of other appropriate investigations should be reviewed. Some of the applicant’s supporting information for this review area might be included in the documents submitted to satisfy the hydrology review area (Section 2.7).

The staff should review the information presented on any economically important minerals and energy-related deposits in addition to the uranium mineralization, including the likely consequences of any production of such related deposits on the *in situ* leach facility.

Data on the geochemistry of the ore zone and the geologic zones immediately surrounding the mineralized zone that will or could be affected by injected lixiviant should be evaluated. Information on unique minerals (including those that might be affected by fluid movement associated with the proposed project, such as bentonite) or paleontologic deposits of particular scientific interest, should also be reviewed. The staff should examine descriptions of any effects that planned operations at the site might have on the future availability of other mineral resources.

2.6.2 Review Procedures

The staff should review the application to determine whether a thorough evaluation of the geologic setting for the proposed *in situ* leach activity has been presented along with the basic data supporting all conclusions. In addition to a description of the basic geology, both at the surface and at the depths of interest, the establishment of the continuity of the geologic strata at the site should be reviewed for applicability, correctness, inclusivity, and likely ability of the strata to isolate *in situ* leach fluids. The reviewer should particularly focus attention on fractures or faults, permeable stratigraphic units, and lateral facies changes that might preclude the applicant-identified geologic barriers to fluid migration from performing adequately.

The reviewer should determine that the application contains accurate geologic maps, isopach maps of the mineralized strata and of the confining layers, geologic cross sections at places critical to a thorough understanding of the selected site, descriptions of representative supporting core samples, geophysical and lithologic logs, and other data required for a thorough understanding of the pertinent geology. The reviewer should determine that regional stratigraphic and geologic information is discussed in sufficient detail to give clear perspective and orientation to the site-specific material presented. The discussion of regional geology and stratigraphy should be assessed to determine if it is adequately referenced and is illustrated by regional surface and subsurface geologic maps, stratigraphic columns, and cross sections. Seismic information should be evaluated to assess its suitability for evaluating seismic hazard for the proposed facility.

The staff may also perform an independent analysis of the data provided to assess whether reasonable and conservative alternative interpretations are indicated.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.6.3 Acceptance Criteria

The characterizations of the site geology and seismology are acceptable if they meet the following criteria:

(1) The application includes a description of the local and regional stratigraphy based on techniques such as

  (a) Surface sampling and descriptions

  (b) Cuttings and core logging reports

  (c) Wireline geophysical logs, such as electrical resistivity, neutron density, and gamma logs

  (d) Geologic interpretations of surface geology and balanced cross sections

These interpretations may be based either on original work submitted by the applicant, or on an appropriate evaluation of previous work in the region performed by state or federal agencies (e.g., U.S. Geological Survey, U.S. Bureau of Land Reclamation, U.S. Bureau of Mines), universities, mining companies, or oil and gas exploration companies. The interpretations should be accompanied by

(i) Maps such as geologic, topographic, and isopach maps that show surface and subsurface geology and locations for all wells used in defining the stratigraphy

(ii) Cross-sections through the ore deposit roughly perpendicular and parallel to the principal ore trend

(iii) Fence diagrams showing stratigraphic correlations among wells

(2) All maps and cross-sections are at sufficient scale and resolution to show clearly the intended geologic information. Maps show the locations of all site explorations such as borings, trenches, seismic lines, piezometer readings, and geologic cross sections.

(3) In the local stratigraphic section, all mineralized horizons, confining units, and other important units such as drinking water aquifers and deep well injection zones are clearly shown, with their depths from the surface clearly indicated. Isopach maps are prepared showing the variations in thickness of the mineralized zones and the confining units over the proposed mining area.

(4) A geologic and geochemical description of the mineralized zone and the geologic units immediately surrounding the mineralized zone is provided.

(5) An inventory of economically significant mineral and energy-related deposits, in addition to the uranium mineralization, is provided. Locations of all known wells, surface and underground mine workings, and surface impoundments that may have an effect on the proposed operations are provided.

These items should be located on a map of sufficient scale and clarity to identify their relationship to the proposed facility. For existing wells, the depth should be shown, if possible. To allow evaluation of connections between the mineralized zone and underground sources of drinking water, plugging and abandonment records provided from state, federal, and local sources, as appropriate, should be provided. The applicant should provide evidence that action has been undertaken to properly plug and abandon all wells that cannot be documented in this manner.

(6) A description of the local and regional geologic structure, including folds and faults, is provided.

Folds and faults can be shown on the geologic maps used to describe the stratigraphy. Major and minor faults traversing the proposed site should be evaluated for the likely consequences of any future effects of faulting on the uranium production activities and on the ability of the strata to contain lixiviant should fault motion occur. Geologic structures that are preferential pathways or barriers to fluid flow must be described and the basis for likely effects on flow given.

(7) A discussion of the seismicity and the seismic history of the region is included.

Historical seismicity data should be summarized on a regional earthquake epicenter map, including magnitude, location, and date of all known seismic events. Where possible, seismic events should be associated with the tectonic features described in the geologic structures.

(8) A generalized stratigraphic column, including the thicknesses of rock units, representation of lithologies, and definition of the mineralized horizon, is presented.

(9) The sources of all geological and seismological data are documented in U.S. Geological Survey open files or other published documents. If data have been generated by the applicant, the documentation should include a description of the investigations and data reduction techniques.

(10) Maps have designation of scale, orientation (e.g., North arrow), and geographic coordinates.

(11) Short-term seismic stability has been demonstrated for the *in situ* leach facility in accordance with Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills,” Section 2.6 (NRC, 1977).

(12) A general description of the site soils and their properties has been provided to support an evaluation of the environmental effects of construction and operation on erosion.

(13) A detailed description of soils and their properties has been provided for any areas where land application of water is anticipated to support an assessment of the impacts.

2.6.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the characterization of the geology and seismology, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with geology and seismology at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.6.2 and acceptance criteria outlined in standard review plan Section 2.6.3.

The licensee has acceptably described the geology and seismology by providing (i) a description of the local and regional stratigraphy; (ii) geologic, topographic, and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and site explorations used in defining stratigraphy; (iii) a geologic and geochemical description of the mineralized zone and the geologic units adjacent to the mineralized zone; (iv) an inventory of nearby economically significant minerals and energy-related deposits; (v) a description of the local and regional geologic structure; (vi) a discussion of the seismicity and seismic history of the region; (vii) a generalized stratigraphic column that includes thickness of rock units, representation of lithologies, and definition of mineralized horizon; and (viii) a description and map of the soils.

Based on the information provided in the application, and the detailed review conducted of the characterization of the geology and seismology at the ______________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the geologic and seismologic characteristics of the site, supports associated conceptual and numerical models, and is in compliance with 10 CFR 40.31(f), which requires inclusion of an environmental report in the application, and 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis. The characterization is sufficient to meet the requirements of 10 CFR Part 40, Appendix A, Criteria 4(e), which requires locations away from faults capable of causing impoundment failure and 5G(2), which requires adequate descriptions of the characteristics of the underlying soils and geologic formations.

2.6.5 Reference

NRC. Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1977.

2.7 Hydrology

2.7.1 Areas of Review

Characterization of the hydrology at *in situ* leach uranium extraction facilities must be sufficient to establish potential effects of *in situ* leach operations on the adjacent surface-water and ground-water resources and the potential effects of surface-water flooding on the *in situ* leach facility. The areas of review include:

(1) Descriptions of surface-water features in the site area including type, size, pertinent hydrological or morphological characteristics, and proximity to *in situ* leach processing plants, well fields, evaporation ponds, or other facilities that might be negatively affected by surface erosion or flooding.

(2) Assessment of the potential for erosion or flooding that may require special design features or mitigation measures to be implemented.

(3) A description of site hydrogeology, including (i) identification of aquifer and aquitard formations that may affect or be affected by the *in situ* leach operations; (ii) a description of aquifer properties, including material type, formation thickness, effective porosity,

hydraulic conductivity, and hydraulic gradient; (iii) estimated thickness and lateral extent of aquitards, and other information relative to the control and prevention of excursions; and (iv) data to support conclusions concerning the local ground-water flow system, based on well borings, core samples, water-level measurements, pumping tests, laboratory tests, soil surveys, and other methods

(4) Assessment of available ground-water resources and ground-water quality within the proposed permit boundaries and adjacent properties, including quantitative description of the chemical and radiological characteristics of the ground water and potential changes in water quality caused by operations

(5) An assessment of typical seasonal ranges and averages and the historical extremes for levels of surface-water bodies and aquifers

(6) Information on past, current, and anticipated future water use, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals

In conducting these evaluations, the reviewer shall consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. Ground-water compliance and protection reviews are the primary technical areas impacted by overlapping authorities. The desired outcome is to identify any areas where duplicative NRC reviews may be reduced or eliminated. The NRC staff must make the necessary evaluations of compliance with applicable regulations for licensing the facility. However, the reviewer may, as appropriate, rely on the applicant's responses to inquiries made by a state or another federal agency to support the NRC evaluation of compliance. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

2.7.2 Review Procedures

At a minimum, the reviewer should evaluate whether the applicant has developed an acceptable conceptual model of the site hydrology and whether the conceptual model is adequately supported by the data presented in the site characterization. To this end, the reviewer should:

(1) Review surface-water data, including maps that identify nearby lakes, rivers, surface drainage areas, or other surface-water bodies; stream flow data; and the applicant's assessment of the likely consequences of surface-water contamination from *in situ* leach operations. Verify that the applicant has generally characterized perennial surface-water bodies, such that an assessment of impacts from operations can be made.

(2) Evaluate the applicant's assessment of the potential for erosion or flooding. If surface water or erosion modeling is used by the applicant, verify that acceptable models and input parameters have been used in the flood analyses and that the resulting flood forces have been acceptably accommodated in the design of surface impoundments.

Regardless of whether modeling is used, ensure that the evaluation of flooding and erosion potential is consistent with available geomorphological, and topographic data or analysis of paleodischarge information.

(3) Evaluate the site hydrogeologic conceptual model for ground-water flow in potentially affected aquifers. Review available data from well logs and hydrologic tests and measurements to obtain confidence that sufficient data have been collected and that the data support the applicant's hydrologic conceptual model for ground-water flow within and around the permit boundary. The applicant's interpretation of ground-water hydraulic gradients (used to infer flow direction), horizontal hydraulic conductivity, and the thickness, areal extent, and vertical hydraulic conductivity of confining formations should be evaluated. Examine pumping tests, analyses, and/or other measurement techniques used to determine the hydrologic properties of the local aquifers and aquitards that affect or may be affected by the proposed *in situ* leach activities. Also examine pumping tests that are used to investigate vertical confinement or hydraulic isolation between the ore production zone and upper and lower aquifers.

(4) Evaluate the applicant's assessment of water quality of potentially affected ground-water resources. This information will provide the basis for evaluating potential effects of *in situ* leach extraction on the quality of local ground-water resources. Verify that a sufficient number of baseline ground-water samples are collected to provide meaningful statistics, that samples are spaced in time sufficiently to capture temporal variations, and that the chemical constituents and water quality parameters evaluated are sufficient to establish pre-operational water quality, including classes of use.

(5) Review the applicant's assessment of seasonal and, if data are available, the historical variability for levels of surface-water bodies and water levels or potentiometric heads in aquifers and ensure that sufficient time intervals have elapsed between measurements to allow assessment of seasonal variability.

(6) Verify that the applicant has provided information on past, current, and anticipated future water uses, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals.

In conducting an evaluation of ground-water activities, the reviewer should follow the reviews conducted by the state. Where appropriate, the evaluation should not duplicate state regulatory efforts. Although NRC must make its own independent findings, reviewers need not duplicate questions if a state or other federal regulatory agency has already addressed the issue. If the applicant response to questions from a state or other federal agency is submitted to NRC so that it becomes part of the license application to NRC, then the reviewer can use the information to prepare the technical evaluation report on ground-water issues.

2.7.3 Acceptance Criteria

The hydrologic characterization should establish a hydrologic conceptual model for the *in situ* leach site and surrounding region. The conceptual model provides a framework for the applicant to make decisions on the optimal methods for extracting uranium from the mineralized zones, and to minimize environmental and safety concerns caused by *in situ* leach operations. Hydrologic characterizations that accomplish this objective are considered acceptable.

The characterization of the site hydrology is acceptable if it meets the following criteria:

(1) The applicant has characterized surface-water bodies and drainages within the licensed area and affected surroundings. Maps provided in the application identify the location, size, shape, hydrologic characteristics, and uses of surface-water bodies near the proposed site, including likely surface drainage areas near the proposed facilities. An acceptable application should also identify the zones of interchange between surface-water and ground-water.

(2) The applicant has provided an assessment of the potential for flooding and erosion that could affect the *in situ* leach processing facilities or surface impoundments. The staff recognizes that the flooding and erosion protection design of impoundments for *in situ* facilities may be relatively simple. This is true when impoundments are located near or on a drainage divide and little or no diversion of runoff is necessary to protect the impoundment side slopes from erosion. In such cases, it will be easy to demonstrate that no erosion to the slopes will occur. In flood-prone areas, however, it may be necessary to conduct surface-water and erosion modeling. Information regarding acceptable models may be found in NUREG–1623 (NRC, 1999). The reviewer should recognize, however, that the staff guidance (NRC, 1999) was prepared for use in evaluating a 1,000-year design life for large tailings impoundments, whereas the design life of the surface impoundments at *in situ* leach facilities is on the order of tens of years.

(3) The applicant has described the local and regional hydraulic gradient and hydrostratigraphy. The applicant has shown that subsurface water level measurements were collected by acceptable methods, such as American Society for Testing and Materials D4750 (American Society for Testing and Materials, 2001). Potentiometric maps are the recommended means for presenting hydraulic gradient data. These maps should include two levels of detail: regional and local. The regional map should represent the mineralized zone aquifer and should encompass the likely consequences on any affected highly populated areas. The local (site-scale) map should encompass the entire licensed area. If overlying and underlying aquifers exist, local-scale potentiometric or water surface elevation maps of these aquifers should also be included. These maps should clearly show the locations, depths, and screened intervals of the wells used to determine the potentiometric surface elevations. Alternatively, this information can be provided in separate maps and/or tables. The appropriate contour interval will vary from site to site; however, contour intervals should be sufficient to clearly show the ground-water flow direction in the ore zone and in the overlying and underlying aquifers. The number of piezometer elevation measurements used to construct each map should be sufficient to determine the direction of ground-water flow in the mineralized zone(s) and the overlying aquifer. To construct a regional potentiometric map, a reasonable effort should be made to consider as many existing wells as possible.

Hydrogeologic cross-sections are recommended for illustrating the interpreted hydrostratigraphy. These cross-sections should be constructed for the area within the license boundary. For very large or irregularly shaped well field areas, more than one cross section may be necessary. Cross sections must be based on borehole data collected during well installation or exploratory drilling. All significant borehole data should be included in an appendix. Staff should verify that, an adequate number of boreholes is used to support the assertion of hydrogeologic unit continuity, if shown as such in the cross sections.

The applicant should describe all hydraulic parameters used to determine expected operational and restoration performance. Aquifer and aquitard hydraulic properties may be determined using aquifer pumping tests for parameters such as hydraulic conductivity, transmissivity, and specific storage. Any of a number of commonly used aquifer pumping tests may be used including single-well drawdown and recovery tests, drawdown versus time in a single observation well, and drawdown versus distance pumping tests using multiple observation wells. The methods or standards used to analyze pumping test data should be described and referenced: acceptable methods of analysis include use of curve fitting techniques for drawdown or recovery curves that are referenced to peer-reviewed journal publications, texts, or American Society for Testing and Materials Standards. It is important for the reviewer to ensure that where fitted curves deviate from measured drawdown, the applicant explains the probable cause of the deviation (e.g., leaky aquitards, delayed yield effects, boundary effects, etc.). For estimates of porosity, it is acceptable to use laboratory analysis of core samples, borehole geophysical methods, and analysis of the barometric efficiency of the aquifer (e.g., Lohman, 1979). The applicant should distinguish between total porosity estimated from borehole geophysical methods and effective porosity that determines transport of chemical constituents.

(4) Reasonably comprehensive chemical and radiochemical analyses of water samples, obtained within and at locations away from the mineralized zone(s), have been made to determine pre-operational baseline conditions. Baseline water quality should be determined for the mineralized and surrounding aquifers. These data should include water quality parameters that are expected to increase in concentration as a result of *in situ* leach activities and that are of concern to the water use of the aquifer (i.e., drinking water, etc.). The applicant should show that water samples were collected by acceptable sampling procedures, such as American Society for Testing and Materials D4448 (American Society for Testing and Materials, 1992).

For example, *in situ* leach operations are not expected to mobilize aluminum, and unless an ammonia-based lixiviant is used, ammonia concentrations in the ground water should not increase as a result of *in situ* leach operations. Therefore, little is gained by sampling these parameters. Studies have shown that thorium-230 is mobilized by bicarbonate-laden leaching solutions. However, studies have also shown that after restoration, thorium in the ground water will not remain in solution because the chemistry of thorium causes it to precipitate and chemically react with the rock matrix (Hem, 1970). As a result of its low solubility in natural waters, thorium is found in only trace concentrations. Additionally, chemical tests for thorium are expensive, and are not commonly included in water analyses at *in situ* leach facilities.

The applicant should identify the list of constituents to be sampled for baseline concentrations. The list of constituents in Table 2.7.3-1 is accepted by the NRC for *in situ* leach facilities. Alternatively, applicants may propose a list of constituents that is tailored to a particular location. In such cases, sufficient technical bases must be provided for the selected constituent list.

Table 2.7.3-1. Typical Baseline Water Quality Indicators to be Determined During Pre-operational Data Collection

A. Trace and Minor Elements		
Arsenic	Iron	Selenium
Barium	Lead	Silver
Boron	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
Copper	Nickel	
Fluoride	Radium-226 and 228	
B. Common Constituents		
Alkalinity	Chloride	Sodium
Bicarbonate	Magnesium	Sulfate
Calcium	Nitrate	
Carbonate	Potassium	
C. Physical Indicators		
Specific Conductivity*		Total Dissolved Solids#
pH*		
D. Radiological Parameters		
Gross Alpha†	Gross Beta	

*Field and Laboratory determination.
#Laboratory only.
†Excluding radon, radium, and uranium.

At least four sets of samples, spaced sufficiently in time to indicate seasonal variability, should be collected and analyzed for each listed constituent for determining baseline water quality conditions. Some samples should be split and sent to different laboratories as part of a quality assurance program. Sets of samples should be taken with a minimum of a week or two between sampling to provide an indication of how the water quality of the aquifers changes with time. The applicant should document any variability in the ground-water flow rates or recharge that are observed in the collected data. Additional sampling to establish the natural cyclical fluctuations of the water quality is necessary if natural ground-water flow rates and recharge conditions vary considerably. Where perennial surface-water sources are present, surface-water quality measurements should be taken on a seasonal basis for a minimum of 1 year before implementation of *in situ* leach operations. Surface-water samples can be obtained by grab sampling and should be taken at the same location each time. The average water quality for each aquifer zone and the range of each indicator in the zone have been tabulated and evaluated. If zones of distinct water quality characteristics are identified, they are delineated and referenced on a topographic map. For example, since uranium rollfront deposits are formed at the interface between chemically oxidizing and reducing environments, water quality characteristics may differ significantly across the rollfront.

(5) The applicant has provided an assessment of seasonal and the historical variability for potentiometric heads and hydraulic gradients in aquifers and water levels of surface-water bodies. This assessment should include water levels or water potentials measurements over at least 1 year and collected periodically to represent any seasonal variability.

(6) The applicant has provided information on past, current, and anticipated future water use, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals. This information must be sufficient to evaluate potential risks to ground-water or surface-water users in the vicinity of the *in situ* leach facility.

For license renewals and amendment applications, most or all of the preceding acceptance criteria may previously have been met. Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.7.4 Evaluation Findings

If the staff's review as described in this section results in the acceptance of the site hydrology, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the hydrologic site characterization information for the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.7.2 and acceptance criteria outlined in standard review plan Section 2.7.3.

The licensee has acceptably described the hydrology by providing (i) estimates of the local and regional hydraulic gradients, using potentiometric surface maps with acceptable contour intervals, including the mineralized aquifer and other overlying or underlying aquifers, and the likely consequences to affected populated areas; (ii) hydrologic cross-sections, based on an appropriate number of boreholes; (iii) acceptable comprehensive chemical and radiochemical analyses of water samples from in and near the mineralized zone(s) that define the pre-operational baseline water quality conditions; (iv) all hydraulic parameters used to determine expected operational and restoration performance; and (v) characterization of surface water in the *in situ* leach facility and nearby areas, including presentation of such information on maps. Zones of interchange between surface-and ground-water have been identified. The applicant has provided acceptable erosion protection against the effects of flooding from nearby streams and for drainage and diversion channels, such that the suggested criteria in NUREG–1620 (NRC, 2002) have been followed and that the design meets the requirements of 10 CFR Part 40, Appendix A.

Based on the information provided in the application, and the detailed review conducted of the characterization of the hydrology at the ________________________________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the site and associated conceptual and numerical models and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.7.5 References

American Society for Testing and Materials. “Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).” Test Method D4750-87. West Conshohcken, Pennsylvania: American Society for Testing and Materials. 2001.

———. “Standard Guide for Sampling Groundwater Monitoring Wells.” Guide D4448-85a. West Conshohcken, Pennsylvania: American Society for Testing and Materials. 1992.

Crippen, J.R. and C.D. Bue. “Maximum Floodflows in the Conterminous United States.” USGS Water Supply Paper No. 1887. Denver, Colorado: U.S. Geological Survey. 1977.

Hem, J.D. “Study and Interpretation of the Chemical Characteristics of Natural Water.” USGS Water Supply Paper 1473. Denver, Colorado: U.S. Geological Survey. 1970.

Lohman, S.W. “Groundwater Hydraulics.” USGS Professional Paper 708. Reston, Virginia: U.S. Geological Survey. 1979.

NRC. NUREG–1620, “Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act.” Rev. 1. Washington, DC: NRC. 2002.

U.S. Army Corps of Engineers. “Flood Hydrograph Package.” HEC–1. Washington, DC: U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1997a.

———. “Water Surface Profiles.” HEC–2. Davis, California: Hydrologic Engineering Center. 1997b.

———. “Wave Runup and Wind Setup on Reservoir Embankments.” ETL 1110-2-221. 1966.

U.S. Bureau of Reclamation. “Comparison of Estimated Maximum Flood Peaks with Historic Floods.” Washington, DC: U.S. Department of the Interior. 1986.

2.8 Ecology

2.8.1 Areas of Review

The staff should review descriptions of the flora and fauna in the vicinity of the licensed area, their habitats, and their distribution. The review should include identification of important species that are (i) threatened or endangered, (ii) commercially or recreationally valuable, (iii) affecting the well-being of some important species within Criterion (i) or (ii), or (iv) critical to the structure and function of the ecological system or a biological indicator of radionuclides or chemical pollutants in the environment.

The review should include the inventory of the majority of the terrestrial and aquatic organisms on or near the site and their relative (qualitative) abundance, the quantitative abundance of the important species, and species that migrate through the area or use it for breeding grounds. The staff should review discussions of the relative importance of the proposed site environs to the total regional area for the living resources (potential or exploited).

For operations involving drying of yellowcake, disposal of waste or generation of hazardous effluents, the staff should examine data on the count and distribution of important domestic fauna, in particular cattle, sheep, and other meat animals that may be involved in the exposure of man to radionuclides. Important game animals should receive similar treatment. A map showing the distribution of the principal plant communities should be reviewed.

The staff should also review the discussion of species-environment relationships, including descriptions of area usage (e.g., habitat, breeding) for important species, life histories of important regional animals and aquatic organisms, normal seasonal population fluctuations and habitat requirements, and identification of food chains and other interspecies relationships, particularly when these contribute to prediction or evaluation of the impact of the facility on the regional biota. The staff should examine any information presented on definable pre-existing environmental stresses from sources such as pollutants, as well as pertinent ecological conditions suggestive of such stresses and the status of ecological succession. As appropriate, the staff should review a list of pertinent published material dealing with the ecology of the region and ecological or biological studies of the site or its environs currently in progress or planned.

2.8.2 Review Procedures

The reviewer should consult with the U.S. Fish and Wildlife Service using procedures in 50 CFR Part 402, "Interagency Cooperation—Endangered Species Act of 1973," as amended. The staff should review the descriptions and inventories of the flora and fauna in the vicinity of the site, including habitats and distribution. The review should include terrestrial and aquatic organisms on or near the site, and their relative (qualitative) abundance should be established. Particular attention should be given to species based on their relative importance to the community. The reviewer should determine that all important species have been identified. Important species should be a part of the larger inventory of species. If important species are determined to be present, the staff should evaluate any likely detrimental effects on the organism by the proposed facility and its operations.

The reviewer should determine that information on the various species is presented in two separate subsections: terrestrial ecology and aquatic ecology. The reviewer should also determine that the discussion of the species-environment relationships includes descriptions of area usage (e.g., habitat, breeding) for important species and discussions of life histories of important regional animals and aquatic organisms, including normal seasonal population fluctuations and their habitat requirements. Food chains and other interspecies relationships should be examined, particularly when these may bear on predictions or evaluations of the impact of the proposed facility on the stability of regional biota. The reviewer should also examine documentation provided for any pre-existing environmental stresses from sources such as pollutants, as well as pertinent ecological indicators suggestive of such stresses. A discussion of the status of ecological succession should be evaluated.

For any operation involving the drying of yellowcake, disposal of waste, or generation of hazardous effluents, the staff should review data on the number and distribution of locally significant domestic flora and fauna, in particular cattle, sheep, commercial fish, and other meat animals, and commercial crops that may be part of the food chain delivering radiation exposure to man. Important game animals should be treated similarly. A map showing the distribution and estimates of numbers of commercially significant species should be examined. Specific review guidance is provided in NUREG–1748 (NRC, 2001).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.8.3 Acceptance Criteria

The characterization of the site ecology is acceptable if it meets the following criteria:

(1) Inventories of terrestrial and aquatic species are compiled by the applicant based on reports or databases of state or federal agencies (e.g, U.S. Fish and Wildlife Service, EPA).

Historical sitings of important species, as defined in the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982) should be included in the inventory. If such reports do not exist, inventories should be prepared by the applicant based on a radius within which impacts are reasonably expected to occur. Documentation should be provided that inventories were prepared in consultation with appropriate local, state, and federal agencies to confirm the presence or absence of important species (especially threatened or endangered species). Inventories may be based on historical data, but should be updated to within 2 years of the time of application to establish current baselines.

(2) Inventories of locally significant domestic flora and fauna, in particular cattle, sheep, commercial fish, and other meat-producing animals and commercial crops are based on recent production figures from local, state, and federal agencies (e.g., U.S. Department of Agriculture).

The statistics should cover at least 3 years and have been conducted within 2 years of the date of the application to establish reasonable baselines. Important game animals should be treated similarly. A map showing the distribution and estimates of numbers of commercially significant species should be provided and may be combined with land use maps discussed in Section 2.2 of the standard review plan.

(3) The applicant has identified any endangered species as listed in 50 CFR Part 17, “Endangered and Threatened Wildlife and Plants.”

Any discussion should include nonpermanent inhabitants migrating through the area or using it for breeding grounds. The preservation of habitat, particularly for important species, should be a prime consideration. A map of the principal floral and faunal communities has been provided. Additional information can be found in 50 CFR Parts 401–453.

(4) The application provides a thorough description of the species-environment relationships for each important species identified within a radius where impacts are reasonably expected to occur. If no important species are identified within this radius, the application should plainly state so, and no additional review is necessary.

The application should take these relationships into account in providing a discussion of any likely detrimental effects that operation of the site may have on the species through changes in habitat, pollution, and aspects of the operations that may place stress on the species-environment relationship. Finally, the application should provide information regarding steps that will be taken to minimize the effect of operating the facility on the species-environment relationship.

(5) All sources of ecological information are documented in open file reports or other published documents. If data have been generated by the applicant, the documentation should provide a description of the investigations and data reduction techniques.

A list of pertinent published material dealing with the ecology of the region should be included. Any ecological or biological study of the site or its environs either in progress or planned should be described and referenced.

2.8.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the description of the site ecology, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with ecology at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.8.2 and acceptance criteria outlined in standard review plan Section 2.8.3.

The licensee has described the ecology by providing acceptable (i) inventories of terrestrial and aquatic species, including threatened or endangered species listed in 50 CFR Part 17
(ii) inventories of locally significant domestic flora and fauna (e.g., cattle, sheep, goats),
(iii) discussions of important species found within a radius where impacts are reasonably expected to occur and estimations of their current and historical abundance, and
(iv) descriptions of the species-environment relationships for any important species.

Based on the information provided in the application and the detailed review conducted of the characterization of the ecology at the _______________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the site ecology and associated conceptual and numerical models and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.8.5 References

NRC. NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs.” Washington, DC: NRC. 2001.

———. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

2.9 Background Radiological Characteristics

2.9.1 Areas of Review

The reviewer should examine site-specific radiological data provided in the application including the results of measurements of radioactive materials occurring in important species, soil, air, and in surface and ground waters that could be affected by the proposed operations. The reviewer should examine the design of the pre-operational monitoring program, including which radionuclides are analyzed, sampling locations, sample type, sampling frequency, location and density of monitoring stations, and the detection limits.

2.9.2 Review Procedures

The reviewer should examine data from the pre-operational monitoring program with particular attention paid to the design of the monitoring program, the radionuclides monitored, the results, and the detection limits reported for each radionuclide in each sample medium. The reviewer should compare and contrast the pre-operational monitoring program as implemented against the guidance provided in Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC, 1980) and NUREG–5849 (draft), "Manual for Conducting Radiological Surveys in Support of License Termination" (Berger, 1992) or NUREG–1575, Revision 1, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.9.3 Acceptance Criteria

The characterization of the site background radiological characteristics is acceptable if it meets the following criteria:

(1) Monitoring programs to establish background radiological characteristics, including sampling frequency, sampling methods, and sampling location and density are established in accordance with pre-operational monitoring guidance provided in Regulatory Guide 4.14, Revision 1, Section 1.1 (NRC, 1980). Air monitoring stations are located in a manner consistent with the principal wind directions reviewed in Section 2.5 of the standard review plan.

(2) Soil sampling is conducted at both a 5-cm [2-inch] depth as described in Regulatory Guide 4.14, Section 1.1.4 (NRC, 1980) and 15 cm [6 in] for background decommissioning data.

2.9.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the description of the site background radiological characteristics, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the characterization information concerned with the background radiological characteristics at the ______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.9.2 and acceptance criteria outlined in standard review plan Section 2.9.3.

Table 2.9.3-1. Standard Format for Water Quality Data Submittal to the NRC for Uranium Recovery Facilities

1. Water quality sampling techniques and analysis should be in accordance with U.S. Environmental Protection Agency (EPA) (1974)
2. All water quality data submitted to NRC should
   a. Be submitted in tabular form with the appropriate standards (i.e., EPA national interim primary drinking water regulations, livestock standards, baseline or excursion levels, or 10 CFR Part 20, Maximum Permissible Concentrations)[1] listed in the same table, for ease of data comparison. Methods of sampling and preserving and the laboratory utilized should be indicated in the table. The sampled depths, formation(s) sampled, water-level elevations and data measured, and distances from the tailings pond [2] or well field for each monitor should be noted in the table.
   b. Be submitted graphically to illustrate water quality and water-level elevation changes with time with applicable governing standards, EPA national interim primary drinking water standards and livestock standards, baseline or excursion levels, or maximum permissible concentrations[3] (whatever is appropriate), for the particular constituent on the graph.
   c. Include a short summary of the data interpretation, noting any anomalies, with an explanation.
   d. Water quality data reports should include a map that shows all water quality sampling points.

Reference: EPA. "Manual for Chemical Analysis of Water and Wastes". EPA–625–/6–74–003a. Cincinnati, Ohio: EPA, Office of Research and Development Publications. 1974.
[1]10 CFR Part 20 liquid effluent control limits are specified in Table 2 of Appendix B and are not termed Maximum Permissible Concentrations. This table is a direct extraction from the EPA reference.
[2]Tailings ponds do not exist at *in situ* leach facilities. This table is a direct extraction from the EPA reference.
[3]10 CFR Part 20 liquid effluent control limits are specified in Table 2 of Appendix B and are not termed Maximum Permissible Concentrations. This table is a direct extraction from the EPA reference.

The licensee has acceptably established the background radiological characteristics by providing (i) monitoring programs to determine background radiologic characteristics that include radionuclides monitored, sampling frequency, and methods, location, and density; (ii) air quality stations located consistent with the prevailing wind directions; (iii) time periods for preoperational monitoring that allow for 12 consecutive months of sampling; and (iv) radiologic analyses of soil samples at 5-cm [2-in.] and 15-cm [6-in.] depths.

Based on the information provided in the application, and the detailed review conducted of the characterization of the background radiological characteristics at the ______________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the radiological background of the site and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.9.5 References

Berger, J.D. NUREG/CR–5849, “Manual for Conducting Radiological Surveys in Support of License Termination.” Washington, DC: NRC. 1992.

NRC. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1980.

———. “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).” Revision 1. Washington, DC: NRC. 2000.

EPA. “Manual for Chemical Analysis of Water and Wastes.” EPA–625–/6–74–003a. Cincinnati, Ohio: EPA, Office of Research and Development Publications. 1974.

2.10 Other Environmental Features

2.10.1 Areas of Review

This review should include environmental site characterization information that does not clearly fall into any of the other subsections in Section 2 of the standard review plan. These will typically be site-specific, and may be used by the applicant to mitigate unfavorable conditions, or to provide additional information in support of the description of the proposed facility. Information that the applicant believes is important to establish the value of the site and site environs to important segments of the population is appropriately included in this subsection.

2.10.2 Review Procedures

The staff should consider environmental information provided in this section as auxiliary information to support an application for a given facility. The information should be considered in a site-specific context and should be consistent with the information provided in other sections of the application. Depending on the site-specific situation, there may be no information in this section of the application.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.10.3 Acceptance Criteria

The characterization of other site environmental features is acceptable if it meets the following criteria:

(1) It is consistent with information provided in previous subsections.

(2) Information is provided in a manner consistent with good scientific practice, is supported by objective data to the extent possible, and is relevant to the site under consideration.

(3) Information supports a determination that the *in situ* leach facility can be operated in a manner that will protect public health and safety and the environment.

2.10.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the description of other environmental features at the site, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the characterization information for other environmental features at the ______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 2.11.2 and acceptance criteria outlined in standard review plan Section 2.11.3.

The licensee has acceptably described any other important environmental features by providing information that is (i) consistent with other aspects of the site description, (ii) supported by objective data, (iii) relevant to the site under consideration, and (iv) supportive of a determination that the *in situ* leach facility can be operated while protecting public health and safety.

Based on the information provided in the application, and the detailed review conducted of the characterization of the other environmental features at the ________________ *in situ* leach facility, the staff concludes that the information is acceptable to allow evaluation of the other environmental features, supports associated conceptual and numerical models, and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis; and 10 CFR Part 40, Appendix A, Criterion 6(7), which provides requirements for control of non-radiological hazards.

2.10.5 References

None.

3.0 DESCRIPTION OF PROPOSED FACILITY

3.1 *In Situ* Leaching Process and Equipment

3.1.1 Areas of Review

The staff should review the *in situ* leaching process as described in the application. This review should include, but not be limited to

(1) A description of the mineralized zone(s) and the feasibility of processing the defined well field areas

(2) Well construction techniques and integrity testing procedures to ensure well installations will not result in hydraulic communication between production zones and adjacent non-mineralized aquifers

(3) A process description including injection/production rates and pressures; plant material balances and flow rates; lixiviant makeup; recovery efficiency; and gaseous, liquid, and solid wastes and effluents that will be generated

(4) Proposed operating plans and schedules that include timetables and sequences for well field operation, surface reclamation, and ground-water restoration

(5) Review of techniques for ensuring that a proliferation of small waste disposal sites is avoided.

The review should also include maps showing the facilities layout, descriptions of the process and/or circuit, water and material balances, and the chemical recycling system.

3.1.2 Review Procedures

The staff should determine whether the description of the *in situ* leaching process provided in the application is sufficient to permit evaluation of the operations and processes involved in conformance with the acceptance criteria contained in Section 3.1.3. Staff should ensure the following are included in this section: a map or maps showing the proposed sequence and schedules for uranium extraction and ground-water quality restoration operations, a flow diagram of the process or circuit, a material balance diagram, a description of any chemical recycle systems, a water balance diagram for the entire system, and a map or maps showing the proposed sequence and schedules for land reclamation of the well field areas.

If wells are not properly completed, lixiviant can flow through casing breaks and into overlying aquifers. Casing breaks can occur if the well is damaged during well construction activities. Casing breaks can also occur if water injection pressures exceed the strength of the well materials. Well completion techniques should be reviewed in sufficient detail to give the reviewer a clear understanding of how recovery, injection, and monitor wells are drilled; how their location and spacing are selected; and what materials and methods are used in construction, casing installation, and abandonment. The reviewer should pay particular attention to the techniques employed to prevent hydraulic communication between overlying or underlying aquifers through well boreholes and ensure that secondary ground-water protection standards are not violated (10 CFR Part 40, Appendix A, Criteria 5B, 5C, and 13). Additionally, the applicant should describe methods for well abandonment. The reviewer should ensure that the well casing material used is appropriate for the depths to which the wells are drilled. The reviewer should examine a description of the procedures used to test well integrity. The wells should be retested with sufficient frequency to ensure the integrity of the well construction. The reviewer should examine in detail the justification provided by the licensee for the recommended time interval between successive well integrity tests. The reviewer may refer to a well handbook (e.g., Driscoll, 1989) to verify the appropriateness and expected performance of well installation, testing, and abandonment methods.

To ensure that hydraulic communication between overlying or underlying aquifers through well boreholes is promptly detectable, the reviewer should pay particular attention to the design and installation of vertical and horizontal excursion monitoring wells. Additional review procedures for excursion monitoring systems are provided in Section 5.7.8.2 of this standard review plan.

The reviewer should also pay particular attention to the methods used for effective detection of leaks in surface and near-surface pipes carrying the lixiviant solutions to individual wells within a well field or between the well fields and the processing facilities. Spills of pregnant lixiviant in particular can constitute a significant hazard to health and the environment if allowed to pond and dry on the ground surface, to run off into surface-water bodies, or to infiltrate and transport to ground-water.

The reviewer should determine that any lined impoundment to contain wastes is acceptably designed, constructed, and installed. Materials used to construct the liner should be reviewed to determine that they have acceptable chemical properties and sufficient strength for the design application. The reviewer should determine that the liner will not be overtopped. The reviewer should determine that a proper quality control program is in place. The review should be based on the concept that the site will be in compliance with 10 CFR Part 40, Appendix A, Criterion 2, which precludes long-term disposal of byproduct material onsite and ensures that the proliferation of small waste disposal sites is avoided. The reviewer shall examine the terms of the approved waste disposal agreement.

For surface impoundments containing 11e.(2) byproduct material, the reviewer should ensure that the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 5(A) have been met. If the waste water retention impoundments are located below grade, the reviewer should determine that the surface impoundments have an acceptable liner and leak detection system in place to ensure protection of ground water. The location of a surface impoundment below grade will eliminate the likelihood of embankment failure that could result in any release of waste water. Should the applicant propose to construct a surface impoundment to handle waste water, the reviewer should determine that the design of associated dikes is such that they will not experience massive failure. The design of such dikes to resist erosion and protect against possible flooding events is evaluated in Section 2.7 of this standard review plan. In this section, the reviewer should evaluate the stability of any dikes with respect to seismic events.

In addition, the reviewer should evaluate any proposed surface impoundment to determine if it meets the definition of a dam as given in Regulatory Guide 3.11 (NRC, 1977). If this is the case, the surface impoundment should be included in the NRC Dam Safety Program, and be subject to Section 215, National Dam Safety Program of the Water Resources Development Act of 1996. If the reviewer finds that the impoundment meets the definition of a dam, an evaluation of the dam ranking (low or high hazard) should be made. If the dam is considered a high hazard, an Emergency Action Plan is needed consistent with Federal Emergency Management Agency requirements. For low-hazard dams, no Emergency Action Plan is required. For either ranking of dam, the reviewer should also determine that the licensee has an acceptable inspection program in place to ensure routine checks, and that performance is properly maintained (see Section 5.3 of this standard review plan).

In conducting these evaluations, the reviewer shall consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. Ground-water compliance and protection reviews are the primary technical areas impacted by overlapping authorities. The desired outcome is to identify any areas where duplicative NRC reviews may be reduced or eliminated. The NRC staff must make the necessary evaluations of compliance with applicable regulations for licensing the facility. However, the reviewer may, as appropriate, rely on the applicant’s responses to inquiries made by a state or another federal agency to support the NRC evaluation of compliance. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining historical aspects of facility operations and the approach that should be used in evaluating amendments and renewal applications.

3.1.3 Acceptance Criteria

The *in situ* leaching process and equipment are acceptable if they meet the following criteria:

(1) The description is sufficiently detailed to identify the mineralized zone(s), their areal distribution, and their approximate thickness.

If more than one mineralized zone is to be leached, each zone should be defined separately. The estimated U_3O_8 grade should be specified.

(2) Well design, testing, and inspection reflect accepted NRC practice for *in situ* leach operations.

(a) Well Design and Construction—Injection and recovery wells should be constructed from materials that are inert to lixiviants and are strong enough to withstand injection pressures. Polyvinyl Chloride, fiberglass, or acrylonitrile butadiene styrene plastic casings are generally used in wells less than 300-m [1,000-ft] deep. Wells deeper than 300-m [1,000-ft], or those subjected to high-pressure cementing techniques, are subject to collapse. With appropriate design and installation techniques, however, Polyvinyl Chloride can be used for wells greater than 300 m [1,000 ft]. In these instances, steel or fiberglass casing is generally necessary. In all wells (including monitor wells), the annular space between the side of the borehole and the casing should be backfilled with a sealant from the bottom of the casing to the surface in one continuous operation. Proper backfilling isolates the screened formation against vertical migration of water from the surface or from other formations, and also provides support for the casing. Cement or cement-bentonite grout is generally acceptable as a sealant.

Procedures in American Society for Testing and Materials D 5092 provide acceptable methods for design and construction of monitoring wells (American Society for Testing and Materials, 1995). Material normally used for monitor well casing is either metal or plastic. The possibility that chemical reactions may take place between the casing and the mineral constituents in the water affects the choice of casing material used for monitor wells. For example, iron oxide in steel-cased wells will adsorb trace and heavy metals dissolved in the ground water. Therefore, a baseline water sampling program should be used to determine concentrations of trace metals. The applicant should use casing that is inert to these metals, such as Polyvinyl Chloride or fiberglass. When any well is completed, it should be developed until production of essentially sediment-free water is assured for the life of the well. One acceptable development method is to use a swab in the well to create a vacuum on the upstroke and positive pressure on the downstroke. Air lifting is also an acceptable method for well development. Other state- or EPA-approved well development methods may also be used.

(b) Well Integrity Testing—Injection and recovery wells should be tested for mechanical integrity. The following are examples of well integrity testing procedures that have been considered acceptable in previous applications. To inspect for casing leaks after a well has been completed and opened to the aquifer, a packer is set above the well screen, and each well casing is filled with water. At the surface, the well is pressurized with either air or water to above the expected operating pressure. The well pressure is then monitored for a period of 30 minutes to 1 hour to ensure significant pressure drops do not occur through borehole leaks. Operating pressure varies with the depth of the well and should be less than formation fracture pressure. Well integrity tests should be performed on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, each well should be retested with sufficient frequency (once each 5 years or less) to ensure the integrity of the well construction if it is in use. Sole reliance on single-point resistance geophysical tools is not acceptable for determining the mechanical integrity at a well.

(3) The number, location, and screened intervals of excursion monitoring wells are described in sufficient detail, follow industry standard practice, and are adequate to ensure prompt detection of horizontal and vertical excursions, taking into account site specific parameters such as local geology and hydrology. Acceptance criteria for

methods and calculations used to determine the placement of horizontal and vertical excursion monitoring wells are presented in Section 5.7.8.3 of this standard review plan.

(4) Methods for timely detection and cleanup of leaks from surface and near-surface pipes within the well fields and between the well field and processing facilities are clearly described and included in the design.

(5) The description of the *in situ* leaching process includes the following information and demonstrations:

(a) Projected down-hole injection pressures with the hydrostatic pressure of the fluid column should be demonstrated to be maintained below casing (casing and cement) failure pressures and formation fracture pressures, to avoid hydrofracturing the aquifer and promoting leakage into the overlying units. Piping burst strength should be considered in deep well fields {greater than about 305 m [1,000 ft]}.

(b) Overall production rates should be higher than injection rates.

(c) Proposed plant material balances and flow rates should be acceptably described.

(d) Lixiviant makeup should be such that impact on the ground-water quality and the prospects for long-term ground-water restoration will be maintained at levels that ensure acceptable restoration goals can be achieved in a timely manner. Oxidants such as gaseous oxygen and hydrogen peroxide, and carbonates such as sodium bicarbonate or carbon dioxide gas have been demonstrated in a number of *in situ* leach facilities to be suitable lixiviants.

(e) The description should identify gaseous, liquid, and solid wastes and effluents that will be generated. Effluent monitoring and control measures are discussed in Section 4.0 of this standard review plan.

(f) An analysis of the effects that *in situ* leach operations are likely to have on surrounding water users has been provided. An acceptable impact analysis should be based on results of numerical or analytical modeling calculations that are used to estimate ground-water travel times from the proposed extraction areas to the nearby points of ground-water or surface-water usage, estimate the amount of process bleed necessary to prevent migration of lixiviant from the well field, and describe the applicant’s mitigative measures to recover lixiviant excursions. If the applicant chooses to use nominal parameter estimates, parameter uncertainties should be considered to ensure that the selected values represent expected conditions. An acceptable impact analysis should describe the following:

(i) The ability to control the migration of lixiviant from the production zones to the surrounding environs

(ii) Ground-water and surface-water pathways that might transport extraction solutions offsite in the event of an uncontrolled excursion, surface piping leak, or incomplete restoration

(iii) The impact of *in situ* leach operations on ground-water flow patterns and aquifer levels

(iv) The expected post-extraction impact on geochemical properties and water quality

(6) Proposed operating plans and schedules include timetables for well field operation, surface reclamation, and ground-water restoration. Water balance calculations should be provided that demonstrate that the liquid waste disposal facilities (surface impoundments, land application, deep well injection) are adequate to process the proposed production and restoration efforts at any time.

(7) The staff should verify the applicant analyses or perform independent review analyses of floods and flood velocities. If the design assumptions and calculations are reasonable, accurate, and compare favorably with independent staff estimates, the designs are acceptable.

(8) The staff should evaluate the design of diversion channels in several critical areas using the criteria and guidance presented in NUREG–1623 (NRC, 1998). For the main channel area, the staff should verify that appropriate models and input parameters have been used to design the erosion protection. The staff should assure that flow rates, flow depths, and shear stresses have been correctly computed. The diversion channels should be sized and protected to pass a probable maximum flood with minimal, if any, damage to the diversion channel. No release of contained materials should occur during a probable maximum flood. The staff should determine that the depth of burial of any disposed of material is sufficient to preclude bottom scouring, if an existing or constructed channel is located in or near a pit or impoundment. Where practical, the use of diversion channels at new facilities should be avoided to lessen costs of reclamation and future maintenance.

(9) The staff should review the plans, specifications, inspection programs, and quality assurance/quality control programs to assure that acceptable measures are being taken to construct the facility according to accepted engineering practices. The staff will compare the information provided with typical programs used in the construction industry.

(10) Results from research and development or other production operations are used to support the description of the *in situ* leaching process, where appropriate.

(11) The applicant has an approved waste disposal agreement for 11e.(2) byproduct material disposal at an NRC or NRC Agreement State licensed disposal facility. This agreement is maintained onsite. The applicant has committed to notify NRC in writing within 7 days if this agreement expires or is terminated and to submit a new agreement for NRC

approval within 90 days of the expiration or termination (failure to comply with this license condition will result in a prohibition from further lixivient injection).

3.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the *in situ* leaching process and equipment, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the *in situ* leaching process and equipment proposed for use at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 3.1.2 and the acceptance criteria in standard review plan Section 3.1.3.

The applicant has acceptably described the mineralized zone(s) demonstrated protection against vertical migration of water, proposed tests for well integrity, and demonstrated that the *in situ* leaching process will meet the following criteria: (i) down hole injection pressures are less than formation fracture pressures; (ii) overall production rates are higher than injection rates; (iii) plant material balances and flow rates are appropriate; (iv) lixiviant makeup is such that restoration goals can be achieved in a timely manner; (v) recovery efficiency is assessed through mass balance calculations; and (vi) reasonable estimates of gaseous, liquid, and solid wastes and effluents are provided (used in evaluation of effluent monitoring and control measures in standard review plan Section 4.0). The applicant has used the results from research and development or other production operations to support the evaluation of the *in situ* leaching process. The applicant has provided acceptable operating plans, schedules, and timetables for well field operation, surface reclamation, and ground-water restoration.

Based on the information provided in the application and the detailed review conducted of the *in situ* leaching process and equipment for the _______________ *in situ* leach facility, the staff concludes that the proposed *in situ* leaching process and equipment are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR Part 40, Appendix A, Criteria 2 for non-proliferation of small disposal sites; 5(A) for ground-water protection; 5B for secondary ground-water protection; 5C for maximum values for ground-water protection; and 13 for hazardous constituents. The related reviews of the 10 CFR Part 20 radiological aspects of the *in situ* leaching process and equipment in accordance with standard review plan Sections 4.0, "Effluent Control Systems;" 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

3.1.5 References

American Society for Testing and Materials. "Standard Practice for Design and Installaiton of Ground Water Monitoring Wells in Aquifers." Designation D5092-90. Philadelphia, Pennsylvania: American Society for Testing and Materials. 1995.

Driscoll, F.G. "Groundwater and Wells." St. Paul, Minnesota: Johnson Filtration Systems, Inc. 1989.

NRC. "Recommendation on Ways to Improve the Efficiency of NRC Regulation at *In Situ* Leach Uranium Recovery Facilities." SECY–99–0013. Washington, DC: NRC. 2000.

———. NUREG–1623, "Design of Erosion Protection for Long-Term Stabilization." Washington, DC: NRC. 1998.

———. Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Washington, DC: NRC, Office of Standards Development. 1977.

3.2 Recovery Plant, Satellite Processing Facilities, Well Fields, and Chemical Storage Facilities—Equipment Used and Materials Processed

3.2.1 Areas of Review

The staff should review the physical descriptions and reported operating characteristics for the major equipment items of the processing cycle. The staff should also review descriptions of the proposed process information and controls, as well as radiation sampling and monitoring equipment. Controls mean the apparatus or mechanisms that could affect the chemical, physical, metallurgical, or nuclear processes of the facility in such a manner as to influence radiation health and safety. The staff should review a diagram that indicates the plant layout and locations where dusts, fumes, or gases would be generated; locations of all ventilation, filtration, confinement, and dust collection systems; and radiation safety and radiation monitoring devices.

In addition, staff should review the list and specifications related to all radioactive and hazardous materials used in the recovery plant, satellite processing facilities, well fields, and chemical storage facilities. These should be reviewed for the hazards associated with the quantities, locations, operating flow rates, temperatures, and pressures associated with these materials.

While safety concerns with the use of all hazardous materials are important and need to be addressed, direct NRC regulatory authority is limited to situations where hazardous materials have a potential affect on radiological safety. Chemicals of concern typically used in the uranium *in situ* leach facilities are identified in NUREG/CR–6733 (NRC, 2001). Therefore, staff should review the list of applicable federal, state, and local regulations that the licensee intends to use, to ensure that all hazardous chemicals that have the potential to impact radiological safety, are safely handled. Staff should also review the safety features used in the facility process design for eliminating or mitigating the hazards presented by these materials.

3.2.2 Review Procedures

The staff should determine whether the physical descriptions and reported operating characteristics for the major equipment items of the processing cycle, the proposed controls, and safety/radiation instrumentation are sufficient to evaluate the performance of the proposed uranium *in situ* leach facility. Staff should ensure that the application identifies all areas where releases of radioactive and hazardous materials (such as radon gas and uranium dust) can occur and that locations of control equipment (e.g., ventilation and exhaust systems) and instrumentation are provided.

Staff should determine whether the hazards associated with the storage and processing of the radioactive materials and those hazardous materials with the potential to impact radiological safety, have been sufficiently addressed in the process design for the recovery plant, satellite processing facilities, well fields, and chemical storage facilities.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

3.2.3 Acceptance Criteria

The description of the equipment used and materials processed in the recovery plant, satellite processing facilities, well fields, and chemical storage facilities is acceptable if it meets the following criteria:

(1) The application provides diagrams showing the proposed (or existing) plant/facilities layout in adequate detail.

(2) Areas where dusts, fumes, or gases would be generated are clearly identified, along with a description of the source of the emissions.

(3) All ventilation, filtration, confinement, dust collection, and radiation monitoring equipment are described as to size, type, and location.

(4) Availability requirements for safety equipment are adequately stated, and measures for ensuring availability and reliability are clearly identified.

(5) Specifications, quantities, locations, and operating conditions such as flow rates, temperatures, and pressures of radioactive materials and those hazardous materials with the potential to impact radiological safety, are clearly identified together with the hazards associated with these materials.

(6) A list of applicable federal, state and local regulations that the licensee intends to use to ensure that process chemicals having the potential to impact radiological safety are safely handled, is provided.

(7) Controls used for eliminating or mitigating the hazards presented by the radioactive materials and those hazardous materials with the potential to impact radiological safety, are adequately described.

Further discussion on Criteria 4–7 may be found in NUREG/CR–6733 (NRC, 2001).

3.2.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the equipment used and materials processed in the *in situ* leach facility, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the equipment proposed for use and materials to be processed in the recovery plant, satellite processing facilities, well fields, and chemical storage facilities at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 3.2.2 and the acceptance criteria outlined in standard review plan Section 3.2.3.

Based on the information provided in the application and the detailed review conducted of the equipment to be used and materials to be processed in the recovery plant, satellite processing facilities, well fields and chemical storage facilities for the _______________ *in situ* leach facility, the staff concludes that the proposed equipment to be used and materials to be processed in the recovery plant, satellite processing facilities, well fields, and chemical storage facilities are acceptable and are in compliance with 10 CFR 40.32(c), which requires that applicant proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; and 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license. The related reviews of the 10 CFR Part 20 radiological aspects of the recovery plant equipment in accordance with standard review plan Sections 4.0, “Effluent Control Systems;” 5.0, “Operations;” and 7.0, “Environmental Effects” are addressed elsewhere in this technical evaluation report.

3.2.5 Reference

NRC. NUREG/CR–6733, “A Baseline Risk-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licensees.” Washington, DC: NRC. 2001.

3.3 Instrumentation and Control

3.3.1 Areas of Review

The staff should review descriptions of the proposed process instrumentation and controls and radiation safety sampling and monitoring instrumentation, including their minimum specifications and operating characteristics. This review should include well field process control equipment for monitoring injection pressures, injection rates, and production rates. It should also include safety related process monitoring and control equipment used in the recovery plant, satellite processing facilities, well fields, chemical storage facilities, and surface impoundments.

3.3.2 Review Procedures

The staff should review the descriptions of the proposed instrumentation and control systems provided in the application to determine whether they are sufficient to evaluate the interrelationship between the proposed instrumentation systems and the operations or processes to be controlled or monitored. The staff should also determine whether the proposed instrumentation systems are sufficient to control and monitor operations and processes identified in the description of the proposed facility. Particular attention should be focused on whether proposed monitoring and control instrumentation is adequate to quickly identify and remedy *in situ* leaching and processing problems that can increase exposures to radiological and chemical hazards. Areas of concern include monitoring and ventilation systems designed to detect and control elevated releases of yellowcake dust from drying and storage operations and radon gas buildup in buildings. Areas of concern also include instrumentation used to record, monitor and control key operating parameters of the yellowcake dryers and their associated stack emission scrubbing systems. Instrumentation to detect and control liquid releases from well field and processing pipe failures, surface impoundment leaks, and chemical tank valve failures should also be evaluated in the staff review.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

3.3.3 Acceptance Criteria

The facility instrumentation is acceptable if it meets the following criteria:

(1) Instrumentation has been described for the various components of the processing facility, including well fields, well field houses, trunk lines, the production circuit, surface impoundments, and deep injection disposal wells.

(2) Instrumentation is designed to allow the plant operator to continuously monitor and control a variety of systems and parameters, including total flow into the plant, total waste flow leaving the plant, tank levels, and the yellowcake dryer. Instrumentation includes alarms and interlocks in the event of a failure.

(3) Control components of the systems are equipped with backup systems that activate in the event of a failure of the operating system or a common cause failure such as power failure.

(4) Well field operating pressures are kept below casing and formation rupture pressures to prevent vertical excursions. Well field operation pressures are routinely monitored either at the well head or on the entire system, and are measured and recorded daily.

(5) Manufacturer’s recommendations for maintenance and operation of yellowcake dryers, and checking and logging requirements contained in 10 CFR Part 40, Appendix A. Criterion 8 are followed.

3.3.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the facility instrumentation and control systems, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the instrumentation and control proposed for use at the ______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 3.3.2 and the acceptance criteria outlined in standard review plan Section 3.3.3.

The instrumentation and control systems have been acceptably described for components including the well fields, well field houses, trunk lines, production circuit, surface impoundments, and deep injection disposal wells. The instrumentation allows for continuous monitoring and control of systems, including total inflow to the plant, total waste flow exiting the plant, tank levels, and the yellowcake dryer. Appropriate alarms and interlocks are part of the instrumentation systems. Each control system is equipped with an acceptable backup system that automatically activates in the event of a failure of the operating system or a common cause failure such as a power failure.

Based on the information provided in the application and the detailed review conducted of the instrumentation and control for the ________________ *in situ* leach facility, the staff concludes that the proposed instrumentation is acceptable and is in compliance with 10 CFR 40.32(c), which requires applicant proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; and 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license. The related reviews of the 10 CFR Part 20 radiological aspects of the solution mining process and equipment, in accordance with standard review plan Sections 4.0, “Effluent Control Systems;” 5.0, “Operations;” and 7.0, “Environmental Effects” are addressed elsewhere in this technical evaluation report.

3.3.5 References

None.

4.0 EFFLUENT CONTROL SYSTEMS

4.1 Gaseous And Airborne Particulates

4.1.1 Areas of Review

The staff should review the proposed ventilation, filtration, and confinement systems that are to be used to control the release of radioactive materials to the atmosphere. The staff should also review analyses of equipment as designed and operated to prevent radiation exposures and to limit exposures and releases to as low as is reasonably achievable. A review should also be conducted of a physical description of discharge stacks, types and estimated composition and flow rates of atmospheric effluents, and proposed methods for controlling such releases.

4.1.2 Review Procedures

The staff should review facilities, designs, and operational modes to determine whether the proposed ventilation, filtration, and confinement systems and equipment described in the application are sufficient to control the release of radioactive materials to the atmosphere to meet acceptance criteria identified in Section 4.1.3.

4.1.3 Acceptance Criteria

The gaseous and airborne particulate effluent control systems are acceptable if they meet the following criteria:

(1) Monitoring and control systems for the facility are located to optimize their intended function. Monitors used to assess worker exposures are placed in locations of maximum anticipated concentration based upon determination of airflow patterns.

(2) Monitoring and control systems for the facility are appropriate for the types of effluents generated. The intended purposes of measurement devices are clearly stated and criteria for monitoring are provided. The acceptance criteria from Section 5.7.7.3 of this standard review plan should be met.

(3) The application provides a demonstration that adequate ventilation systems are planned for process buildings to avoid radon gas buildup. Ventilation systems should be consistent with the requirements of Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be as Low as Is Reasonably Achievable,” Section 3.3 (NRC, 2002).

    The review emphasis should be on radon gas mobilization from (i) recovery solutions entering the plant, (ii) the extraction process (where tanks are vented), and (iii) uranium particulate emissions resulting from drying and packaging operations and spills. For facilities using an open air design for processing (i.e., processing equipment is not enclosed by a building), ventilation will be less of a safety concern. Aspects of design that can significantly limit airborne releases include closed production systems (i.e., no venting) and the use of vacuum dryers that eliminate airborne uranium particulate releases from drying operations.

Effluent Control Systems

(4) The application demonstrates that the effluent control systems will limit exposures under both normal and accident conditions. The application also provides information on the health and safety impacts of system failures and identifies contingencies for such occurrences.

(5) The application demonstrates that the operations will be conducted so that all airborne effluent releases are as low as is reasonably achievable.

4.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the effluent control systems for gaseous and airborne particulates, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the effluent control systems for gaseous and airborne particulates proposed for use at the _______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 4.1.2 and the acceptance criteria outlined in standard review plan Section 4.1.3.

The applicant has acceptably described the discharge stacks and the types, estimated composition, and flow rates of effluents released to the atmosphere. The applicant has designated monitoring and control systems (e.g., ventilation, filtration, and confinement) for the types of effluents generated. Also, the applicant has specified acceptable monitoring criteria and has located the facility monitoring and control systems for the required functions to optimally assess worker exposure in locations of likely maximum concentrations determined by the applicant’s analysis of airflow patterns. The applicant has demonstrated that ventilation systems are acceptable to prevent radon gas buildup where (i) recovery solutions enter the plant, (ii) tanks are vented during the extraction process, and (iii) drying and packaging operations occur. By providing information on the health and safety impacts of system failures and identifying contingencies for such occurrences, the applicant has acceptably shown that effluent control systems will limit radiation exposures under both normal and accident conditions. The applicant has committed to occupational radiation doses and doses to the general public that meet dose limits and as low as is reasonably achievable goals.

Based on the information provided in the application and the detailed review conducted of the effluent control systems for gaseous and airborne particulates for the ______________*in situ* leach facility, the staff concludes that the proposed effluent control systems for gaseous and airborne particulates are acceptable and are in compliance with 10 CFR 20.1101, which requires that an acceptable radiation protection program that achieves as low as is reasonably achievable goals is in place and that a constraint on air emissions, excluding Radon-222 and its decay products, will be established to limit doses from these emissions; 10 CFR 20.1201, which defines the allowable occupational dose limits for adults; 10 CFR 20.1301, which defines dose limits allowable for individual members of the public; 10 CFR 20.1302, which requires compliance with dose limits for individual members of the public; 10 CFR Part 40, Appendix A, Criterion 5(G)(1), which requires that the chemical and radioactive characteristics of wastes be defined; and 10 CFR Part 40, Appendix A, Criterion 8, which provides requirements for control of airborne effluent releases. The related reviews of the 10 CFR Part 20 radiological aspects of the effluent control systems for gaseous and airborne radionuclides in accordance with standard review plan Sections 5.0, “Operations;” and 7.0, “Environmental Effects” are addressed elsewhere in this technical evaluation report.

4.1.5 Reference

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills will be as low as is Reasonably Achievable.” Washington, DC: NRC, Office of Standards Development. 2002.

4.2 Liquids and Solids

4.2.1 Areas of Review

The staff should review estimates of quantities and compositions of waste residues expected during construction and operation and the procedures proposed for their management. The staff should also review design specifications for effluent control systems for liquids and solids. Staff should review the design specifications of any retention systems such as surface impoundments. If effluents are to be released into surface waters or injected into disposal wells, the staff should also review the plans to obtain any water quality certifications and discharge permits that may be necessary.

Areas to be reviewed include

(1) Information related to surface impoundment design, monitoring programs, freeboard requirements, and leak reporting procedures

(2) Liquid effluent disposal plans

(3) Contingency plans for dealing with leaks and spills

(4) Contaminated solid waste generation and disposal plans

(5) Non-contaminated solid waste generation and disposal plans

4.2.2 Review Procedures

The staff should ensure that facility descriptions include a discussion of design features to contain contamination from spills resulting from normal operations and the likely consequences of any accidents (e.g., valve and tank failures, leaks in impoundment liners). The staff should perform the following assessments:

(1) Verify that surface impoundments rely on standard engineering design to ensure proper containment performance, including appropriate leak detection systems. The staff

should also ensure that appropriate freeboard requirements are established, and that appropriate monitoring programs and reporting procedures are in place.

(2) If liquid effluents are to be released into surface waters, applied to land surfaces, or injected into disposal wells, determine whether the applicant has applied for or been issued appropriate water quality certifications and discharge permits (see standard review plan Section 10.0 for review of these documents). If the applicant has not yet applied for or been issued such permits, the reviewer should determine that the applicant has identified the necessary permits, and should ensure that a license condition is required prohibiting mineral extraction until all permits are received.

(3) Ensure that contingency plans are in place for dealing with spills of process fluids from valve, pipe, or tank failures.

(4) Ensure that an agreement is in place for disposal of 11.e(2) byproduct material in an NRC licensed disposal facility or a licensed mill tailings facility.

In evaluating surface impoundments, an evaluation of environmental impacts must be made, and a conclusion of the acceptability of those impacts should be documented. The reviewer should also determine if the design of the impoundment meets the applicable requirements of 10 CFR Part 40, Appendix A.

4.2.3 Acceptance Criteria

The liquids and solids effluent control systems are acceptable if they meet the following criteria:

(1) Common liquid effluents generated from the process bleed, process solutions (e.g., backwash, resin transfer waters), wash-down water, well development water, pumping test water, and restoration waters are properly controlled.

Acceptable control methods include diversion of liquid wastes to surface impoundments, deep well injection, and land application/irrigation. Solid effluents can be considered either as contaminated or as noncontaminated. Contaminated solid effluent that can be decontaminated and released for unrestricted use is discussed in detail in Section 5.7.6 of this standard review plan.

To dispose of liquid waste by on-site land application, the applicant must provide (i) a description of the waste including its physical and chemical properties that are important to risk, (ii) a description of the proposed manner and conditions of waste disposal, (iii) an analysis and evaluation of pertinent information on the affected environment, (iv) information on the nature and location of other facilities likely to be affected, and (v) analyses and procedures to ensure that doses are maintained as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301.

For land application, the applicant must analyze and assess projected (i) concentrations of radioactive contaminants in the soils to show that the concentration of radium and other nuclides in the soil will not exceed the standard in 10 CFR Part 40, Appendix A, Criterion 6(6); (ii) impacts on ground-water and surface-water quality; (iii) impacts on land use, particularly crops and vegetation; and (iv) exposures and health risks that may be associated with radioactive constituents reaching the food chain. All projected doses and risks must conform to the risk levels permitted under 10 CFR Part 20. The applicant should propose periodic soils surveys that include contaminant monitoring to verify that contaminant levels in the soil do not exceed the projected levels. A remediation plan must be in place to be implemented in the event that the projected levels are exceeded.

The applicant must conduct analyses to assess the chemical toxicity of radioactive and nonradioactive constituents to evaluate health risks associated with land application involving irrigation at particular sites. The staff should determine that the specific toxicity evaluations and any necessary permits are sufficient to conform to the applicable regulations such as 10 CFR 20.2007. In the absence of compliance monitoring wells in the uppermost aquifer in the area used for land application, the applicant must demonstrate that contaminants will not be returned to the ground water and cause any exceedance of site-specific ground-water protection standards.

Applicants are required to comply with NRC requirements for decommissioning before facility closure and license termination. (Decommissioning requirements are discussed in Section 6 of this standard review plan.)

(2) On-site evaporation systems are designed and operated in a manner that prevents migration of waste from the evaporation system to the subsurface.

The following discussion provides guidelines for an acceptable application section dealing with surface impoundments.

The monitoring and inspection program consists of documented daily checks of impoundment freeboard and the leak detection system. Because small amounts of condensation can accumulate in leak detection sumps, samples for chemical analysis are not commonly collected until water levels greater than a specified amount are detected. NRC has found 15 cm [6 in.] to be an acceptable level. When significant water levels are detected, the water in the standpipes must be sampled for indicator parameters to confirm that the water in the detection system is from the impoundment. The applicant should specify and provide the basis for selecting the indicator parameter(s) used to verify leaks.

Corrective actions should commence on leak confirmation and should consist of transferring the solution to another impoundment so that liner repairs can be made. Thus, sufficient freeboard capacity should be maintained in the surface impoundments such that any one impoundment could be transferred to the remaining impoundments in the event of a leak. An additional freeboard requirement is that water levels should be kept far enough below the top of the impoundment to prevent waves from overtopping during high wind conditions.

Actions to be taken in the event that surface impoundment water analyses indicate leakage include (i) notifying NRC by telephone within 48 hours of verification, (ii) analyzing standpipe water quality samples for leak parameters once every 7 days during the leak period and once every 7 days for at least 14 days following repairs, and (iii) filing a written report with NRC within 30 days of first notifying NRC that a leak exists. (This report includes analytical data and describes the corrective actions and the results of those actions.)

(3) The design, installation, and operation of surface impoundments at the site used to manage 11e.(2) byproduct material meet relevant guidance provided in Regulatory Guide 3.11, Section 1 (NRC, 1977). The impoundments should have sufficient capacity that the entire contents of one impoundment can be transferred to the other surface impoundments in the event of a leak. (See Section 2.7.3 of this standard review plan for additional discussion of design and evaluation of retention systems and diversion facilities.) Inspections of impoundments will be done consistent with Regulatory Guide 3.11.1, “Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings” (NRC, 1980).

The surface impoundment must have sufficient capacity and must be designed, constructed, maintained, and operated to prevent overtopping resulting from (i) normal or abnormal operations, overfilling, wind and wave actions, rainfall, or run-on; (ii) malfunctions of level controllers, alarms, and other equipment; and (iii) human error. If dikes are used to form the surface impoundment, the dikes must be designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes. In ensuring structural integrity, the applicant must not assume that the liner system will function without leakage during the active life of the impoundment.

Controls should be established over access to the impoundment, including access during routine maintenance. A procedure should be provided that assures that unnecessary traffic is not directed to the impoundment area.

(4) The design of surface impoundments used in the management of 11e.(2) byproduct material meets or exceeds the requirements in 10 CFR Part 40, Appendix A, Criterion 5(A) .

The design of a clay or synthetic liner and its appurtenant component parts should be presented in the application or related amendment applications for a uranium recovery operation. At a minimum, design details, drawings, and pertinent analyses should be provided. Expected construction methods, testing criteria, and quality assurance programs should be presented. Planned modes of operation, inspection, and maintenance should be discussed in the application. Deviation from these plans should be submitted to and approved by the staff before implementation.

The liner for a surface impoundment used to manage 11e.(2) byproduct material must be designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the subsurface soil, ground-water, or surface-water at any time during the active life of the surface impoundment. The liner may be constructed of materials that allow wastes to migrate into the liner provided that the impoundment decommissioning includes removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate.

The liner must be constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure because of pressure gradients, physical contact with the waste or leachate, climatic conditions, and the stresses of installation and daily operation. The subgrade must be sufficient to prevent failure of the liner because of settlement, compression, or uplift. Liners must be installed to cover all surrounding earth which is likely to be in contact with the wastes or leachate.

Tests should show conclusively that the liner will not deteriorate when subjected to the waste products and expected atmospheric and temperature conditions at the site. Applicant test data and all available manufacturers test data should be submitted with the application. For clay liners, tests, at a minimum, should consist of falling head permeameter tests performed on columns of liner material obtained during and after liner installation. The expected reaction of the impoundment liner to any combination of solutions or atmospheric conditions should be known before the liner is exposed to them. Field seams of synthetic liners should be tested along the entire length of the seam. Representative sampling may be used for factory seams. The testing should use state-of-the-art test methods recommended by the liner manufacturer. Compatibility tests that document the compatibility of the field seam material with the waste products and expected weather conditions should be submitted for staff review and approval. If it is necessary to repair the liner, representatives of the liner manufacturer should be called on to supervise the repairs.

Proper preparation of the subgrade and slopes of an impoundment is very important to the success of the surface impoundment. The strength of the liner is heavily dependent on the stability of the slopes of the subgrade. The subgrade should be treated with a soil sterilant. The subgrade surface for a synthetic liner should be graded to a surface tolerance of less than 2.54 cm [1 in.] across a 30.3 cm [1 ft] straightedge. NRC Regulatory Guide 3.11, Section 2 (NRC, 1977) outlines acceptable methods for slope stability and settlement analyses, and should be used for design. If a surface impoundment with a synthetic liner is located in an area where the water table could rise above the bottom of the liner, under drains may be required. The impoundment will be inspected in accordance with Regulatory Guide 3.11.1 (NRC, 1980).

A quality control program should be established for the following factors: (i) clearing, grubbing, and stripping; (ii) excavation and backfill; (iii) rolling; (iv) compaction and moisture control; (v) finishing; (vi) subgrade sterilization; and (vii) liner subdrainage and gas venting.

To prevent damage to liners, some form of protection should be provided, including (i) soil covers, (ii) venting systems, (iii) diversion ditches, (iv) side slope protection, or (v) game-proof fences. A program for maintenance of the liner features should be developed, and repair techniques should be planned in advance.

Effluent Control Systems

A leak detection system should be installed at all sites using natural or synthetic liners. The system should be designed to perform the following functions: (i) detect accidental leaks from the impoundment, (ii) identify the location of the leak so that liner repair can be implemented immediately, and (iii) isolate the leakage and control it.

Inspections should be made of the liner, liner slopes, and other earthwork features. Any damage or defects that could result in leakage should be immediately reported to the staff. Appropriate repairs should be implemented as soon as possible.

(5) Plans and procedures are provided for addressing contingencies for all reasonably expected system failures and include:

(a) A listing of the likely consequences of any failures in process or well field equipment that could result in a release of material

(b) Identification of appropriate plant and corporate personnel who must be notified in the event of specific types of failures

(c) Measures for quickly containing and mitigating the impacts of released materials

(d) Provisions for issuing radiation work permits for workers to mitigate impacts

(e) Specific procedures for complying with notification requirements in the regulations, license, and other permits, as appropriate

Processing plants should have sump capacity sufficient to contain the volume of the largest tank in the plant that contains hazardous material. Well field flow circuits should be equipped with alarms to notify the operator in the event of loss of pressure or excess pressure anywhere within the production circuit. NRC should be notified of spills in accordance with criteria in Section 5.3.1.3(2) of this standard review plan.

(6) The application contains a description of the methods to be used for disposing of contaminated solid wastes that are generated during operation of the facility. Decommissioning wastes are addressed separately in Chapter 6 of this review plan.

Equipment that can be decontaminated and released for unrestricted use is discussed in Section 5.7.6 of this standard review plan. The storage of byproduct material that either cannot or will not be decontaminated and released for unrestricted use will be managed to ensure compliance with occupational dose limits in 10 CFR Part 20, Subpart C. The detailed review of occupational doses will be completed as described in Section 5.7 of this standard review plan. The application should provide an estimate of the amount of contaminated material that will be generated and objective evidence of an agreement for disposal of these materials either in a licensed waste disposal site or at a licensed mill tailings facility.

The applicant has an approved waste disposal agreement for 11e.(2) byproduct material disposal at an NRC or NRC Agreement State licensed disposal facility. This agreement is maintained onsite. The applicant has committed to notify NRC in writing within 7 days if this agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination (failure to comply with this license condition will result in a prohibition from further lixivient injection).

(7) Water quality certification and discharge permits have been obtained, or plans are in place to obtain them (review requirements for the status of these permits are addressed in Section 10.0 of the standard review plan). If such permits are not yet applied for or issued, the reviewer should determine that the applicant has identified the necessary permits and should ensure that a license condition is required prohibiting lixiviant injection until all permits are received. Table 4.2.3-1 provides a list of non-NRC permits that may be required to support liquid effluent disposal at *in situ* leach facilities.

(8) Acceptable methods for effluent disposal by release to surface water, evaporation from surface impoundments, land application, and deep well injection are consistent with NRC guidance.

(9) Alternatives to liquid management activities have been considered and none is found to be obviously superior to the selected option. In addition, environmental impacts from all liquid waste management activities have been found to be acceptable.

4.2.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the effluent control systems for liquids and solids, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the effluent control systems for liquids and solids proposed for use at the _______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 4.2.2 and the acceptance criteria outlined in standard review plan Section 4.2.3.

The applicant has acceptably described the common liquid effluents generated at the facility. Appropriate control methods, including diversion to surface impoundments, deep well injection, and land application/irrigation (select appropriate methods) are identified. On-site evaporation system designs are prescribed in acceptable detail, including engineering plans and drawings. The applicant has shown that liquid waste disposal facilities are adequate to handle production and restoration efforts and has designed installation and operation of surface impoundments such that the impoundments can contain the entire contents of any other leaking or inoperative impoundment. The applicant has described how any dikes used to form a surface impoundment are designed, constructed, and maintained with sufficient structural integrity to prevent massive failure. Additionally, surface impoundments and associated liners are properly designed. The applicant has proposed daily checks of impoundment freeboard and leak

Table 4.2.3-1. Non-NRC Permits That May Be Required to Support Liquid Effluent Disposal at Uranium *in Situ* Leach Facilities	
Permit	**Comments**
Underground Injection Control	Mandatory. Issued either by EPA or a state under EPA authority. EPA reserves exclusive aquifer exemption action.
Surface-Water Discharge	Optional. Usually issued by the state, under U.S. Environmental Protection Agency (EPA) authority.
Air	Mandatory with dryer. Usually issued by state under EPA authority; may also be local.
Mining	Mandatory. Usually issued by state under legislative authority.
Wetlands	Issued by U.S. Army Corps of Engineers
Consumptive Water Use	Mandatory. Issued by a state under legislative authority. (Secure water rights)
Leases/Permits on Federal Lands	Issued by U.S Bureau of Land Management , U.S. Bureau of Indian Affairs (Department of the Interior), U.S. Forest Services. U.S. Department of Agriculture, or U.S. Bureau of Reclamation.
Construction/Sewage	Issued by local authorities: building codes, utility authorities, and planning authorities.
Leases/Permits on State Lands	Issued by state land offices.

detection systems. Chemical sampling is initiated when levels are greater than 15 cm [6 in.]. The planned sampling and analysis of contaminants in the leak detection systems are acceptable.

An appropriate corrective action plan is described that allows for the contents of a given impoundment to be transferred to another impoundment with no release of contamination. The applicant has an acceptable action plan to notify NRC, analyze samples, and file a written report in the event of leaks. The applicant has ensured that disposal plans are in compliance with applicable directives. Acceptable plans and procedures that address contingencies for all reasonably expected system failures are provided. The applicant has demonstrated that sump capacity is sufficient to contain the volume of the largest hazardous material source. The facility has acceptable alarms to notify the operator of loss of or excess pressure within the production circuits. The applicant log of significant solution spills is acceptable. Applicant plan for spill notification is acceptable. The applicant has an acceptable plan for the disposal of contaminated solid wastes that are generated by the facility. The applicant has proposed storage of contaminated material that either cannot or will not be decontaminated and released for unrestricted use. The applicant has demonstrated that the contamination will be managed to insure compliance with occupational dose limits, as discussed in Section 5.7 of this standard review plan. The applicant has demonstrated possession of the appropriate water quality certification and discharge permits or has plans in place to obtain them. By providing information on the health and safety impacts of system failures and identifying preventive measures and mitigation for such occurrences, the applicant has shown that effluent control systems will limit radiation exposures under both normal and accident conditions. The applicant has committed to maintaining occupational radiation doses and doses to the general public within applicable 10 CFR Part 20 exposure limits and as low as is reasonably achievable.

Based on the information provided in the application and the detailed review conducted of the effluent control systems for liquids and solids for the _________________*in situ* leach facility, the staff has concluded that the proposed effluent control systems for liquids and solids are acceptable and are in compliance with 10 CFR 20.1101, which requires that an acceptable radiation protection program that achieves as low as is reasonably achievable goals is in place; 10 CFR 20.1201, which defines the allowable occupational dose limits for adults; 10 CFR 20.1301, which defines dose limits allowable for individual members of the public; 10 CFR 20.1302, which requires compliance with dose limits for individual members of the public; 10 CFR 20.2007, which requires that disposal by injection in deep wells must also meet any other applicable federal, state, and local government regulations pertaining to deep well injection; 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide an estimate of the amount of contaminated material that will be generated and objective evidence of an agreement for disposal of these materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate nonproliferation of waste disposal sites; 10 CFR Part 40, Appendix A, Criteria 5A(1) through 5A(5), which define design provisions for surface impoundments; Criterion 5E which requires measures to protect ground water; Criterion 5F which provides requirements for seepage control; Criterion 5G(1), which requires that the chemical and radioactive characteristics of wastes be defined; Criterion 6(6), which defines cleanup standards for radium. The related reviews of the 10 CFR Part 20 radiological aspects of the effluent control systems for liquids and solid radionuclides, in accordance with standard review plan Sections 5.0, “Operations” and 7.0, “Environmental Effects” are addressed elsewhere in this technical evaluation report.

The design of dikes used to construct surface-water impoundments complies with Regulatory Guide 3.11, Sections 2 and 3 (NRC, 1977), and therefore meet the requirements of 10 CFR Part 40, Appendix A, Criterion 5(A)5. In addition, because the impoundment dikes may meet the definition of a dam as given in the Federal Guidelines for Dam Safety, they are subject to the NRC Dam Safety Program, and to Section 215, “National Dam Safety Program, of the Water Resources Development Act of 1966” (optional, staff should add only if appropriate).

The staff has also considered the environmental impacts from the proposed liquid waste management approach. Considered in the evaluation were the potential environmental impacts as well as alternatives and mitigative measures. In evaluating the environmental impacts, the staff examined effects from radiological as well as non-radiological aspects. Alternatives considered include [staff should list as appropriate]. In addition, the applicant will take the following preventive and mitigative measures to reduce the environmental impacts (staff should list measures and discuss how they reduce impact based on this evaluation). The staff has determined that the environmental impacts from the proposed facility are acceptable.

4.2.5 References

NRC. Regulatory Guide 3.11.1 “Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings.” Revision 1. Washington, DC: NRC. 1980.

———. Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1977.

4.3 Contaminated Equipment

The review in this area will be conducted using Section 5.7.6 of this standard review plan.

5.0 OPERATIONS

5.1 Corporate Organization And Administrative Procedures

5.1.1 Areas of Review

The staff should review the detailed description of the applicant's proposed organization and administrative procedures, including a description and/or chart depicting the key positions in the management structure, and the responsibilities and functions of each with respect to development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and ground-water monitoring programs, quality assurance programs, routine and non-routine maintenance activities, and changes to any of these. These include procedures that evaluate the consequences of a spill or incident/event against 10 CFR Part 20, Subpart M and 10 CFR 60.40 criteria. In addition, the reviewer should examine the plans proposed by the applicant for establishing a Safety and Environmental Review Panel, or similarly named panel, including the proposed composition and responsibilities of the Panel.

5.1.2 Review Procedures

The staff should determine whether the proposed organization and administrative procedures are defined in sufficient detail to evaluate the responsibilities and authority of persons in positions responsible for developing, reviewing, approving, implementing, and enforcing the proposed programs related to radiological safety, environmental safety, ground-water protection, quality assurance, and maintenance. In addition, the reviewer should examine the plans proposed by the applicant for establishing a Safety and Environmental Review Panel including the proposed composition and responsibilities of the Panel.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.1.3 Acceptance Criteria

The corporate organization and administrative procedures are acceptable if they meet the following criteria:

(1) The applicant has provided adequate descriptions of the corporate organization, clearly defining management responsibilities and authority at each level.

Specifically, the radiation safety officer should have the responsibilities and authority outlined in Regulatory Guide 8.31, Section 1.2 (NRC, 2002).

(2) The organizational structure shows integration among groups that support the operation and maintenance of the facility. If the facility is new, integration between plant construction and plant management should be detailed.

Operations

(3) The applicant has established a Safety and Environmental Review Panel that will consist of at least three individuals. One member of the Safety and Environmental Review Panel will have expertise in management and will be responsible for implementing managerial and financial changes. One member will have expertise in operations and/or construction and will have responsibility for implementing any operational changes. One member will be the radiation safety officer, or equivalent, with the responsibility for assuring that changes conform to radiation safety and environmental requirements. Additional members may be included in the Safety and Environmental Review Panel, as appropriate, to address specific technical issues such as health physics, ground-water hydrology, surface-water hydrology, and specific earth sciences or other technical disciplines. Temporary members may include consultants. A description of when additional members will be used is provided.

(4) To the extent possible, proposed administrative procedures conform with Regulatory Guide 8.2, “Guide for Administrative Practices in Radiation Monitoring” (NRC, 1973) and with Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Normal Operations)—Effluent Streams and the Environment, Revision 1, (NRC, 1979).

(5) Sufficient independence is available to the plant supervisor, radiation safety officer, and Safety and Environmental Review Panel such that significant safety issues can be raised to senior management.

5.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the corporate organization and administrative procedures, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the corporate organization and administrative procedures proposed for use at the _______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.1.2 and the acceptance criteria outlined in standard review plan Section 5.1.3.

The applicant has an acceptable corporate organization that defines management responsibilities and authority at each level. The applicant’s definition of the responsibilities and procedures with respect to development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and ground-water monitoring programs, quality assurance programs, routine/non-routine maintenance activities, and changes to any of these is acceptable. Integration among groups that support operation and maintenance of the facility is demonstrated. In the case of a new facility, integration between facility construction and plant management is acceptably detailed. The applicant has established a Safety and Environmental Review Panel with at least three individuals representing expertise in management/financial, operations/construction, and radiation safety matters. The applicant has demonstrated that specific technical issues will be dealt with by the Safety and Environmental Review Panel, with support from other qualified staff members, or consultants, as appropriate.

Based on the information provided in the application and the detailed review conducted of the corporate organization and administrative procedures for the _______________*in situ* leach facility, the staff concludes that the proposed corporate organization and administrative procedures are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements. In addition, the requirements of 10 CFR 40.32(b), (c), and (d) are also met as they relate to the proposed corporate organization and Safety and Environmental Review Panel functions.

5.1.5 References

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Normal Operations)–Effluent Streams and the Environment.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1979.

———. Regulatory Guide 8.2, “Guide for Administrative Practices in Radiation Monitoring.” Washington, DC: NRC, Office of Standards Development. 1973.

5.2 Management Control Program

5.2.1 Areas of Review

The staff should review the management control program and administrative procedures proposed to ensure that activities affecting health, safety, and the environment will be conducted in accordance with written standard operating procedures, including records keeping and reporting. The reviewer should evaluate the management control and decision bases to be used by the Safety and Environmental Review Panel in deciding when it is necessary to apply for a license amendment. Procedures governing non-routine work or maintenance that is not covered by a standard operating procedure, such as use of radiation work permits, should be reviewed.

The staff should examine the applicant’s program for cultural resources protection.

The staff should review the applicant’s record keeping and retention plans for the materials control and tracking program; the radiation protection program; the sampling, survey and calibration programs; for planned special exposures; to track doses to workers and members of the public; for the disposal of source, and byproduct materials made under 10 CFR 20.2002 and 20.2003; and for the records important to decommissioning the facility, including records of spills or unusual occurrences involving the spread of contamination, cleanup actions taken, and the location of remaining contamination. The staff should also review the licensee’s plans and arrangements to identify and maintain the records that must be retained for the life of the facility and ultimately be transferred to NRC at the termination of the license.

Operations

While occupational and safety concerns are important and need to be included in the development of standard operating procedures, NRC regulatory authority is limited to those instances where occupational safety concerns may affect radiological operations or accidents.

5.2.2 Review Procedures

The reviewer should determine that the proposed management control program and administrative procedures are sufficient to assure that any activities affecting health, safety, and the environment, including compliance with any license commitments or conditions, will be conducted in accordance with written operating procedures. The review should include the process for identifying and developing standard operating procedures for routine work, and the review and approval process to be used by the radiation safety staff to modify standard operating procedures when appropriate. Methods for review and approval of non-routine work or maintenance activity by the radiation safety staff should be examined.

The reviewer should determine whether the licensee has agreed to administer a cultural resources inventory before engaging in any development activity not previously assessed by NRC. The reviewer should verify that any disturbances to be associated with such development will be completed in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. Additionally, the reviewer should evaluate if the licensee has committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. The reviewer should confirm that any such artifacts will be inventoried and evaluated, and no further disturbance will occur until the licensee has received authorization from the NRC to proceed.

The reviewer should determine whether the proposed record keeping and retention programs are adequate to ensure that the licensee will be able to track, control, and demonstrate control of, the source and byproduct material at the site, such that on-site and off-site dose limits will not be exceeded. The reviewer should determine whether records important to decommissioning, such as descriptions of spills and other unusual occurrences, will be maintained by the licensee, and will be in an identifiable or, preferably, separate file. The reviewer should also determine whether the licensee has a plan to maintain the records that will be turned over to NRC at license termination.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.2.3 Acceptance Criteria

The management control program is acceptable if

(1) The proposed management control program is sufficient to assure that all proposed activities that may affect health, safety, and the environment, including compliance with any license commitments or conditions, will be conducted in accordance with written

operating procedures. These shall include procedures that evaluate the consequences of a spill or incident/event against 10 CFR Part 20, Subpart M and 10 CFR 40.60 reporting criteria.

(2) The applicant provides a process that will be used to identify and prepare operating procedures for routine work.

There is an adequate mechanism for the development, approval, and review (on an annual basis) of standard operating procedures by the radiation safety staff. Subsequent inspections will ensure that standard operating procedures are adequate and applied correctly.

The process includes procedures covering all aspects of radiation safety, routine maintenance activities (especially in radiation areas), and Safety and Environmental Review Panel reviews and activities.

For standard operating procedures for radiation safety, refer to Regulatory Guide 8.31, Section 2 (NRC, 2002).

(3) The applicant presents methods for review and approval of non-routine work or maintenance activity by the radiation safety staff. The methods include the preparation and issuance of radiation work permits for activities where standard operating procedures do not apply.

(4) The applicant provides for the establishment of a Safety and Environmental Review Panel. (A detailed review of Safety and Environmental Review Panel composition is addressed in Section 5.1 of this standard review plan.) Procedures governing the functioning of the Safety and Environmental Review Panel ensure that approvals of any changes in the facility, the operating procedures, or the conduct of tests or experiments are appropriately documented and reported. These changes, tests, or experiments may be effected without obtaining a license amendment pursuant to 10 CFR 40.44, so long as the change, test, or experiment does not

(a) Create a possibility for an accident of a different type than previously evaluated in the license application (as updated)

(b) Create a possibility for a malfunction of a structure, system, or control with a different result than previously evaluated in the license application (as updated)

(c) Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report or the environmental assessment or technical evaluation reports or other analyses and evaluations for license amendments

Quantitative likelihood and consequence analyses may not be required for changes at uranium *in situ* leach facilities.

Operations

The Safety and Environmental Review Panel records will include written safety and environmental evaluations made by the Safety and Environmental Review Panel that provide the basis for determining whether changes, tests, or experiments were implemented in accordance with the bases described in Section 5.2.3. Changes pages should have both a change indicator for the area changed (e.g., a bold line vertically drawn in the right margin adjacent to the portion actually changed) and a page change indication (date of change or change number, or both).

The annual Safety and Environmental Review Panel report and page changes may be furnished along with reports normally submitted to satisfy 10 CFR 40.65 reporting requirements.

(5) The licensee is exempted from the requirements of 20 CFR 1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted with the words “ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL.”

(6) The licensee has agreed to administer a cultural resources inventory before engaging in any development activity not previously assessed by NRC. Any disturbances to be associated with such development will be completed in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. The licensee has committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until the licensee has received authorization from the NRC to proceed.

(7) The record keeping and retention plans demonstrate that the licensee will maintain and retain records of the receipt, transfer, and disposal of any source or byproduct material processed or produced at the licensed facility, for the period set out in the license conditions, or until the Commission terminates the license.

(8) The following will be permanently maintained and retained until license termination:

(a) Records of on-site radioactive waste disposal such as by deep well injection, land application, or burial under 10 CFR 20.2002 and 20.2007.

(b) Records required by 10 CFR 20.2103(b)(4).

(c) Records required by 10 CFR Part 40, Appendix A, Criteria 8 and 8A and included in Regulatory Guide 3.11.1 (NRC, 1980).

(d) Records containing information important to decommissioning and reclamation, including

(i) Descriptions of any spills, excursions, contamination events or unusual occurrences, including the dates, locations, areas, or facilities affected; assessments of hazards; corrective and cleanup actions taken;

assessment of cleanup effectiveness, and the location of any remaining contamination; nuclides involved; quantities, forms and concentrations, and descriptions of hazardous constituents; descriptions of inaccessible areas that cannot be cleaned up; and sketches, diagrams, or drawings marked to show areas of contamination and places where measurements were made. Significant spills that should be included are any radiological spills that have the potential to exceed site cleanup standards and any radiological spill that leaves the site. A license condition will be established to this effect.

(ii) Information related to site characterization; residual soil contamination levels; on-site locations used for burials of radioactive materials; hydrology and geology, with particular emphasis on conditions that could contribute to ground-water or surface-water contamination; and locations of surface impoundments, waste water ponds, lagoons, and well field aquifer anomalies.

(iii) As-built drawings or photographs of structures, equipment, restricted areas, well fields, areas where radioactive materials are stored, and any modifications showing the locations of these structures and systems through time.

(iv) Drawings of areas of possible inaccessible contamination, including features such as buried pipes or pipelines.

(v) Pre-operational background radiation levels at and near the site.

These records will be maintained with adequate safeguards against tampering and loss.

(9) The licensee demonstrates that records can be provided to a new owner or new licensee in the event that the property or license is transferred, or to NRC, after license termination.

(10) New licensees or owners demonstrate that any such records received from a previous owner or licensee will be retained, along with their own records, to be turned over to NRC after license termination.

(11) Records will be maintained as hard copy originals, as copies on microfiche, or will be electronically protected, and will be readily retrievable for NRC inspection.

(12) Reports of spills; evaporation pond leaks; excursions of source, 11e.(2) byproduct material, or process chemicals; will be made to the Headquarters Project Manager by telephone or electronic mail (email) within 48 hours of the event. This notification shall be followed, within thirty (30) days of the notification, by submittal of a written report to the NRC Headquarters Project Manager, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved. A license condition will be established to this effect.

Operations

(13) An annual report will be submitted to the NRC that includes the as low as is reasonably achievable audit report, land use survey, monitoring data, corrective action program report, one of the semiannual effluent and environmental monitoring reports, and the Safety and Environmental Review Panel information. A license condition will be established to this effect.

5.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the management control program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the management control program proposed for use at the ______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.2.2 and the acceptance criteria outlined in standard review plan Section 5.2.3.

The applicant has an acceptable management control program that assures that all safety-related operating activities can be conducted according to written operating procedures. The applicant has provided acceptable operating procedures or a process that will be used to develop standard operating procedures. The applicant has acceptably identified radiation protection, maintenance activities (especially in radiation areas), development of well fields, and Safety and Environmental Review Panel reviews as areas where standard operating procedures are acceptable and correctly applied. The applicant has demonstrated that non-routine work or maintenance activity will comply with radiation safety requirements and that radiation work permits will be issued for activities where standard operating procedures do not apply.

The applicant will administer a cultural resources protection program in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. The applicant will cease any work resulting in the discovery of previously unknown cultural artifacts until such artifacts are inventoried and evaluated and authorization has been obtained from the NRC to proceed.

The applicant has acceptable record keeping and retention and reporting programs that will be adequate to ensure that the licensee is able to track, control, and demonstrate control over the source and byproduct materials that are processed, produced, or stored at the facility during its operating life, through decommissioning, and to license termination. The record keeping and retention plans will assist in ensuring that both on-site and off-site exposures are kept within regulatory limits and in documenting compliance with NRC regulations. The applicant has demonstrated an acceptable program to maintain records on spills, likely contamination events, and unusual occurrences for use in calculating annual surety amounts and to ensure acceptable decommissioning. The applicant will maintain records for decommissioning, on-site and off-site disposal, personnel exposure, and off-site releases of radioactivity, as permanent records for the facility that will be transferred to any new owner or licensee, and ultimately to NRC, before license termination. Reports will be made to the NRC as required by regulations.

Based on the information provided in the application and the detailed review conducted of the management control program for the _______________*in situ* leach facility, the staff concludes that the proposed management control program is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criteria 8 and 8A, which specify documentation requirements for airborne effluents and waste retention systems; 10 CFR 20.1101, which defines radiation protection program requirements; the National Historic Preservation Act and the Archeological Resources Protection Act, which define requirements for the protection of cultural resources; 10 CFR Part 20, Subpart L and Subpart M, which define requirements for record keeping and reporting; and 10 CFR 40.61(d) and (e), which also define requirements for record keeping.

5.2.5 References

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills will be as low as is Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

—— Regulatory Guide 3.11.1, Revision 1, “Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1980.

5.3 Management Audit and Inspection Program

5.3.1 Areas of Review

The staff should review the proposed management audit, inspection, and as low as is reasonably achievable program, including the frequencies, types, and scopes of reviews and inspections; action levels; corrective action measures; and the responsibilities of each participant. The staff should also review the program for ensuring that employee exposures (to both airborne and external radiation) and effluent releases are as low as is reasonably achievable.

5.3.2 Review Procedures

The reviewer should determine whether the management audit and inspection program is acceptable and will provide reasonable assurance that employee exposures and effluent releases will be as low as is reasonably achievable. The reviewer shall ensure that yellowcake drying and packaging operations are in accordance with 10 CFR Part 40, Appendix A, Criterion 8, and inspection of waste retention systems is in accordance with Criterion 8A.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.3.3 Acceptance Criteria

The management audit, and inspection program is acceptable if it meets the following criteria:

(1) The proposed frequencies, types, and scopes of reviews and inspections; action levels; and corrective action measures are acceptable to implement the proposed controls.

Management responsibilities for audit and inspection are adequately defined. Acceptable programs for inspection of embankment systems on a regular basis are described in Regulatory Guide 3.11 (NRC, 1977) and Regulatory Guide 3.11.1 (NRC, 1980).

Acceptable programs for annual as low as is reasonably achievable audits are described in Regulatory Guide 8.31 (NRC, 2002).

5.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the management audit and inspection program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the management audit and inspection program proposed for use at the _______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.3.2 and the acceptance criteria outlined in standard review plan Section 5.3.3.

The applicant has an acceptable management audit and inspection program that provides frequencies, types, and scopes of reviews and inspections; action levels; and corrective action measures sufficient to implement the proposed actions.

Based on the information provided in the application and the detailed review conducted of the management audit and inspection program for the ______________*in situ* leach facility, the staff concludes that the proposed programs are acceptable and are in compliance with 10 CFR 20.1702, which requires the use of process or other engineering measures to control the concentrations of radioactive material in the air; and 10 CFR 20.1101 which contains requirements for maintaining radiation exposure limits as low as is reasonably achievable. In addition, the requirements of 10 CFR 40.32(b), (c), and (d) are met as they relate to the acceptability of management audits to ensure protection of health and minimize danger to life and property. The requirements of 10 CFR Part 40, Appendix A, Criteria 8 and 8A are met as they relate to yellowcake drying and packaging operations, and inspection of waste retention systems.

5.3.5 References

NRC. Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills will be as low as is Reasonably Achievable." Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

—— Regulatory Guide 3.11.1, Revision 1, "Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mills." Washington, DC: NRC, Office of Standards Development. 1980.

———. Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Revision 2. Washington, DC: NRC, Office of Standards Development. 1977.

5.4 Qualifications for Personnel Conducting the Radiation Safety Program

5.4.1 Areas of Review

The staff should review descriptions of the minimum qualifications and experience levels required for personnel who will be assigned the responsibility for developing, conducting, and administering the radiation safety program. The staff should also review the qualifications of people specifically proposed for these positions.

5.4.2 Review Procedures

The reviewer should determine whether the minimum qualifications and experience levels required for personnel who will be assigned the responsibility for developing, conducting, and administering the radiation safety program are sufficient to meet the guidance provided by Regulatory Guide 8.31 (NRC, 2002). The staff should also determine whether the qualifications of people specifically proposed for these positions are consistent with the minimum qualifications and experience levels.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.4.3 Acceptance Criteria

The qualifications of radiation safety personnel are acceptable if they meet the following criteria:

(1) The personnel meet minimum qualifications and experience for radiation safety staff that are consistent with Regulatory Guide 8.31, Section 2.4 (NRC, 2002). The emphasis of this guidance is for uranium recovery facilities; however, the training requirements apply equally to *in situ* leach facilities.

5.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the qualifications of facility personnel conducting the radiation safety program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the qualifications of facility personnel conducting the radiation safety program at the ___________________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.4.2 and the acceptance criteria outlined in standard review plan Section 5.4.3.

Based on the information provided in the application and the detailed review conducted of the qualifications of the personnel conducting the radiation safety program for the_____________ *in situ* leach facility, the staff concludes that the qualifications of the personnel are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), which provides requirements for applicant qualifications. The qualifications of personnel conducting the radiation safety program are acceptable consistent with NRC Regulatory Guide 8.31 (NRC, 2002).

5.4.5 Reference

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

5.5 Radiation Safety Training

5.5.1 Areas of Review

The staff should review the proposed radiation safety training program, including the content of the initial training or indoctrination, testing, on-the-job training, and the extent and frequency of retraining. The staff should also review the proposed written radiological safety instructions that will be provided to employees to include personal hygiene, contamination surveying before eating or leaving the operating area, requirements for personal monitoring devices and respirators, house keeping requirements, spill cleanup procedures, and emergency actions.

5.5.2 Review Procedures

The staff will examine plans for initial training or indoctrination, testing, on-the-job training, and the extent and frequency of retraining to determine whether they are consistent with Regulatory Guide 8.31 (NRC 2002), Regulatory Guide 8.13 (NRC, 1999), and Regulatory Guide 8.29 (NRC, 1996).

The staff should determine whether the applicant has a radiation safety training program that is adequate to provide radiological safety instructions to the employees. The staff should also determine whether the proposed radiological safety instructions that will be provided to employees will be sufficiently detailed to meet acceptance criteria identified in Section 5.5.3.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.5.3 Acceptance Criteria

The training program is acceptable if it meets the following criteria:

(1) It is consistent with the approach described in Regulatory Guide 8.31, Section 2.5 (NRC, 2002).

This guide recommends that before beginning their jobs, all new employees should be instructed, by means of an established course, in the inherent risks of exposure to radiation and the fundamentals of protection against exposure to uranium and its daughters.

(2) It is consistent with Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure, Revision 3” (NRC, 1999).

This guide provides guidance for protection of the fetus.

(3) It is consistent with Regulatory Guide 8.29, “Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1” (NRC, 1996).

This guide provides a basis for training employees on the risks from radiation exposure in the work place.

5.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiation safety training program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiation safety training program at the _____________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.5.2 and the acceptance criteria outlined in standard review plan Section 5.5.3.

The radiation safety training program at the _____________*in situ* leach site is consistent with the guidance contained in NRC Regulatory Guides 8.31 (NRC, 2002), 8.13 (NRC, 1999), and 8.29 (NRC, 1996). The content of the training material, testing, on-the-job training, and the extent and frequency of retraining are acceptable. Radiation safety instructions for employees are acceptable.

Operations

Based on the information provided in the application and the detailed review conducted of the radiation safety training program for the _______________ *in situ* leach facility, the staff concludes that the radiation safety training program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), as it relates to applicant qualifications through training.

5.5.5 References

NRC. Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable." Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure." Revision 3. Washington, DC: NRC, Office of Standards Development. 1999.

———. Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure." Revision 1." Washington, DC: NRC, Office of Standards Development. 1996.

5.6 Security

5.6.1 Areas of Review

The staff should review the security measures proposed to prevent unauthorized entry into the controlled area.

5.6.2 Review Procedures

The staff should determine whether the proposed security measures are sufficient to prevent unauthorized entry into the controlled area in accordance with regulatory requirements in 10 CFR Part 20, Subpart I.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.6.3 Acceptance Criteria

The security program is acceptable if the applicant has acceptable passive controls, such as fencing for well fields, and active controls, such as daily inspections and locks for plant buildings.

5.6.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the security measures, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the security measures at the _____________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.6.2 and the acceptance criteria outlined in standard review plan Section 5.6.3.

The security measures at the _______________ *in situ* leach site demonstrate that the applicant has acceptable active and passive constraints on entry to the licensed and restricted areas. The applicant has identified acceptable passive controls, for example, barbed wire fencing, locked gates, and warning signage for site control and active security systems for buildings.

Based on the information provided in the application and the detailed review conducted of the security measures for the _______________ *in situ* leach facility, the staff concludes that the security measures are acceptable and are in compliance with 10 CFR Part 20, Subpart I, which provides requirements for the security of stored material and control of material not in storage.

5.6.5 References

None.

5.7 Radiation Safety Controls And Monitoring

5.7.1 Effluent Control Techniques

5.7.1.1 Areas of Review

The staff should review descriptions of the effluent control techniques (e.g., ventilation, confinement, filtration) designed to minimize in-plant and environmental emissions at each step of the process where releases might occur. Major airborne radioactive effluents include radioactive particulates (from drying and packaging areas) and radon gas emanating from production solutions. Radon gas mobilization can occur from recovery solutions at process locations where systems allow venting. The staff should evaluate effluent control techniques for uranium particulate emissions located in drying and packaging areas and in any other areas where release of significant quantities of uranium particulate is a concern. Closed systems can eliminate releases of uranium particulates and radon gas. For example, the use of vacuum packaging equipment has been shown to eliminate uranium releases from packaging operations.

Common liquid effluent sources are process bleed, process solutions (e.g., backwash, resin transfer waters), and wash-down water. The staff should review the facility design for containment of contamination from spills resulting from normal operations and probable accidents (e.g., tank, valve, or pipe joint failure). For surface impoundments used in the management of 11e.(2) byproduct material, the staff should also review engineering design to ensure proper containment performance, and evaluate leak detection and monitoring systems for surface impoundments containing contaminated effluents.

Operations

The staff reviews should include minimum performance specifications such as filtration or scrubber efficiency and ventilation airflow at their reasonably expected best performance and the frequency of tests and inspections to ensure that these specifications are being met.

The staff should review contingency plans and notification requirements to be implemented in the event of equipment failures, spills, or excursions.

5.7.1.2 Review Procedures

The staff should determine whether the proposed effluent control techniques are sufficient to limit radiation exposures and radioactive releases to as low as is reasonably achievable and to ensure conformance with regulatory requirements identified in 10 CFR Part 20.

In general, the reviewer should be familiar with 10 CFR Part 40, Appendix A, Criterion 8 and Regulatory Guide 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable” (NRC, 1977). Additional guidance is found in Regulatory Guide 8.37, “ALARA Levels for Effluent from Materials Facilities” (NRC, 1993); Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mill Will Be As Low As Is Reasonably Achievable” (NRC, 2002); and Regulatory Guide 3.56, “General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills” (NRC, 1986). The staff should determine whether the proposed effluent control techniques (e.g., ventilation, confinement, filtration) are acceptably described and sufficient to control in-plant and environmental emissions at each step of the process where releases might occur. The staff should ensure that minimum performance specifications for ventilation, filtration, and confinement systems throughout the recovery plant and laboratories are provided and are consistent with assumptions made in exposure estimates for areas of the facility where the systems are operating. The staff should also check that the frequencies of equipment tests and inspections are consistent with manufacturers' recommendations to ensure that these specifications are being met. Engineering design should be adequate to meet the performance specifications. Contingencies for equipment failures, maintenance shutdowns, and spills should be reviewed to ensure procedures are in place to maintain exposures as low as is reasonably achievable.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.1.3 Acceptance Criteria

The effluent control techniques are acceptable if they meet the following criteria:

(1) Radon gas from processing tanks within enclosed buildings is properly controlled.

Effective control of radon gas can be achieved by using a pressurized processing tank system that eliminates venting in process buildings, or by using appropriate ventilation systems in buildings where radon gas venting is expected.

(2) Emissions from yellowcake drying operations are properly controlled.

Acceptable control of yellowcake emissions from the dryer is achieved by meeting the criteria of 10 CFR Part 40, Appendix A, Criterion 8 and Regulatory Guide 3.56, Section 1 (NRC, 1986).

(3) Release of liquids into surface waters must comply with the public dose limits in 10 CFR 20.1301, which may be demonstrated by one of the following methods:

(a) The licensee demonstrates compliance with 10 CFR Part 20, Appendix B, by one of the following methods and shows that if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.02 mSv/hr [2 mrem/hr] or 0.5 mSv/yr [50 mrem/yr]:

(i) Showing that the discharge of effluent from any surface impoundment is within 10 CFR Part 20, Appendix B, limits at the point of discharge.

(ii) Monitoring the incoming process water to demonstrate compliance with the effluent discharge requirements of 10 CFR Part 20, Appendix B, for process water.

(b) The licensee demonstrates that the total effective dose equivalent to the individual likely to receive the highest dose from the facility does not exceed the annual dose limit for the public.

(4) The applicant describes minimum performance specifications for the operation of the effluent controls and the frequencies of tests and inspections to ensure proper performance to specifications. Details of acceptable excursion control techniques are found in Section 5.7.8.3 of this standard review plan.

Acceptable methods for testing, maintenance, and inspection of effluent controls are given in Regulatory Guide 3.56, Section 1 (NRC, 1986).

(5) Record keeping for the effluent control techniques is sufficient to meet requirements in 10 CFR 20.2103(b)(4).

(6) The applicant describes emergency procedures in the event of equipment failures or spills, references existing emergency procedures, or commits to the development of emergency procedures.

For license renewal applications, the historical effluent control program summary is included through the most recent reporting period preceding the submittal of the application.

The effectiveness of the historical program should be discussed with regard to all applicable 10 CFR Part 20 regulatory requirements identified in the preceding paragraphs. Long-term trends should be discussed, and any short-term deviations from the long-term trend should be explained.

(7) The effluent control techniques are designed to keep exposures to members of the public as low as is reasonably achievable as described in Regulatory Guide 8.37, Section 2 (NRC, 1993).

(8) The effluent control techniques are designed to limit exposures to members of the public from emissions to air (excluding Radon-222 and progeny) to no greater than 0.1 mSv [10 mrem/yr].

5.7.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effluent control techniques, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the effluent control techniques at the ______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.1.2 and the acceptance criteria outlined in standard review plan Section 5.7.1.3.

The applicant has acceptable effluent control techniques at the _______________ *in situ* leach site and has demonstrated that important effluent streams are controlled and monitored. The applicant has used an acceptable pressurized processing tank system or appropriate ventilation systems in buildings where radon gas is vented. Acceptable control of the yellowcake dryer system is evidenced by a vacuum dryer or other appropriate particulate scrubber equipment on the dryer stack. The applicant has shown that the discharge of process water is within the dose limits of 10 CFR 20.1301. The applicant has demonstrated acceptable effluent control techniques and associated test and inspection frequencies to ensure specified performance. Record keeping and monitoring procedures are acceptable. Acceptable emergency procedures for managing equipment failures or spills are described by the applicant.

Based on the information provided in the application and the detailed review conducted of the effluent control techniques at the ______________ *in situ* leach facility, the staff concludes that this program is acceptable and is in compliance with 10 CFR 20.1301, which provides dose limits for members of the public; 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR 20.1201(a), which provides occupational dose limits; and 10 CFR Part 20, Subpart M, which defines requirements for reports. In addition, the staff concludes that the effluent control techniques meet the requirements of 10 CFR 40.32(b) to protect health and minimize danger to life and property, and 10 CFR Part 40, Appendix A, Criterion 8, which specifies standards for yellowcake dryer operations.

5.7.1.5 References

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. Regulatory Guide 8.37, “ALARA Levels for Effluent from Materials Facilities.” Washington, DC: NRC, Office of Standards Development. 1993.

———. Regulatory Guide 3.56, “General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1986.

———. Regulatory Guide 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposures as low as is Reasonably Achievable.” Revision 1–R. Washington, DC: NRC, Office of Standards Development. 1977.

5.7.2 External Radiation Exposure Monitoring Program

5.7.2.1 Areas of Review

The staff should review survey methods, instrumentation, and equipment for determining exposures of employees to external radiation during routine and non-routine operations, maintenance, and cleanup activities. This review should include the types of surveys conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. Staff should also review the program for personnel exposure monitoring, the criteria for including workers in the program, the sensitivity and range of devices used, and calibration frequency and methods.

5.7.2.2 Review Procedures

The staff should determine whether proposed monitoring methods, instrumentation, and equipment are sufficient to meet the regulatory requirements for determining the exposures of employees to external radiation in 10 CFR 20.1203. In conducting its review, the staff should ensure that the applicant has provided one or more charts that identify the facility layout and the location of monitors for external radiation as well as providing acceptable criteria for determining the sampling locations. The staff should ensure all monitoring equipment will be identified by type with additional specification of the range, sensitivity, calibration methods and frequency, availability, and planned use. Staff should ensure that the proposed monitoring program is sufficient to adequately protect workers from hazards of beta radiation (skin, extremity, lens of eye) resulting from the decay products of U-238 when effective shielding is not present (e.g., maintenance operations). The staff should also ensure that the monitoring program is acceptable to detect and control gamma radiation from uranium decay products in areas where large volumes of uranium may be present (e.g., processing tanks, yellowcake storage areas).

Operations

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.2.3 Acceptance Criteria

The external radiation exposure monitoring program is acceptable if it meets the following criteria:

(1) The application contains one or more drawings that depict the facility layout and the location of monitors for external radiation. Criteria for determining the external radiation monitor locations, are consistent with Regulatory Guide 4.14, Sections 1.1.5 and 2.1.6 (NRC, 1980).

(2) The application provides criteria to be used in establishing which employees are to receive external exposure monitoring. These criteria are consistent with Regulatory Guide 8.34, “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses,” Section C (NRC, 1992a).

(3) Monitoring equipment is identified by type, sensitivity, calibration methods and frequency, availability, and planned use to protect health and safety. The ranges of sensitivity for the proposed external radiation monitors are consistent with those appropriate to the facility operation.

(4) All monitoring equipment has a lower limit of detection that allows measurement of 10 percent of the applicable limits. Planned surveys of external radiation are consistent with the guidance in Regulatory Guide 8.30, “Health Physics Surveys in Uranium Mills,” Section 1 (NRC, 2002a).

(5) Plans for documentation of radiation exposures are consistent with the approach in Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data, Revision 1" (NRC, 1992b).

(6) The application presents radiation dose levels for corrective action that are consistent with the 10 CFR Part 20 regulatory requirements.

(7) Radiation doses will be kept as low as is reasonably achievable by following Regulatory Guide 8.10 (NRC, 1977) and Regulatory Guide 8.31 (NRC, 2002b).

(8) The applicant monitoring program is adequate to protect workers from hazards of beta radiation (skin, extremity, lens of eye) resulting from the decay products of uranium-238 when effective shielding is not present (e.g., maintenance operations) and is consistent with Regulatory Guide 8.30 (NRC, 2002a).

(9) The monitoring program is sufficient to detect and control gamma radiation from uranium decay products in areas where large volumes of uranium may be present

(e.g., processing tanks, yellowcake storage areas) and is consistent with Regulatory Guide 8.30 (NRC, 2002a).

(10) The program for external exposure monitoring and determining doses from external exposure is consistent with Regulatory Guide 8.34, Section C (NRC, 1992a).

5.7.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the external radiation exposure monitoring program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the external radiation exposure monitoring program at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.2.2 and the acceptance criteria outlined in standard review plan Section 5.7.2.3.

The applicant has proposed an acceptable external radiation exposure monitoring program at the ________________ *in situ* leach site. The applicant has provided an acceptable drawing(s) that depicts the facility layout and the location of external radiation monitors. The external radiation monitors are acceptably placed. The applicant has established appropriate criteria to determine which employees should receive external radiation monitoring. The applicant has demonstrated that the range, sensitivity, and calibration of external radiation monitors will protect health and safety of employees during the full scope of facility operations. Planned radiation surveys are adequate. Planned documentation of radiation exposures is acceptable. The applicant's monitoring program is acceptable to protect workers from beta and gamma radiation.

Based on the information provided in the application and the detailed review conducted of the external radiation exposure monitoring program at the ______________ *in situ* leach facility, the staff concludes that the external radiation exposure monitoring program is acceptable and is in compliance with 10 CFR 20.1101, which defines a radiation protection program and as low as is reasonably achievable requirements; 10 CFR 20.1201(a), which defines occupational dose limits; 10 CFR 20.1501, which provides requirements of surveying and radiation monitoring; 10 CFR 20.1502, which defines conditions requiring individual monitoring of external dose; 10 CFR Part 20, Subpart L, which specifies record keeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting requirements.

5.7.2.5 References

NRC. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities." Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002a.

———. Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Is Reasonably Achievable." Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002b.

Operations

———. Regulatory Guide 8.34, “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.” Washington, DC: NRC, Office of Standards Development. 1992a.

———. Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1992b.

———. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1980.

———. Regulatory Guide 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable.” Washington, DC: NRC, Office of Standards Development. 1977.

5.7.3 Airborne Radiation Monitoring Program

5.7.3.1 Areas of Review

The staff should review the proposed airborne radiation monitoring program to determine concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance, and cleanup. This review should include criteria for determining airborne radiation monitoring locations and sampling frequency with respect to process operations and personnel occupancy, as well as analytical procedures and sensitivity and instrument calibration requirements. Action levels, audits, and corrective action requirements should also be evaluated.

5.7.3.2 Review Procedures

The staff should determine whether the airborne radiation monitoring program proposed by the applicant is sufficient to limit airborne radiation exposures and airborne radioactive releases to as low as is reasonably achievable and is in conformance with regulatory requirements identified in 10 CFR Part 20. The staff should evaluate whether the proposed sampling program to determine concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance, and cleanup is in conformance with the regulatory requirements identified in 10 CFR 20.1301; 20.1501; 20.1502; 20.1204; and the other applicable requirements listed in Section 5.7.3.3 of this standard review plan. The staff should determine whether action levels, audits, and corrective actions will be consistent with these requirements.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.3.3 Acceptance Criteria

The airborne radiation monitoring program is acceptable if it meets the following criteria:

(1) The applicant provides one or more drawings that depict the facility layout and the location of samplers for airborne radiation. Locations are based, in part, on a determination of airflow patterns in areas where monitoring is needed, and determination of monitoring locations is consistent with Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities," (NRC, 2002a).

(2) Monitoring equipment is identified by type, sensitivity, calibration methods and frequency, availability, and planned use to accurately measure concentrations of airborne radioactive species. The application also demonstrates that the ranges of sensitivity are appropriate for the facility operation.

(3) Planned surveys of airborne radiation are consistent with the guidance in Regulatory Guide 8.30 (NRC, 2002a).

(4) The proposed monitoring program is sufficient to adequately protect workers from radon gas releases from venting of processing tanks and from yellowcake dust from drying operations, spills, and maintenance activities and is consistent with Regulatory Guide 4.14, Sections 1.1 and 2.1 (NRC, 1980). The air sampling program is consistent with Regulatory Guide 8.30 (NRC, 2002a).

(5) Plans for documentation of radiation exposures are consistent with the requirements in 10 CFR 20.2102, 20.2103, 20.2106, and 20.2110.

(6) The applicant demonstrates that respirators will routinely be used for operations within drying and packaging areas and identifies the criteria for determining when respirators will be required for special jobs or emergency situations. The respiratory protection program should be consistent with guidance in Regulatory Guide 8.15, Revision 1, "Acceptable Programs for Respiratory Protection" (NRC, 1999) and Regulatory Guide 8.31, Section 2.7 (NRC, 2002b).

(7) For license renewal applications, the historical results summary of the airborne radiation monitoring program is included through the most recent reporting period preceding the submittal of the application. The effectiveness of the historical program is discussed with regard to all applicable 10 CFR Part 20 regulatory requirements identified in the preceding paragraphs. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained.

5.7.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the airborne radiation monitoring program, the following conclusions may be presented in the technical evaluation report.

Operations

NRC has completed its review of the airborne radiation monitoring program at the ______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.3.2 and the acceptance criteria outlined in standard review plan Section 5.7.3.3.

The applicant has an acceptable airborne radiation monitoring program at the ________________ *in situ* leach site. The applicant has provided an acceptable drawing(s) that depicts the facility layout and the locations of airborne radiation monitors. The airborne radiation monitors are acceptably placed. The applicant demonstrated that the range, sensitivity, and calibration of monitors of airborne radiation will enable accurate determinations of the concentrations of airborne radioactive species so as to protect the health and safety of employees during facility operations. The workers are acceptably protected from radon gas releases from venting of processing tanks and from yellowcake dust from drying operations, spills, and maintenance activities. Planned radiation surveys are acceptable. Planned documentation of radiation exposures is consistent with the requirements. The applicant's respiratory protection program is acceptable. The applicant program for monitoring uranium and sampling of radon or its daughters is acceptable. Employee internal exposure calculations will be performed in accordance with 10 CFR 20.1204(a).

Based on the information provided in the application and the detailed review conducted of the airborne radiation monitoring program at the _________________ *in situ* leach facility, the staff has concluded that the airborne radiation monitoring program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR 20.1201(a), which provides individual occupational dose limits; 10 CFR 20.1201(e), which specifies allowed intake of soluble uranium; 10 CFR 20.1202, which describes the means of compliance when summing internal and external doses; 10 CFR 20.1203, for determination of dose from airborne external radiation; 10 CFR 20.1208, which specifies the exposure limits to a fetus during pregnancy; 10 CFR 20.1301 which identifies public dose limits; 10 CFR 20.1702, which allows employees to limit dose to individuals by controlling access, limiting exposure times, prescribing use of respiratory equipment, or use of other controls; 10 CFR Part 20, Subpart L, which specifies record keeping requirements; 10 CFR Part 20, Subpart M, which provides requirements for reports and notification; and 10 CFR Part 40, Appendix A, Criterion 8, which provides requirements for control of airborne effluents.

5.7.3.5 References

NRC. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities." Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002a.

———. Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Reasonably Achievable." Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002b.

———. Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection." Revision 1. Washington, DC: NRC, Office of Standards Development. 1999.

———. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1980.

5.7.4 Exposure Calculations

5.7.4.1 Areas of Review

The staff should review the methodologies proposed to calculate the exposures to radioactive materials by personnel in work areas where airborne radioactive materials could exist. This review should include methods to determine exposures during routine and non-routine operations, maintenance, and cleanup activities.

5.7.4.2 Review Procedures

The staff should evaluate whether the methodologies proposed to calculate the intake of radioactive materials by personnel in work areas where airborne radioactive materials could exist are in accordance with 10 CFR 20.1204 and 20.1201. The review should also place emphasis on the parameters used in exposure calculations to ensure they are representative of conditions at the site. Estimation of airborne uranium concentrations should take into account the maximum production capacity requested in the application and the anticipated efficiencies of airborne particulate control systems reviewed using Section 5.7.1 of this standard review plan.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.4.3 Acceptance Criteria

The methodologies are acceptable if they meet the following criteria:

(1) The methodologies proposed to determine the intake of radioactive materials by personnel in work areas where airborne radioactive materials could exist are in accordance with 10 CFR 20.1204 and 20.1201.

(2) Exposure calculations for natural uranium are consistent with Regulatory Guide 8.30, Section 3 (NRC, 2002).

(3) For airborne radon daughter exposure (working levels), calculations are consistent with Regulatory Guide 8.30 (NRC, 2002) and Regulatory Guide 8.34, Section C (NRC, 1992a).

(4) Calculations and guidance for prenatal and fetal radiation exposure are consistent with Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus” (NRC, 1992b) and Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure” (NRC, 1999).

Operations

(5) Exposure calculations are presented for routine operations, non-routine operations, maintenance, and cleanup activities and are consistent with Draft Regulatory Guide 8.30 (NRC, 2002) and Regulatory Guide 8.34, Section C (NRC, 1992a).

(6) Parameters used in exposure calculations are representative of conditions at the site and include the time-weighted exposure that incorporates occupancy time and average airborne concentrations.

For example, the time of exposure may be arbitrarily set at 40 hours per week; however, workers at some facilities may regularly work longer shifts. Both full-time and part-time employees should be considered in these calculations.

(7) Estimation of airborne uranium concentrations takes into account the maximum production capacity requested in the application and the anticipated efficiencies of airborne particulate control systems reviewed using in Sections 4.1 and 5.7.1 of this standard review plan.

(8) All reporting and record keeping of worker doses is done in conformance with Regulatory Guide 8.7 (NRC, 1982) and 10 CFR 20.2103.

(9) For license renewal applications, the historical results of radiation exposure calculations are included through the most recent reporting period preceding the submittal of the application. The effectiveness of historical radiation exposure calculations is discussed with regard to applicable 10 CFR Part 20 regulatory requirements. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained.

5.7.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the exposure calculations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the exposure calculations at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.4.2 and the acceptance criteria outlined in standard review plan Section 5.7.4.3.

The applicant has provided acceptable techniques for exposure calculations at the _______________ *in situ* leach site. The applicant has techniques to determine intake of radioactive materials by personnel in work areas. The applicant exposure calculations for natural uranium and airborne radon daughter exposure are acceptable and are in conformance with the guidance in Regulatory Guide 8.30 (NRC, 2002) and Regulatory Guide 8.34 (NRC, 1992a). The applicant has acceptable methods to calculate prenatal and fetal radiation exposures consistent with Regulatory Guides 8.13 (NRC, 1999) and 8.36 (NRC, 1992b). All exposure calculation methods for routine operations, non-routine operations, maintenance, and cleanup activities are acceptable and are consistent with Regulatory Guide 8.30 (NRC, 2002) and Regulatory Guide 8.34 (NRC, 1992a). The applicant has used parameters that are representative of the site, such as using both full- and part-time workers in exposure calculations. The applicant has considered maximum production capacity and anticipated efficiencies of airborne particulate control systems in exposure calculations. All reporting and record keeping is in conformance with Regulatory Guide 8.7 (NRC, 1982).

Based on the information provided in the application and the detailed review conducted of the exposure calculations at the ________________ *in situ* leach facility, the staff has concluded that the exposure calculations are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements; 10 CFR 20.1201(a), which specifies individual occupational dose limits; 10 CFR 20.1201(e), which defines allowed intake of soluble uranium; 10 CFR 20.1202, which describes the means of compliance when summing internal and external doses; 10 CFR 20.1203, for determination of dose from airborne external radiation; 10 CFR 20.1204, which provides requirements for determination of internal exposure; and 10 CFR 20.1208, which specifies the exposure limits for a fetus.

5.7.4.5 References

NRC. Regulatory Guide 8.30, “Health Physics Surveys in Uranium Recovery Facilities.” Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure.” Revision 3. Washington, DC: NRC, Office of Standards Development. 1999.

———. Regulatory Guide 8.34, “Monitoring Criteria and Methods To Calculate Occupational Radiation Doses.” Washington, DC: NRC, Office of Standards Development. 1992a.

———. Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus.” Washington, DC: NRC, Office of Standards Development. 1992b.

———. Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1982.

5.7.5 Bioassay Program

5.7.5.1 Areas of Review

The staff should review descriptions of the bioassay program and how the bioassay results will be used to confirm results derived from the airborne radiation monitoring program (standard review plan Section 5.7.3) and the exposure calculations (standard review plan Section 5.7.4). The staff should review the criteria for including workers in the bioassay program, the types and frequencies of bioassays performed, and action levels applied to the results.

5.7.5.2 Review Procedures

The staff should determine whether the bioassay program is adequate to confirm results determined in the airborne radiation monitoring program (standard review plan Section 5.7.3) and the exposure calculations (standard review plan Section 5.7.4). The staff should review the bioassay program to ensure that it is consistent with applicable sections of Regulatory Guide 8.22, “Bioassay at Uranium Mills” (NRC, 1988). The staff review should check to ensure that all workers who are routinely exposed to yellowcake dust are included in the bioassay program and that sampling and analysis frequencies are sufficient to detect and take corrective action against high intakes of uranium in the workplace. Primarily, the program should involve workers stationed in yellowcake drying areas and those who conduct regular maintenance on drying and ventilation/filtration equipment.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.5.3 Acceptance Criteria

The bioassay program is acceptable if it meets the following criteria:

(1) It is consistent with applicable sections of Regulatory Guide 8.22 (NRC, 1988) and Regulatory Guide 8.31 (NRC, 2002) including as low as is reasonably achievable requirements. The bioassay program is adequate to confirm results determined from the airborne radiation monitoring program (standard review plan Section 5.7.3) and the exposure calculations (standard review plan Section 5.7.4).

(2) The determination of which workers will be monitored in the bioassay program is consistent with Regulatory Guide 8.22, Section 2 (NRC, 1988).

(3) Sampling and analysis frequencies include baseline urinalyses for all new employees and exit bioassays on termination of employment and are consistent with Regulatory Guide 8.22, Section 4 (NRC, 1988) and Regulatory Guide 8.9, Revision 1, “Acceptable Concepts, Equations, and Assumptions for a Bioassay Program” (NRC, 1993).

(4) Action levels for bioassay monitoring are set in accordance with Regulatory Guide 8.22, Section 5 (NRC, 1988).

(5) All reporting and record keeping are done in conformance with the requirements of 10 CFR Part 20, Subpart L and Subpart M.

(6) For license renewal applications, the historical bioassay program results are included through the most recent reporting period preceding the submittal of the application. The effectiveness of the historical program is discussed with regard to all applicable 10 CFR Part 20 regulatory requirements. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained.

5.7.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the bioassay program, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the bioassay program at the ______________*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.5.2 and the acceptance criteria outlined in standard review plan Section 5.7.5.3.

The applicant has established an acceptable bioassay program at the _______________ *in situ* leach site that is consistent with Regulatory Guide 8.22 (NRC, 1988). An acceptable program for baseline urinalysis and exit bioassay is in place. Individuals routinely exposed to yellowcake dust are a part of the bioassay program. An acceptable action program to curtail uranium intake is established, and appropriate actions levels are set. The applicant has established reporting and record keeping protocols in conformance with the requirements of 10 CFR Part 20, Subpart L.

Based on the information provided in the application and the detailed review conducted of the bioassay program at the _____________ *in situ* leach facility, the staff concludes that the bioassay program is acceptable and is in compliance with 10 CFR 20.1204, which provides requirements for the determination of internal exposure; and 10 CFR Part 20, Subpart L, which establishes record keeping requirements.

5.7.5.5 References

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. Regulatory Guide 8.9, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1993.

———. Regulatory Guide 8.22, “Bioassay at Uranium Mills.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1988.

5.7.6 Contamination Control Program

5.7.6.1 Areas of Review

The staff should review the contamination control program proposed to prevent employees from entering clean areas or from leaving the site while contaminated with radioactive materials. Levels of radioactive contamination will be monitored by means of a radiation survey program. Review areas include methods for surveying occupational radiation levels, housekeeping and cleanup requirements; specifications in process areas to control contamination; frequency of surveys of clean areas; survey methods; and minimum sensitivity, range, and calibration frequency of survey equipment. Proposed contamination criteria or action levels for clean areas and for the release of materials, equipment, and work clothes from clean areas or from the site should be evaluated. The staff should also review the methods proposed to ensure that the licensee reduces residual contamination below limits before authorizing release of equipment for unrestricted use.

5.7.6.2 Review Procedures

The staff should determine whether the contamination control program proposed to prevent contaminated employees from entering clean areas or from leaving the site is in conformance with regulatory requirements in Regulatory Guide 8.30 (NRC,2002). Requirements for a contamination control program (e.g., maintaining change areas and personal alpha radiation monitoring before leaving radiation areas) should be included in standard operating procedures and discussed in the application. The staff should confirm that the license applicant has a contamination control program consistent with the guidance on conducting surveys for contamination of skin and personal clothing provided in Regulatory Guide 8.30 (NRC, 2002). The staff should ensure that the licensee eliminates residual contamination on equipment and materials to within acceptable release limits before release of the equipment for unrestricted use.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.6.3 Acceptance Criteria

The contamination control program is acceptable if it meets the following criteria:

(1) Radiation surveys of workers will be conducted to prevent contaminated employees from entering clean areas or from leaving the site in conformance with guidance in Regulatory Guide 8.30 (NRC, 2002).

The proposed contamination control program is consistent with the guidance on conducting surveys for contamination of skin and personal clothing provided in Regulatory Guide 8.30 (NRC, 2002).

(2) Requirements for a contamination control program (e.g., maintaining change areas and personal alpha radiation monitoring before leaving radiation areas) are included in standard operating procedures or are discussed in the application.

These procedures should be consistent with the guidance on conducting surveys for contamination of skin and personal clothing provided in Regulatory Guide 8.30 (NRC, 2002).

(3) Action levels for surface contamination are set in accordance with Regulatory Guide 8.30, Section 4 (NRC, 2002).

(4) Monitoring equipment by type, specification of the range, sensitivity, calibration methods and frequency, availability, and planned use is adequately described. The application demonstrates that the ranges of sensitivity for monitoring equipment will be appropriate to expected facility operation.

(5) All reporting and record keeping is done in conformance with the requirements of 10 CFR Part 20, Subpart L and Subpart M.

(6) The licensee will ensure that radioactivity on equipment or surfaces is not covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 5.7.6.3-1 of this standard review plan before application of the covering. A reasonable effort will be made to minimize the contamination before the use of any covering.

(7) The radioactivity of the interior surfaces of pipes, drain lines, or duct work will be determined by making measurements at all traps and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or duct work.

(8) The licensee will make a comprehensive radiation survey, in conformance with Regulatory Guide 8.30, Section 1 (NRC, 2002) and NUREG–1575, Revision 1 (NRC, 2000) “Multi-Agency Survey and Site Investigation Manual (MARSSIM)” that establishes that contamination is within the limits specified in Table 5.7.6.3-1 and is as low as is reasonably achievable before release of equipment or scrap for unrestricted use.

(9) Appropriate criteria are established to relinquish possession or control of equipment or scrap having surfaces contaminated with material in excess of the limits specified in Table 5.7.6.3-1:

(a) The applicant will provide detailed information describing the equipment, or scrap; the radioactive contaminants; and the nature, extent, and degree of residual surface contamination.

(b) The applicant will provide a detailed health and safety analysis that reflects that the residual amounts of contaminated materials on surface areas, together with other considerations such as prospective use of the equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

(c) The applicant includes materials created by special circumstances including, but not limited to, the razing of buildings, transfer of structures or equipment, or conversion of facilities to a long-term storage facility or to standby status.

Table 5.7.6.3-1. Acceptable Surface Contamination Levels (U.S. Atomic Energy Commission, 1974)

Nuclides[a]	Average[b,c,d]	Maximum[b,d,e]	Removable[b,d,f]
Natural Uranium, Uranium-235, -238, and associated decay products	5,000 α dpm/100 cm^2	15,000 α dpm/100 cm^2	1,000 α dpm/100 cm^2
Transuranics, Radium-226, Radium-228, Thorium-230, Thorium-118, Protactinium-231, Actinium-227, Iodine-125, Iodine-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Natural Thorium, Thorium-232, Strontium-90, Radium-223, -224, Uranium-232, Iodine-126, Iodine-131, Iodine-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Strontium-90, and others noted above	5,000 dpm/100 cm^2	15,000 dpm/100 cm^2	1,000 dpm/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate factor for background, efficiency, and geometric factors associated with the instrumentation.
[c] Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average should be derived for each such object.
[d] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.
[e] The maximum contamination level applies to an area of not more than 100 cm^2.
[f] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.
Reference: U.S. Atomic Energy Commission. Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors." Washington, DC: U.S. Atomic Energy Commission. June 1974.

5.7.6.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the contamination control program, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the contamination control program at the ______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.6.2 and the acceptance criteria outlined in standard review plan Section 5.7.6.3.

The applicant has established an acceptable contamination control program at the _______________ *in situ* leach site. Acceptable controls are in place to prevent contaminated employees from entering clean areas or from leaving the site. The standard operating procedures will include provisions for contamination control, such as maintaining changing areas and personal alpha radiation monitoring before leaving radiation areas. Acceptable action levels have been set in accordance with Regulatory Guide 8.30 (NRC, 2002), and plans for surveys are in place for skin and personal clothing contamination. The applicant has established that all items removed from the restricted area are surveyed by the radiation safety staff and meet release limits. All reporting and record keeping is done in conformance with protocols established in Regulatory Guide 8.7 (NRC, 1982). The applicant has demonstrated that the range, sensitivity, and calibration of monitoring equipment will protect the health and safety of employees during the full scope of facility operations. The licensee has demonstrated that contaminated surfaces will not be covered unless, before covering, a survey documents that the contamination level is below the limits specified in Table 5.7.6.3-1. The applicant will determine the radioactivity on the interior surfaces of pipes, drain lines, or duct work by making measurements at appropriate access points that will have been shown to be representative of the interior contamination. The applicant has committed to establishing that contamination on equipment, or scrap will be within the limits in Table 5.7.6.3-1 before unrestricted release. To relinquish possession or control of equipment, or scrap with material in excess of the limits specified in Table 5.7.6.3-1, the applicant will provide detailed information on the contaminated material, provide a detailed health and safety analysis that shows that the release of the contaminated material will not result in an unreasonable risk to the health and safety of the public, and obtain NRC staff approval.

Based on the information provided in the application and the detailed review conducted of the contamination control program at the _______________ *in situ* leach facility, the staff concludes that the contamination control program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program and as low as is reasonably achievable requirements; 10 CFR 20.1501, which provides survey and monitoring requirements; and 10 CFR 20.1702, which allows employees to limit dose to individuals by controlling access, limiting exposure times, prescribing use of respiratory equipment, or other controls.

5.7.6.5 References

NRC. Regulatory Guide 8.30, “Health Physics Surveys in Uranium Recovery Facilities.” Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

———. NUREG–1575, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).” Revision 1. Washington, DC: NRC. 2000.

———. Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1982.

5.7.7 Airborne Effluent and Environmental Monitoring Program

5.7.7.1 Areas of Review

The staff should review the airborne effluent and environmental monitoring programs proposed for measuring concentrations and quantities of both radioactive and non-radioactive materials released to and in the environment surrounding the facility. The staff should review the technical bases proposed for determining environmental concentrations for demonstrating compliance with standards. The staff review should focus on the frequency of sampling and analysis, the types and sensitivity of analysis, action levels and corrective action requirements, the minimum number and criteria for locating effluent and environmental monitoring stations, and the commitments for semiannual effluent and environmental monitoring reporting. The staff should review a topographic map of the site and the surrounding area showing monitoring locations.

5.7.7.2 Review Procedures

The staff should determine whether the proposed environmental monitoring programs are sufficient to limit exposures and releases of radioactive and hazardous materials as required by 10 CFR 20.2007.

The staff should determine whether the airborne effluent and environmental monitoring programs proposed for measuring concentrations and quantities of both radioactive and hazardous materials released to and in the environment around the proposed facility are in accordance with the regulatory requirements.

The staff should ensure that the license applicant has adequately considered site-specific aspects of climate and topography in determining locations for off-site airborne effluent monitoring stations and environmental sampling areas such that they are capable of detecting maximum concentrations expected from facility operations in the environment. In conducting its review, the staff should refer to guidance in Regulatory Guide 4.14, Revision 1 (NRC, 1980) which contains information on determining sampling locations, types, methods, frequencies, and analyses that are sufficient to comply with the applicable requirements for protection of the public from off-site exposures.

The reviewer shall confirm that the applicant has committed to adequate semiannual airborne effluent and environmental monitoring reporting.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.7.3 Acceptance Criteria

The airborne effluent and environmental monitoring program is acceptable if it meets the following criteria:

(1) The proposed airborne effluent and environmental monitoring program is consistent with Regulatory Guide 4.14, Sections 1.1 and 2.1 (NRC, 1980) and as low as is reasonably achievable requirements as described in Regulatory Guide 8.37, Section 3 (NRC, 1993).

(2) The proposed locations of the airborne effluent monitoring stations are consistent with guidance in Regulatory Guide 4.14, Sections 1.1.1 and 2.1.2 (NRC, 1980).

The license applicant adequately considers site-specific aspects of climate and topography in determining the number and locations of off-site airborne monitoring stations and environmental sampling areas. The criteria used in selecting sampling locations should be given. All sampling locations should be clearly shown relative to the proposed facility, nearest residences, and population centers on topographic maps of the appropriate scale.

(3) The proposed airborne effluent and environmental monitoring program should sample radon, air particulates, surface soils, subsurface soils, vegetation, direct radiation, and sediment in accordance with Regulatory Guide 4.14, Section 3 (NRC, 1980).

(4) The proposed sampling methods are consistent with guidance in Regulatory Guide 4.14, Section 3 (NRC, 1980).

(5) For license renewal applications, the historical airborne effluent and environmental monitoring program results are included through the most recent reporting period preceding the submittal of the application. The effectiveness of the historical program is discussed with regard to all applicable regulatory requirements. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained.

(6) The applicant commits to semiannual airborne effluent and environmental monitoring reporting. These reports will be submitted to the appropriate NRC Regional Office with copies to the Chief, Fuel Cycle Facilities Branch and the project manager. The reports will specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous 6 months, injection rates, recovery rates, injection manifold pressures, and injection trunk line pressures for each

satellite facility. The process rate and pressure data are to be reported as monthly averages. A license condition will be imposed to specify these reporting requirements.

5.7.7.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the airborne effluent and environmental monitoring programs, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the airborne effluent and environmental monitoring programs at the _______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.7.2 and the acceptance criteria outlined in standard review plan Section 5.7.7.3.

The applicant has established acceptable airborne effluent and environmental monitoring programs at the ________________ *in situ* leach site. The programs are consistent with guidance in Regulatory Guide 4.14 (NRC, 1980). The applicant will sample radon, air particulates, surface soils, subsurface soils, vegetation, direct radiation, and sediment. Locations of monitoring stations are consistent with Regulatory Guide 4.14 (NRC, 1980). Instrumentation is appropriate.

Based on the information provided in the application and the detailed review conducted of the airborne effluent and environmental monitoring programs at the _______________ *in situ* leach facility, the staff concludes that the airborne effluent and environmental monitoring programs are acceptable and are in compliance with 10 CFR 20.1302, which requires effluent monitoring to determine dose to individual members of the public; 10 CFR 20.1501, which specifies survey and monitoring requirements; 10 CFR Part 20, Subpart L, which establishes record keeping requirements; and10 CFR 40.65, which specifies effluent and environmental monitoring requirements.

5.7.7.5 References

NRC. Regulatory Guide 8.37, “ALARA Levels for Effluent from Materials Facilities.” Washington, DC: NRC, Office of Standards Development. 1993.

———. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1980.

5.7.8 Ground-Water and Surface-Water Monitoring Programs

5.7.8.1 Areas of Review

There are three distinct phases of ground-water and surface-water monitoring: pre-operational, operational, and restoration. Pre-operational monitoring is conducted as a part of site characterization, and review procedures are in Section 2 of this standard review plan. Restoration monitoring is conducted during the ground-water restoration phase of operations, and review procedures are in Section 6. This standard review plan section deals specifically with monitoring ground-water and surface-water quality during the production or operational phase of *in situ* leach activities.

The staff should review the technical bases and procedures for the following components of an effective ground-water and surface-water operational monitoring program:

(1) Well field baseline water quality monitoring programs (ground-water and surface-water)

(2) Selection of excursion indicators and their respective upper control limits

(3) The placement of excursion monitoring wells

(4) Well field testing to verify horizontal continuity between the production zone and perimeter wells and vertical isolation between the production zone and vertical excursion monitor wells

(5) The excursion monitoring program, including well sampling schedules, criteria for placing well fields on excursion status, and corrective actions to be taken in the event of an excursion

(6) The surface-water monitoring program

For all of the preceding aspects of ground-water and surface-water monitoring programs that involve analysis of water samples, procedures for sample collection and analysis should be reviewed.

5.7.8.2 Review Procedures

Well field hydrologic and water chemistry data are collected before *in situ* leach operations to establish a basis for comparing operational monitoring data. Hydrologic data are used to (i) evaluate whether the well field can be operated safely, (ii) confirm monitor wells have been located correctly, and (iii) design aquifer restoration activities. Water chemistry data are used to establish a set of water quality indicators, and the concentrations of these indicators in monitoring wells are used to determine whether the well field is being operated safely. Water chemistry data are also used to set the water quality standard for restoring the production zones and adjacent aquifers after *in situ* leach extraction ceases. The reviewer should determine whether these objectives of the operational monitoring program have been met. To this end, the reviewer should

(1) Verify that procedures for establishing baseline water quality include acceptable sample collection methods, a set of sampled parameters that is appropriate for the site and *in situ* leach extraction method, and collection of sample sets that are sufficient to represent any natural spatial and temporal variations in water quality.

(2) Review the applicant’s selection (or procedure for selecting) the set of water quality parameters and their respective upper control limits that will be used as indicators to

ensure timely detection and reporting of unplanned lixiviant migration (excursions) from production zones.

(3) Review the applicant’s technical basis or procedures for establishing the appropriate monitor well spacing for vertical and horizontal excursion monitoring.

(4) Evaluate whether well field testing is sufficient to show a horizontal hydraulic connection between the production zones and the perimeter monitor well network, and vertical hydraulic separation between the production zones and the shallow and deep monitor wells.

(5) Evaluate whether procedures describing the operational excursion monitoring program include sampling schedules, sampling and analytical procedures, criteria for placing well fields on excursion status, and corrective action and notification procedures to be followed if an excursion is detected.

(6) Evaluate whether a surface-water monitoring program is necessary at the site and, if so, whether the monitoring program will be effective to detect migration of contaminants into surface-water bodies.

In conducting these evaluations, the reviewer should consider the review of ground-water activities conducted by state and other federal agencies to identify any areas where dual reviews can be eliminated. Although the staff must make the necessary findings of compliance with applicable regulations, if a state or other federal agency asks questions in a particular area, the reviewer need not duplicate those questions. Instead, the reviewer can rely on the answers to the state or federal agency questions if they are acceptable, and if the applicant submits them as part of the NRC application. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.8.3 Acceptance Criteria

The ground-water and surface-water monitoring program should ensure that an excursion is detected long before *in situ* leach solutions could seriously degrade the quality of ground-water outside the well field area. Early detection of excursions by a monitor well is influenced by the thickness of the aquifer monitored, the distance that monitor wells are placed from the well field and from each other, the frequency that the monitor wells are sampled, the water quality parameters that are sampled, and the concentrations of parameters that will be used to declare that an excursion has been detected.

The ground-water and surface-water monitoring programs are acceptable if they will allow the early detection and timely restoration of excursions. The following criteria must be met by *in situ* leach operational monitoring programs:

(1) For each new well field, the applicant's approach for establishing baseline water quality data is sufficient to (i) define the primary restoration goal of returning each well field to its pre-operational water quality conditions and (ii) provide a standard for determining when an excursion has occurred. The reviewer should verify that acceptable procedures were used to collect water samples, such as American Society for Testing and Materials D4448 (American Society for Testing and Materials, 1992). The reviewer should also ensure that acceptable statistical methods are used to meet these three objectives, such as American Society for Testing and Materials D6312 (American Society for Testing and Materials, 1998).

Baseline sampling programs should provide enough data to adequately evaluate natural spatial and temporal variations in pre-operational water quality. At least four independent sets of samples should be collected, with adequate time between sets to represent any pre-operational temporal variations. A set of samples is defined as a group of at least one sample at each of the designated baseline monitor wells and analyzed for the water quality conditions of the sampled aquifer at a specific time.

An acceptable set of samples should include all well field perimeter monitor wells, all upper and lower aquifer monitor wells, and at least one production/injection well per acre in each well field. For large well fields, it may not be practical to sample one production/injection well per acre. Consequently, enough production/injection wells must be sampled to provide an adequate statistical population if fewer than one well per acre is used. As a general guideline, for normally and log-normally distributed populations, at least six samples are required to achieve 90 percent confidence that any random sample will lie within two standard deviations from the sample mean. In no case should the baseline sampling density for production/injection wells be less than one per 4 acres.

The applicant should identify the list of constituents sampled for baseline concentrations. Table 2.7.3-1 provides a list of acceptable constituents for monitoring at *in situ* leach facilities. Alternatively, applicants may propose a list of constituents that is tailored to a particular location. In such cases, sufficient technical bases must be provided to demonstrate the acceptability of the selected constituent list. For example, many licensees have decided not to sample for Th-230; Th-230 is a daughter product from the decay of uranium-238, and studies have shown that it is mobilized by bicarbonate-laden leaching solutions. However, studies have also shown that after restoration, thorium in the ground-water will not remain in solution, because the chemistry of thorium causes it to precipitate and chemically react with the rock matrix (Hem, 1985). As a result of its low solubility in natural waters, thorium is found in only trace concentrations. Additionally, chemical tests for thorium are expensive, and are not commonly included in water analyses at *in situ* leach facilities. This example concerning Th-230 demonstrates an acceptable technical basis for excluding Th-230 from the list of sampled constituents. For all constituents that are sampled, laboratory reports documenting the measurements should be maintained by the applicant.

An outlier is a single non-repeating value that lies far above or below the rest of the sample values for a single well. Dealing with outliers in the sample sets should be done using proper statistical methods. The outlier may represent a sampling, analytical, or other unknown source of error or an unidentified randomness in the data. Its inclusion within the sample could significantly change the baseline data, since the outlier is not typical of the bulk of the samples. All calculations, assumptions, and conclusions made by the applicant in evaluating outliers should be fully explained. When an outlier is suspected, perhaps the easiest solution is to take another sample from the source well; if the repeat sample yields the same results, then the outlier should not be discarded. If the repeat sample is more consistent with the statistical population, the outlier can be replaced with the new sample. Another acceptable method for dealing with potential outliers is to accept any value within three standard deviations of the mean (the standard deviation should be calculated without using the suspected outliers). It is often necessary to perform log transformations on data to better approximate a normal distribution before calculating sample statistics. Care should be taken not to exclude suspected outliers that ultimately may represent bimodal distributions. Methods in American Society for Testing and Materials E178 (American Society for Testing and Materials, 1994), NUREG/CR–4604 (NRC, 1988) and NUREG–1475 (NRC, 1994) are acceptable methods for outlier calculation. Other documented and technically justified methods used by applicants will be considered in the evaluation of outliers (e.g., EPA, 1989).

(2) The applicant selects excursion indicator constituents and upper control limits. Upper control limits are concentrations for excursion indicator constituents that provide early warning that leaching solutions are moving away from the well fields and that ground-water outside the monitor well ring may be threatened. Excursion indicator constituents should be parameters that are strong indicators of the *in situ* leach process and that are not significantly attenuated by geochemical reactions in the aquifers. If possible, the chosen parameters should be easily analyzed to allow timely data reporting. The upper control limit concentrations of the chosen excursion indicators should be set high enough that false positives (false alarms from natural fluctuations in water chemistry) are not a frequent problem, but not so high that significant ground-water quality degradation could occur by the time an excursion is identified. A minimum of three excursion indicators should be proposed. The choice of excursion indicators is based on lixiviant content and ground-water geochemistry. Ideal excursion indicators are measurable parameters that are found in significantly higher concentrations during *in situ* leach operations than in the natural waters. At most uranium *in situ* leach operations, chloride is an excellent excursion indicator because it acts as a conservative tracer, it is easily measured, and chloride concentrations are significantly increased during *in situ* leaching. Conductivity, which is correlated to total dissolved solids, is also considered to be a good excursion indicator (Staub, 1986; Deutsch, 1985). Total alkalinity (carbonate plus bicarbonate plus hydroxide) is an excellent indicator in well fields where sodium bicarbonate or carbon dioxide is used in the lixiviant. If conductivity is used to estimate total dissolved solids, measurements will be normalized to a reference temperature, usually 25 °C, because of the temperature dependence of conductivity.

Calcium, sodium, and sulfate are usually found at significantly higher levels in *in situ* solutions than in natural ground-water concentrations. The use of cations (e.g., calcium^{2+}, sodium^{+}) as excursion indicators is generally not appropriate because they are subject to ion exchange with the host rock. The use of sulfate may give false alarms because of induced oxidation around a monitor well (Staub, 1986; Deutsch, 1985). However, this should only be a problem if upper control limit values are set too conservatively. Uranium is not considered a good excursion indicator because, although it is mobilized by *in situ* leaching, it may be retarded by reducing conditions in the aquifer. Although water level changes in artesian aquifers are quickly transmitted, water levels are generally not considered good indicators, because water levels tend to have significant natural variability. The applicant may choose to add a non-reactive, conservative tracer to *in situ* leach solutions to act as an excursion indicator. The applicant is required to provide the technical bases for the selection of excursion indicators.

Upper control limit concentrations must be set to easily identify excursions. An excursion is defined to occur whenever two or more excursion indicators in a monitoring well exceed their upper control limits. The upper control limit for each excursion indicator must generally be less than the lowest concentration that typically occurs in the lixiviant while the well field is in operation. Each upper control limit must also be greater than the baseline concentration for its respective excursion indicator. Applicant site-specific experience is often valuable in determining appropriate upper control limits that provide timely detection and avoid false alarms. Guidance for appropriate statistical methods that can be used to establish upper control limits can be found in American Society for Testing and Materials D6312 (American Society for Testing and Materials, 1998).

Upper control limits for a specific excursion indicator should be determined on a statistical basis to account for likely spatial and temporal concentration variations within the mineralized zone. Statistical techniques, such as the student’s t-test, are acceptable for setting upper control limits. In some cases, the use of a simple percentage increase above baseline values is acceptable. The staff has decided that in areas with good water quality (a total dissolved solids less than 500 mg/L), setting the upper control limit at a value of 5 standard deviations above the mean of the measured concentrations is an acceptable approach. However, in some aquifers of good water quality, low chloride concentrations have been found to have such a narrow statistical distribution that a specified concentration (e.g., 15 mg/L) above the mean or the mean plus 5 standard deviations approach, which ever is greater, has been used to establish the chloride upper control limit.

The same upper control limits may be assigned to all monitor wells within a particular hydrogeologic unit in a given well field if baseline data indicate little chemical heterogeneity. Alternatively, if individual monitor wells in a given unit exhibit unique baseline water quality, upper control limits may be assigned on a well-by-well basis. If upper control limits vary from well to well, a table should be included listing all monitor wells and their respective upper control limits.

(3) The applicant establishes criteria for determining monitor well locations. Production zone perimeter monitor wells are used to detect horizontal excursions outside the well

field boundary. They generally surround the entire well field and are screened over the entire production zone hydrogeologic unit. Perimeter monitor wells should be placed close enough to the well field to provide timely detection, yet they should be far enough away from the well field to avoid numerous false alarms. Previously approved *in situ* leach excursion monitoring systems used monitor wells as far as 180 m [600 ft] and as near as 75 m [250 ft] from the well field edge (NRC, 2001, Table 4-6). The licensee should be afforded some discretion in determining the appropriate distance of horizontal excursion monitor wells from the well field, but should provide justification for distances greater than about 150 m [500 ft]. For example, a rigorous modeling demonstration that a theoretical excursion can be controlled at the monitor well locations within 60 days of detection is an acceptable technical basis. The horizontal excursion monitor wells must be spaced close enough to one another so that the likelihood of missing an excursion plume is low. In determining the appropriate spacing between perimeter monitoring wells, the applicant must consider such factors as the distance of the monitoring wells from the edge of the well field, the minimum likely size of an excursion source zone, ground-water flow directions and velocities outside of the well field, and the potential for mixing and dispersion. Staff should consult NUREG/CR–6733 (NRC, 2001, Section 4.3.3) for an analysis and discussion of acceptable approaches for establishing the appropriate monitor well spacing.

NUREG/CR–6733 (NRC, 2001, Section 4.3.3) established that significant risks for vertical excursions may exist if monitor wells are randomly located, given the typical criteria for spacing of vertical excursion monitor wells at licensed *in situ* leach facilities {e.g., one well per 1.6 ha [4 acres] for overlying aquifers; one well per 3.2 ha [8 acres] for underlying aquifers}. Thus, location of vertical excursion monitor wells within the well field should be such that the likelihood of detecting a vertical excursion is maximized. The appropriate number of these monitor wells may vary from site to site. It may be appropriate to exclude the requirement to monitor water quality in the underlying aquifer if (i) the underlying aquifer is a poor producer of water, (ii) the underlying aquifer is of poor water quality, (iii) there is a large aquitard between the production zone and the underlying aquifer and few boreholes have penetrated the aquitard, or (iv) deep monitor wells would significantly increase the risk of a vertical excursion into the underlying aquifer. Monitor wells completed in aquifers above the first overlying aquifer may not be required when (i) the aquifers are separated from the production zone by thick aquitards, (ii) a high quality mechanical integrity well testing program will be implemented, or (iii) the aquifers are unsubstantial producers of water or of poor water quality. In well fields where the production zone confining layers are particularly thin, or of questionable continuity, a greater number of monitor wells is appropriate. In general, when the direction of ground-water flow in an upper or lower aquifer is well known, the applicant should consider locating these wells on the hydraulically down gradient side of a well field, in areas where production zone confining layers may be thin or incompetent, and in areas where injection pressure may be highest (i.e., closer to injection wells than to production wells).

The process for determining the screened interval of the monitor wells should be described. Fully screened monitor wells sample the entire thickness of the aquifer. Therefore, excursions could not pass above or below the well screens. However, the concentration of the indicator parameters might be diluted and therefore may not provide timely warning that an excursion is occurring. Partially screened monitor wells only sample the zone of extraction within an aquifer. These wells might miss some excursions, but would suffer less from dilution effects than fully screened wells. For most situations the staff favors fully screened monitor wells. Fully screened monitor wells would assure that excursions will eventually be detected, have the advantage of more accurately representing the water quality that a ground-water user is likely to experience, and do not suffer from the uncertainty of predicting the completion intervals of injection and production wells that have not yet been drilled.

(4) The applicant establishes well field test procedures. Once a well field is installed, it should be tested to establish that the production and injection wells are hydraulically connected to the perimeter horizontal excursion monitor wells and are hydraulically isolated from the vertical excursion monitor wells. Such testing will serve to confirm the performance of the monitoring system and will verify the validity of the site conceptual model reviewed in Section 2 of this standard review plan. The reviewer should verify that well field test approaches have sound technical bases. Test approaches typically consist of a pumping test that subjects the well field to a sustained maximum withdrawal rate while monitoring the perimeter and vertical excursion wells for drawdown. The test should continue until the effects of pumping can be clearly seen via drawdown in the perimeter monitor wells. Typically, about 0.3 m [1 ft] of drawdown in the perimeter monitor wells will verify hydraulic connection, but the amount may vary because of the distance from the pumping wells, pumping rates, and hydraulic conductivity. To investigate vertical confinement or hydraulic isolation between the production zone and upper and lower aquifers, water levels in upper or lower aquifers may also be monitored during the pumping tests.

(5) The applicant defines operational approaches for the monitoring program. The monitoring program must indicate which wells will be monitored for excursion indicators, the monitoring frequency, and the criteria for determining when an excursion has occurred. An acceptable excursion monitoring program should indicate that all monitor wells will be sampled for excursion indicators at least every 2 weeks during *in situ* leach operations.

An excursion is deemed to have occurred if two or more excursion indicators in any monitor well exceed their upper control limits. A verification sample must be taken within 48 hours after results of the first analyses were received. If the second sample does not indicate that upper control limits were exceeded, a third sample must be taken within 48 hours after the second set of sampling data was acquired. If neither the second nor the third sample indicates that upper control limits are exceeded, the first sample is considered in error, and the well is removed from excursion status. If either the second or third sample contains indicators above upper control limits, an excursion is confirmed, the well is placed in excursion status, and corrective action must be initiated.

Generally, the risk of contamination to surface-water bodies from *in situ* leach operations is low when proper operational procedures are followed. Any surface-water body that lies within the proposed license boundary should be sampled at upstream and downstream locations, both before and during operations. The reviewer should ensure that pre-operational water quality sampling locations for applicable surface-waters are indicated in the application. The pre-operational data should be collected on a seasonal basis for a minimum of 1 year before *in situ* leach operations. Procedures for monitoring surface-water quality during operations should be discussed in the application: this discussion must include a monitoring schedule, monitor locations, and a list of sampled constituents. The applicant may be exempted from monitoring during operations if the site characterization demonstrates that no significant flow of ground water to surface water occurs near the site (e.g., if surface-water bodies are perched and ephemeral).

The excursion monitoring operational procedures must also include corrective action and notification plans in the event of an excursion. NRC must be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions, and the corrective action results must be submitted to NRC within 60 days of the excursion confirmation. If wells are still on excursion status when the report is submitted, the report must also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the case of a vertical excursion, the report must contain a projected date when characterization of the extent of the vertical excursion would be completed.

Corrective action to retrieve horizontal excursions within the production-zone aquifer is generally accomplished by adjusting the flow rates of the pumping/injection wells to increase process bleed in the area of the excursion. Vertical excursions have proven more difficult to retrieve: at some *in situ* leach facilities, vertical excursions have persisted for years. If an excursion is not corrected within 60 days of confirmation, applicants must either terminate injection of lixiviant into the well field until the excursion is retrieved, or provide an increase to the reclamation surety in an amount that is agreeable to NRC and that would cover the expected full cost of correcting and cleaning up the excursion. The surety increase must remain in force until the excursion is corrected. The written 60-day excursion report should state and justify which course of action will be followed.

If wells are still on excursion status at the time the 60-day report is submitted to NRC, and the surety option is chosen, the well field restoration surety will be adjusted upward. To calculate the increase in surety for horizontal excursions, it is assumed that the entire thickness of the aquifer between the well field and the monitor wells on excursion has been contaminated with lixiviant. The width of the excursion is assumed to be the distance between the monitor wells on excursion status plus one monitor well spacing distance on either side of the excursion. When the excursion is corrected, the additional surety requirements resulting from the excursion will be removed.

To calculate the increase in surety for vertical excursions, an initial estimate of the area contaminated is made. All estimates assume that the entire thickness of the aquifer is contaminated. As characterization of the extent of contamination proceeds, the surety may be increased or decreased, as appropriate. Once the extent of contamination is determined, the area contaminated above background is used to calculate the level of surety. When the vertical excursion is cleaned up, the additional surety requirements resulting from the excursion are removed.

In calculating the increase in surety bonding for horizontal and vertical excursions, the same formula used to calculate the number of pore volumes required to restore a well field is applied to the assumed areas of contamination. This approach is consistent with 10 CFR Part 40, Appendix A, Criterion 9. Increased surety provides assurance that cleanup will be accomplished in the event of licensee default, and surety can be adjusted downward once cleanup is complete. In calculating the area affected by an excursion and the volume of water required to effect restoration, a conservative estimate is taken to ensure that adequate funds are available to clean up the ground water should the licensee fail to do so.

Corrective action for vertical and horizontal excursions can be determined complete when all excursion indicators are below their respective upper control limits, or if only one excursion indicator exceeds its respective upper control limit by less than 20 percent. Stability in the excursion indicator concentrations must be demonstrated by measurements over a suitable time period before the corrective action measures can be discontinued.

(6) If an *in situ* leach facility is located adjacent to bodies of surface-water, the applicant must establish a surface-water monitoring program that will be effective to detect migration of contaminants into surface-water bodies . Alternatively, the applicant may demonstrate that the risk of contamination from *in situ* leach activities is negligible or that potential releases are within limits set by the Safe Drinking Water Act.

5.7.8.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the ground-water and surface-water monitoring programs, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the ground-water and surface-water monitoring programs at the ________________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.8.2 and the acceptance criteria outlined in standard review plan Section 5.7.8.3.

The applicant has established acceptable ground-water and surface-water monitoring programs at the ________________ *in situ* leach site. The applicant has established acceptable well field baseline sampling programs including the number and timing of samples, constituents sampled, and appropriate statistical methods to remove outliers. The applicant has selected acceptable excursion indicator constituents and an approach for establishing upper control limits. Appropriate criteria are used to establish monitor well locations for all aquifers likely to be affected. Appropriate well field test procedures are established. The applicant has defined acceptable operational approaches for the ground-water and surface-water monitoring programs, including identifying appropriate wells for monitoring for excursion indicators, monitoring frequency, and criteria for determining the presence of an excursion. The applicant has defined an acceptable sampling program for any surface-water body that lies within the facility boundary, including downstream sampling locations and standard approaches for monitoring with a schedule and a list of analyzed constituents. The applicant has prepared an acceptable ground-water and surface-water corrective action plan, including notification of NRC and subsequent reporting in the event of an excursion.

Based on the information provided in the application and the detailed review conducted of the ground-water and surface-water monitoring programs at the ______________ *in situ* leach facility, the staff concludes that the ground-water and surface-water monitoring programs are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; and 10 CFR 40.31, which defines requirements for applications for specific licenses. The ground-water and surface-water monitoring programs are also in compliance with 10 CFR Part 40, Appendix A, Criteria 5B(1), 5B(5), and 5C, which provide concentration limits for contaminants; 10 CFR Part 40, Appendix A, Criterion 5D, which requires a ground-water corrective action program; and 10 CFR Part 40, Appendix A, Criteria 7 and 7A, which require ground-water monitoring programs.

Pre-operational monitoring is conducted as part of site characterization and is addressed in Section 2 of this technical evaluation report, whereas restoration monitoring is conducted during ground-water restoration and is addressed in Section 6 of this technical evaluation report.

5.7.8.5 References

American Society for Testing and Materials. "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring." Designation D6312–98. West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1998.

———. "Standard Practice for Dealing with Outlying Observations." Designation E178. West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1994.

———. "Standard Guide for Sampling Groundwater Monitoring Wells." Designation D4448–85a. West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1992.

Deutsch, W.J., et al. NUREG/CR–3709, "Method of Minimizing Ground-Water Contamination From *In Situ* Leach Uranium Mining." Washington, DC: NRC. 1985.

EPA. "Statistical Analysis of Ground-Water Monitoring Data at RCRA (Resource Conservation and Recovery Act) Facilities, Interim Final Guidance." EPA/530–SW–89–026. Washington, DC: EPA. 1989.

Hem, J.D. “Study and Interpretation of the Chemical Characteristics of Natural Water.” USGS Water Supply Paper 2254. Third edition. Reston, Virginia: U.S. Geological Survey. 1985.

NRC. NUREG/CR–6733, “A Baseline Risk-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licensees.” Washington, DC: NRC. 2001.

———. NUREG–1475, “Applying Statistics.” Washington, DC: NRC. 1994.

———. NUREG/CR–4604, “Statistical Methods for Nuclear Material Management.” Washington, DC: NRC. 1988.

Staub, W.P., et al. NUREG/CR–3967, “An Analysis of Excursions at Selected *In Situ* Uranium Mines in Wyoming and Texas.” Washington, DC: NRC. 1986.

5.7.9 Quality Assurance

5.7.9.1 Areas of Review

The staff should review the quality assurance programs proposed for all radiological, effluent, and environmental (including ground water) monitoring programs.

5.7.9.2 Review Procedures

The staff should determine whether the quality assurance program proposed by the applicant is sufficient to limit radiation exposures and radioactive releases to as low as is reasonably achievable and is in conformance with regulatory requirements identified in 10 CFR Part 20. The staff should determine if the quality assurance programs proposed for all radiological, effluent, and environmental (including ground water) monitoring are in accordance with Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills, Revision 1 (NRC, 1980) and Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Normal Operations)—Effluent Streams and the Environment, Revision 1” (NRC, 1979).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

5.7.9.3 Acceptance Criteria

The quality assurance program is acceptable if it meets the following criteria:

(1) The quality assurance program has been established and applied to all radiological, effluent, and environmental programs. The proposed quality assurance plan should be consistent with guidance provided in Regulatory Guide 4.14, Section 3 and 6 (NRC, 1980) and Regulatory Guide 4.15 (NRC, 1979).

Operations

(2) All reporting and record keeping will be done in conformance with the criteria presented in Section 5.3.2 of this standard review plan.

Note that under the existing 10 CFR Part 20 requirements, a licensee must retain survey and calibration records for 3 years instead of the 2 years mentioned in Regulatory Guide 4.15 (NRC, 1979). Furthermore, existing 10 CFR Part 20 requirements have been updated to include a requirement that all licensees maintain records used to demonstrate compliance and evaluate dose, intake, and releases to the environment until NRC terminates the license.

(3) For license renewal applications, the historical quality assurance program results are included through the most recent reporting period preceding the submittal of the application. The effectiveness of the historical program is discussed with regard to all applicable 10 CFR Part 20 regulatory requirements. Long-term trends are discussed, and any short-term deviations from the long-term trend are explained.

5.7.9.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the quality assurance program, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the quality assurance program at the ______________ *in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.9.2 and the acceptance criteria outlined in standard review plan Section 5.7.9.3.

The applicant has established an acceptable quality assurance program at the ______________ *in situ* leach site. The quality assurance program has been applied to all radiological, effluent, and environmental programs consistent with Regulatory Guides 4.14 (NRC, 1980) and 4.15 (NRC, 1979). The applicant has agreed to retain survey and instrument calibration records for 3 years and to retain records to demonstrate compliance and evaluate dose, intake, and releases to the environment until NRC terminates the license.

Based on the information provided in the application and the detailed review conducted of the quality assurance program at the ________________ *in situ* leach facility, NRC staff concludes that the quality assurance program is acceptable and is in compliance with 10 CFR 20.1101, which provides requirements for radiation protection programs; 10 CFR Part 20, Subpart L, which specifies record keeping requirements; and 10 CFR Part 20, Subpart M, which defines reporting and notification requirements.

5.7.9.5 References

NRC. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1980.

———. Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Normal Operations)—Effluent Streams and the Environment.” Revision 1. Washington, DC: NRC, Office of Standards Development. 1979.

6.0 GROUND-WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Ground-Water Quality Restoration

In conducting these evaluations, the reviewer should consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. The desired outcome is to identify any areas where duplicative NRC reviews may be reduced or eliminated. The NRC staff must make the necessary evaluations of compliance with applicable regulations for licensing the facility. However, the reviewer may, as appropriate, rely on the applicant's responses to inquiries made by a state or another federal agency to support the NRC evaluation of compliance. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

Some of the review methods and acceptance criteria in the following sections are more rigorous than those previously used by the NRC staff. They provide increased confidence in the adequacy of ground-water restoration plans and the sureties associated with them.

Technical assessment of the selected ground-water restoration methods, restoration time and pore volume displacements, and sureties may entail use of detailed, small-scale process models to large-scale, simplified models. Small-scale process models are generally used to evaluate potentially important complexities and mechanisms that govern the evolution of the contaminated areas, while large-scale, simplified models generally consider fewer complexities but may be suitable for evaluating average or effective processes for large areas. Model adequacy should be evaluated regardless of the level of complexity.

This review should be coordinated with the site hydrologic characteristics review conducted using Section 2.7 of this standard review plan.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.1.1 Areas of Review

The staff should review the following aspects of the ground-water quality restoration program:

(1) Ground-water modeling used to estimate restoration time and the extent of uncertainties in processes and data. Specifically, the modeling review should include:

   (a) Techniques used to collect data on the geology, hydrology, geochemistry, processes, plume geometry/extent

   (b) Technical bases for evaluating effects of the geology, hydrology, geochemistry, processes, and physical phenomena on flow and transport pathways

   (c) Consistency and adequacy of model assumptions

(d) Technical bases for the concentrations of contaminants

(e) Sufficiency of data and selection of model parameters and simplifications

(f) Evaluation of uncertainty associated with model parameters

(g) Model results compared to more detailed model results or site data (i.e., model validation)

(2) Estimates of the concentrations and lateral and vertical dispersion of those chemicals that may persist in leached-out well field production zones after termination of *in situ* leaching operations and before restoration activities.

(3) Descriptions of proposed methods and techniques to be used to restore ground-water quality, including identification of *in situ* chemical reactions that may hinder or enhance restoration.

(4) A schedule for sequential restoration of well fields.

(5) Descriptions of the expected post-reclamation conditions and quality of restored ground waters, compared with the pre-operational water quality characteristics, and any prior experience restoring ground water at the site.

(6) Adverse effects of the proposed water quality restoration operations on ground waters outside production zones.

(7) Procedures to be used for plugging, sealing, capping, and abandoning wells.

(8) Methods of effluent disposal, such as deep-well injection, discharge to surface water, and land application.

6.1.2 Review Procedures

The staff should review plans and schedules for ground-water quality restoration, and perform the following actions:

(1) If numerical ground-water flow or transport modeling is used to support or develop the ground-water restoration plans, examine the descriptions of features, physical phenomena, and the geological, hydrological, and geochemical aspects of the modeled aquifers. The staff should verify that the descriptions are adequate and that the conditions and assumptions used in the modeling are realistic or reasonably conservative and supported by the body of data presented in the descriptions.

Evaluate the sufficiency of data used to support model input parameter values. Data sources may include a combination of techniques such as laboratory experiments, aquifer hydraulic testing and water level measurements in wells, geochemical analyses, or other site-specific field measurements.

Evaluate the technical bases for parameter ranges, probability distributions, or bounding values. The reviewer should determine whether the parameter values are derived from either site-specific data, or an analysis to show assumed parameter values bound data uncertainty in a manner that is not overly optimistic.

Evaluate whether there are aspects of the model where additional data could provide new information that could invalidate the modeling results and significantly affect the ground-water restoration plan. For example, if constant head boundary conditions are used in a numerical ground-water flow model, could additional wells or sampling during a different season result in a significantly different interpretation of model boundary conditions? If so, is a different interpretation of boundary conditions likely to significantly alter model results used to develop or support the restoration plan?

Examine the initial conditions and boundary conditions used in any numerical modeling for consistency with available data. The staff should also consider the potential importance of temporal and spatial variations in boundary conditions and source terms used to support the ground-water restoration plan.

Evaluate the applicant’s assessment of uncertainty and variability in model parameters. The reviewer should determine whether uncertainty in both temporal and spatial parameter variability is incorporated into or bounded by parameter values.

Examine the technical bases for the identification of post-extraction changes to ground-water quality. The staff should examine how the evolution of water quality has been incorporated into estimates of restoration time or the number of pore volumes required to attain restoration goals.

Examine the assumptions used to develop any model of reactive transport that accounts for site geochemical processes, such as sorption or any other geochemical reaction, that reduce concentrations of, or retard, contaminants. The modeling should consider available data about the native ground-water downgradient of the production areas, the geochemical environment, hydraulic and transport properties, and the spatial variations of aquifer properties and ground-water volumetric fluxes along the flow paths.

Evaluate the estimated restoration time or required number of pore volume displacements for consistency with the output from any numerical model of ground-water restoration.

The reviewer should evaluate whether the applicant has appropriately reduced the dimensionality and complexity of models. The dimensionality of models, heterogeneity of aquifer parameters, and significant process couplings may be reduced if it is shown that the reduced and simplified dimension model bounds the prediction of the full dimension model. The staff should evaluate the acceptability of the sensitivity analyses used to support the model of the ground-water restoration and the estimation of restoration time and pore volume displacements.

Where appropriate, the reviewer may use an alternative model to perform an independent technical assessment of ground-water restoration.

(2) Evaluate estimates of post-extraction ground-water quality by comparison to descriptions of lixiviant composition and host rock geochemistry. Ensure that methods for estimating the affected pore volume are consistent with the methods used at any research and development site or other sites upon which restoration estimates may be based.

(3) Compare descriptions of the proposed restoration methods with those methods that have been successfully applied at other *in situ* leaching facilities. Sources of information can include research and development and production sites that are located in similar hydrogeologic environments and have used similar restoration techniques. However, the applicant is not required to present operational experience from a research and development facility as part of an application. Ensure that the proposed restoration methods are appropriate for the host rock and lixiviant chemistry.

(4) Assess whether the applicant has provided a reasonable standard for the determination of restoration success and a realistic assessment of the expected post-restoration water quality by comparing standards with previous restoration work at the research and development site or other previously restored *in situ* leaching facilities.

(5) Evaluate the ability of the post-reclamation stability monitoring program to verify successful restoration.

(6) Consider whether the proposed restoration program adequately addresses water quality cleanup because of well field flare (undetected spread of extraction solutions between the well field and monitor wells of the production zone), and whether the quantity of water pumped during restoration will adversely affect off-site ground-water uses.

(7) Assess whether plans for plugging and abandoning wells before license termination are consistent with generally accepted techniques.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.1.3 Acceptance Criteria

The primary purpose of restoring the ground-water quality in a well field after the completion of uranium extraction operations is to assure the protection of public health and the environment. NRC shares the regulatory oversight of ground-water restoration with the EPA under its

Underground Injection Control Program (40 CFR Part 144) and those underground injection control programs administered by EPA Authorized States. In addition to the NRC license, the EPA Authorized States issue underground injection control permits for *in situ* leaching operations, after the EPA grants an exemption from ground-water protection provisions for the portion of the aquifer undergoing uranium extraction (the exploited ore zone in an aquifer). The EPA aquifer exemption effectively removes that portion of the aquifer from any future consideration for ground-water protection; however, the ground-water protection provisions are still in effect for the aquifer adjacent to the exempted area. The EPA Authorized State may impose ground-water restoration requirements that are more stringent than the delegated federal program. Ground-water restoration requirements may vary from state to state. The reviewer is advised to closely coordinate the NRC licensing review activities with the underground injection control permitting programs of EPA Authorized States to avoid unnecessary duplication of effort. The following acceptance criteria should serve as the minimum requirements for demonstrating acceptability for the NRC licensing review.

The plans and schedules for ground-water quality restoration are acceptable if they meet the following criteria:

(1) The application includes estimates of the volume and quality of extraction solutions that need to be cleaned up during ground-water restoration. Generally, these estimates may be based on either experience with previous *in situ* leach operations or research and development investigations in similar host rock. Documentation of such prior experience should be included or referenced in the application. The applicant may also use numerical or analytical ground-water flow and transport modeling to support development of the ground-water restoration plan. When flow and transport modeling is used, the applicant must provide data and model justification to demonstrate that conclusions used to develop the restoration plan are reasonable. Data and model justification must meet the following criteria.

    Important design features, physical phenomena, and consistent and appropriate assumptions are identified and described sufficiently for incorporation into the modeling that supports the ground-water restoration plan.

    The applicant provides sufficient data to justify the selection of models used to develop the ground-water restoration plan and to adequately define model parameters, initial and boundary conditions, and any simplifying assumptions.

    Parameter values, assumed ranges, probability distributions, and/or bounding assumptions used in modeling ground-water restoration are technically defensible and reasonably account for uncertainties and variabilities. The technical bases for each parameter value, ranges of values, or probability distributions used in the modeling ground-water restoration are provided.

    In the case of sparse data and/or low confidence in the quality of available data or parameter estimates, the applicant demonstrates by sensitivity analyses or other methods that the proposed ground-water restoration approach is appropriate, and the contingency built into the surety is consistent with the uncertainties.

For reactive transport models, adequate site geochemical data are provided to support the ground-water restoration plans and models. Water chemistry data are needed to develop an understanding of geochemical evolution as ground water is restored in the subsurface. The important geochemical parameters that should be delineated include pH, Eh, dissolved oxygen, temperature, major cation and anion concentrations, concentrations of potential contaminants, and host-rock mineralogy.

Reactive transport models incorporate thermodynamic data on solid phases and aqueous species, allowing the mass action calculations that determine estimated aqueous concentrations and solid phase evolution. Thermodynamic parameters constitute a major source of uncertainty in geochemical modeling, with potentially large effects on predicted aqueous ion concentrations. Therefore, geochemical modeling supporting ground-water restorations should include sensitivity analyses that provide assurance that contaminant concentrations will not be underestimated. Likewise, any kinetic models employed are subjected to critical analysis because of the large influence of kinetic effects at low temperatures. Additionally, consideration of geochemical model limitations and their effects on uncertainty is an important component of the review by the NRC. Such limitations include: the assumption of local equilibrium, neglect of porosity changes caused by precipitation or dissolution of the solid phase, omitting colloidal transport; neglect of density effects due to varying total dissolved solids, simplifying the mineralogical suite, and neglecting surface reactions such as ion exchange.

The applicant documents how the model output is validated in relation to site characteristics.

(2) The applicant describes the method used for estimating well field *pore volume*[1] and the associated horizontal and vertical *flare.*[2]

A pore volume is an indirect measurement of a unit volume of aquifer water affected by *in situ* leach extraction. It represents the volume of water that fills the void space inside a certain volume of rock or sediment. Typically, a pore volume is calculated by

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[1]*Pore volume* is a term of convenience used by the *in situ* leach industry to describe the quantity of free water in the pores of a given volume of aquifer material. It provides a unit reference that an operator can use to describe the amount of lixiviant circulation needed to leach an ore body, or describe the unit number of treated water circulations needed to flow through a depleted ore body to achieve restoration. A pore volume provides a way for an operator to use relatively small-scale studies and scale the results to field-level pilot tests or to commercial well field scales.

[2]*Flare* is a proportionality factor designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the extraction phase. The flare is usually expressed as a horizontal and vertical component to account for differences between the horizontal and vertical hydraulic conductivity of an aquifer material.

multiplying the surficial area of a well field (the area covered by injection and recovery wells) by the thickness of the production zone being exploited and the estimated or measured porosity of the aquifer material. The horizontal and vertical flares are usually expressed as additional percentages that are multiplied to the calculated pore volume. Specific flare factors approved in the past vary from 20 to 80 percent and are typically based on experience from research and development pilot demonstrations. The pore volume and flare factors provide a means of comparing the level of effort required to restore ground water regardless of the scale of the test. In general, the more pore volumes of water it takes to restore ground-water quality, the more effort it will cost to achieve restoration.

(3) The application includes well field restoration plans.

Restoration plans contain descriptions of the process to be used for well field restoration and projected completion schedules. This description should include restoration flow circuits, treatment methods, methods for disposal or treatment of wastes and effluents, monitoring schedules, a discussion of chemical additives used in the restoration process, anticipated effects of chemical additives, and alternate techniques that may be employed in the event that primary plans are not effective. Typically, restoration is divided into distinct sequential phases in which different techniques are employed. Ground-water sweep is used to pump water from the ore zone without reinjecting, to recall lixiviant from the aquifer and draw in surrounding uncontaminated water. Reverse osmosis/permeate injection circulates water from the well field through a reverse osmosis treatment process and reinjects the permeate into the well field, typically at rates similar to those used during production. Ground-water recirculation is used to evenly distribute water throughout the restored well field, to dilute any pockets of remaining contamination. An additional acceptable restoration method is the injection of chemical reductants (usually hydrogen sulfide, sodium sulfide, or sodium bisulfide) into the well field. These reductants are used to immobilize metals that may have been dissolved by the oxidizing lixiviant; however, some general water quality parameters, such as total dissolved solids, may be adversely affected by reductants.

NRC allows flexibility and innovation in approaches to restoration. Therefore, applicants are not limited to one restoration method for all well fields. Rather, they should describe the sequential phases of restoration that may be used and the most likely restoration scenario, based on research and development results and restoration experience. Other restoration approaches, such as in-place biological remediation techniques, have been discussed by some applicants. These techniques show promise, but have not been tested or evaluated at commercial scale *in situ* leach operations. The application of other restoration techniques may necessitate some form of pilot demonstration to evaluate the potential for unanticipated impacts, such as clogging of aquifer pore spaces or potential health impacts from introduced compounds and organisms, before the techniques are applied to full-scale operations.

Restoration plans should also include a list of monitored constituents, a monitoring interval, and the sampling density (wells/acre). An acceptable constituent list should be based on the chemistry of the production and restoration solutions used and on the host rock geochemistry. In the interest of minimizing expense, the applicant may propose a limited set of indicator constituents to monitor restoration progress and a sampling density that does not include all production and injection wells. The applicant may also propose monitoring composite samples from the restoration stream. However, all wells that were sampled for baseline conditions should be sampled for the full list of monitored constituents before a determination of restoration success is made.

The applicant should specify the criteria that will be used to determine restoration success. Generally, the acceptance criteria for restoration success are based on the ability to meet the predetermined numerical standards of the restoration program and the absence of a significant increasing trends of monitored indicator constituent concentrations during the stability monitoring period.

For purposes of surety bonding, restoration plans must include estimates of the level of effort (typically in terms of pore volume displacements) necessary to achieve the primary restoration target concentrations. These estimations may be based on historical results obtained from the research and development site or experience in other well fields having similar hydrologic and geochemical characteristics.

(4) Restoration standards are established in the application for each of the monitored constituents.

The applicant has the option of determining numerical restoration limits for each monitored constituent on a well-by-well basis, or as a statistical average applied over the entire well field. Restoration standards must be established for the production zone and for any overlying or underlying aquifers that have the potential to be affected by *in situ* leach solutions.

(a) Primary Restoration Standards—The primary goal of a restoration program is to return the water quality within the exploited production zone and any affected aquifers to pre-operational (baseline) water quality conditions. Recognizing that *in situ* leach operations fundamentally alter ground-water geochemistry, restoration activities are likely to return ground-water quality to the exact water quality that existed at every location prior to *in situ* leach operations. Still, as a primary restoration goal, licensees are required to attempt to return the concentrations of the monitored water quality indicator constituents to within the baseline range of statistical variability for each constituent. This standard requires licensees to identify the type of statistical analysis and criteria that will be used to determine whether concentrations of water quality parameters in the affected aquifers fall within an acceptable range of baseline variability. Statistical approaches for determining whether contamination persists in affected aquifers are found in American Society for Testing and Materials Standard D 6312 (American Society for Testing and Materials, 2001).

(b) Secondary Restoration Standards—*In situ* leach operations may cause permanent changes in water quality within the exploited production zone, because the *in situ* leach extraction process relies on changing the chemistry in the production zone to remove the uranium. The applicant may therefore propose returning the water quality to its pre-operational class of use (e.g., drinking water, livestock, agricultural, or limited use) as a secondary restoration standard. Applications should state the principal goal of the restoration program and that secondary standards will not be applied so long as restoration continues to result in significant improvement in ground-water quality. The applicant must first attempt to return ground-water quality to primary restoration standards before falling back on secondary restoration standards. License conditions should be set up such that a license amendment is necessary before the applicant can revert to secondary goals. The applicant must commit to use reasonable efforts to reach primary restoration standards.

It is acceptable to establish secondary restoration standards on a constituent-by-constituent basis, with the numerical limits established to ensure state or EPA primary or secondary drinking water standards will not be exceeded in any potential source of drinking water. For radionuclides not included in the drinking water standards, it is acceptable to determine, on a constituent-by-constituent basis, secondary standards from the concentrations for unrestricted release to the public in water, from Table 2 of 10 CFR Part 20, Appendix B.

(c) If a constituent cannot technically or economically be restored to its secondary standard within the exploited production zone, an applicant must demonstrate that leaving the constituent at the higher concentration would not be a threat to public health and safety or the environment or produce an unacceptable degradation to the water use of adjacent ground-water resources. This situation might arise with respect to general water quality parameters such as the total dissolved solids, sulfate, chloride, iron, and others which do not typically present a health risk. However, not all the major constituents have a primary or secondary drinking water standard (e.g., bicarbonate, carbonate, calcium, magnesium, and potassium). Consequently, ground-water restoration may achieve the secondary standard for total dissolved solids, but may not achieve a secondary standard for individual major ions that contribute to total dissolved solids. If such a situation occurred, the applicant must show that leaving the individual constituent at a concentration higher than secondary standard would not be a threat to public health and safety nor the environment or produce an unacceptable degradation to the water use of adjacent ground-water resources. Such proposed alternatives must be evaluated on a case-by-case basis as a license amendment request only after restoration to the primary or secondary standard is shown not to be technically or economically achievable. This approach is consistent with the as low as is reasonably achievable philosophy that is used broadly within NRC.

(5) The post-restoration stability monitoring program is described in the application.

The purpose of a stability monitoring program is to ensure that chemical species of concern do not increase in concentration subsequent to restoration. The applicant should specify the length of time that stability monitoring will be conducted, the number of wells to be monitored, the chemical indicators to be monitored, and the monitoring frequency. These requirements will vary based on site-specific post-extraction water quality and geohydrologic and geochemical characteristics. Before final well field decommissioning is completed, all designated monitor wells must be sampled for all monitored constituents. Well fields may be decommissioned when all constituent concentrations meet approved restoration standards and no post-restoration degradation in ground-water quality occurs outside of the aquifer exemption boundary.

(6) The application includes a discussion of the likely external effects of ground-water restoration.

Ground-water restoration operations, and the expected post-reclamation ground-water quality, must not adversely affect ground-water use outside the exploited production zone. Water users from nearby municipal or domestic wells that were in use before *in situ* leach operations should be provided reasonable assurance that their water quality will not be impacted. Impacts are not limited to chemical constituent concentrations, but also include changes in color, odor, hardness, and taste of the water. The water quality outside the exploited production zone should not, as a result of *in situ* leach operations, exceed EPA primary or secondary drinking water standards for ground water. Ground-water quality should not exceed the appropriate state water-use standards for aquifers that cannot support a drinking water use.

(7) Methods for abandoning wells are included in the application.

The basic purpose for sealing abandoned wells and bore holes is to restore the well field to pre-operational hydrogeologic conditions. Any well or bore hole to be permanently abandoned should be completely filled in such a manner that vertical movement of water along the borehole is prevented. *In situ* leach operators usually rely on a drilling contractor to perform well abandonment. The application should specify the methods and materials to be used to plug holes, and that records documenting the well abandonment will be maintained by the licensee. Abandonment procedures that: (i) conform to American Society for Testing and Materials Standard D 5299 (1992); (ii) are from the State Engineer's Office; or (iii) are codified in state regulations or rules are considered acceptable. An applicant may propose other generally accepted standards for abandoning wells and boreholes. References for these standards should be specified in the application and copies should be kept on file by the applicant. Techniques proposed by the applicant that are not considered to be generally accepted abandonment practices should be described in detail and may require additional time for review.

(8) Descriptions of water consumption impacts.

During *in situ* leach operations, water quality impacts usually are more of a concern than water consumption impacts. This is because water consumption during *in situ* leach operations is relatively small. However, when restoration activities begin, water consumption may significantly increase. The amount of increase will depend on the restoration techniques applied. Techniques that clean up the aquifer by pumping water from the aquifer, cleaning the water, and reinjecting the clean water consume the least amount of water. Water consumption impacts will result in water loss from the aquifer and water level declines. The impacts of water consumption on local wells and water users should be evaluated. Water level declines can result in increased pumping costs or inability to obtain water from the aquifer in local wells. Water loss from the aquifer may mean that less water could be available to down gradient ground-water and surface-water users.

(9) The applicant may propose alternatives to restoring an exploited production zone to primary or secondary ground-water restoration standards in lieu of the above criteria. These alternatives must be evaluated on a case-by-case basis and must assure protection of human health and the environment and assure no unacceptable degradation to adjacent ground-water resources. As an example, if an applicant proposes no ground-water restoration activities within the exploited production zone, the applicant would be required to show that adequate institutional control provisions are in place to assure potential water supplies adjacent to the exploited production zone would not be accessed for a use that would harm human health or the environment. If predictive computer modeling is used to support this alternative, the model must be validated by comparing the modeling results to ground-water monitoring for an appropriate period of time after *in situ* leach operations cease in a well field. The applicant must maintain a financial surety to cover potential restoration costs in the event that monitoring results are contrary to model predictions and ground-water restoration must be initiated.

6.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the plans and schedules for ground-water quality restoration, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans and schedules for ground-water quality restoration proposed for use at the ________________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the ground-water restoration program and schedules using the review procedures in standard review plan Section 6.1.2 and the acceptance criteria outlined in standard review plan Section 6.1.3.

The applicant has committed to adopt well field ground-water restoration standards that are representative of the pre-operational baseline ground-water conditions. As a secondary restoration goal, the applicant has identified and committed to ensure federal or state drinking water standards will not be exceeded outside of the aquifer exemption boundary as a result of operations.

The applicant's method for estimating well field pore volume is acceptable, taking into account the estimated effective porosity of the contaminated region and the lateral and vertical extent of contamination. With respect to the methodology for undertaking restoration, the applicant provided an acceptable approach that includes a mix of ground-water sweep, reverse osmosis, and ground-water recirculation. The well-field-specific mix of these approaches will be determined as part of the ground-water restoration plan for each individual well field. In addition, the applicant has proposed an acceptable method for determining the extent of well field flare and for ensuring acceptable restoration of the flare. The applicant has committed to an acceptable schedule for complete restoration for any well field after ore extraction ceases.

The applicant has presented an acceptable list of indicator constituents to be monitored and has specified acceptable criteria to determine the success of restoration either on a well-by-well or well field average basis. The number of pore volume replacements necessary to achieve the primary restoration targets has been provided and is acceptable. The applicant has adopted a primary restoration program that will return the water quality of the production zone and affected aquifers to pre-extraction (baseline) water quality, that any secondary restoration standards proposed by the applicant are acceptable, or that final water quality will protect public health and safety and the environment in compliance with as low as is reasonably achievable principles. The applicant's post-restoration stability monitoring program is acceptable.

The methods proposed for abandoning wells and sealing them to restore the well field to pre-extraction hydrologic conditions are acceptable. The applicant has evaluated the consumptive water impacts of the *in situ* leach facility using acceptable methods.

Based on the information provided in the application and the detailed review conducted of the plans and schedules for ground-water quality restoration for the _______________ *in situ* leach facility, the staff concludes that the proposed plans and schedules for ground-water quality restoration are acceptable and are in compliance with 10 CFR 40.32(c), requiring the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), requiring that the issuance of the license will not be adverse to the common defense and security or to the health and safety of the public; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis. The related reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

6.1.5 References

American Society for Testing and Materials. “Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs, Designation: D6312.” West Conshohocken, Pennsylvania: American Society for Testing and Materials. 2001.

———. “Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, and Other Devices for Environmental Activities, Designation: D 5299.” West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1992.

6.2 Plans For Reclaiming Disturbed Lands

6.2.1 Areas of Review

Prior to commencement of reclamation, the licensee will provide the NRC with maps and data that document the post-operational condition. The staff should also review plans for (i) reclaiming temporary diversion ditches and impoundments, (ii) reestablishing surface drainage patterns disrupted by the proposed activities, and (iii) returning the ground surface and structures for post-operational use (i.e., license termination), in accordance with the criteria in Section 6.4 of the standard review plan.

Staff should review the pre-remediation radiological survey program that will identify areas of the site that need to be cleaned up to comply with NRC concentration limits. The staff should evaluate measurement techniques and sampling procedures proposed for determining the radionuclide concentrations and the extent of contamination of structures and soils. In addition, the review should confirm that the licensee will have an approved decommissioning radiation protection program in place before the start of reclamation and cleanup work and that an acceptable agreement is in place for off-site disposal of 11e.(2) byproduct material.

6.2.2 Review Procedures

The staff should determine whether the described approaches for reclaiming temporary diversion ditches and impoundments, reestablishing surface drainage patterns disrupted by the proposed activities, and returning the ground surface and structures for post-operational use are consistent with regulatory guidance and are sufficient to satisfy the requirements of 10 CFR Part 40, Appendix A, Criterion 6(6), and 10 CFR 40.42. The staff should ensure that the licensee intends to restore topography and vegetation to a state that is similar to pre-operational conditions. The staff should review the pre-reclamation survey plan to ensure that it provides adequate coverage to designate contaminated areas for cleanup. Particular attention should be focused on sampling temporary diversion ditches and surface impoundments, well field surfaces, process and storage areas, transportation routes, and operational air monitoring locations. These areas are expected to have higher levels of contamination than surrounding areas. The staff should also ensure that plans exist for the disposal of contaminated soils at an existing licensed byproduct material disposal facility, consistent with 10 CFR Part 40, Appendix A, Criterion 2. The staff should confirm that the licensee has an approved radiological protection program to ensure worker safety during decommissioning, reclamation, and cleanup activities. Prior to commencement of reclamation, the NRC should review licensee commitments and any changes the licensee has proposed. The program for radiation protection is addressed in Section 5.7 of the standard review plan but additional review is needed to ensure any hazards specific to decommissioning are addressed (e.g., yellowcake dryer demolition). The staff should review the compliance history for the radiation safety program to identify any deficient areas that may require special consideration before the start of work.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.2.3 Acceptance Criteria

The plans for reclaiming disturbed lands are acceptable if they meet the following criteria:

(1) Appropriate cleanup criteria will be used in conducting the pre-reclamation surveys and planned cleanup activities. Acceptable cleanup criteria are discussed in standard review plan Sections 6.3 (for structures) and 6.4 (for soils).

(2) The pre-reclamation radiological survey program for buildings and soils identifies instruments and techniques similar to those used in the pre-operational survey program to determine baseline site conditions (e.g., background radioactivity) but also takes into account current technology (acceptable sensitivity), results from operational monitoring, and other information that provide insights to areas of expected contamination.

Survey areas should include diversion ditches, surface impoundments, well field surfaces and structures in process and storage areas, on-site transportation routes for contaminated material and equipment, and other areas likely to be contaminated. A sampling grid of 100 m^2 (for soil) should be used and a statistical basis for sample size should be provided. Acceptable methods for sampling are provided in NUREG–1575, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)” (NRC, 2000).

(3) The licensee provides the procedures for interpretation of the pre-reclamation survey results and describes how they will be used to identify candidate areas for cleanup operations. Acceptable survey methods are discussed in standard review plan Section 6.4, “Procedures for Conducting Post-Reclamation and Decommissioning Radiological Surveys.”

(4) The discussion of surface restoration includes a pre-construction surface contour map, a description of any significant disruptions to surface features during facility construction and operation, and a description of planned activities for surface restoration that identifies any important features that cannot be restored to the pre-operations condition.

(5) Any changes to the existing NRC-approved radiation safety program that are needed for decommissioning and reclamation work are identified with appropriate justification to assure continued safety for workers and the public. Acceptable approaches for the radiation safety program are evaluated in accordance with Section 5.7 of this standard review plan, "Radiation Safety Controls and Monitoring."

(6) The applicant has an approved waste disposal agreement for 11e.(2) byproduct material disposal at an NRC or NRC Agreement State licensed disposal facility. This agreement is maintained on site. The applicant has committed to notify NRC in writing within 7 days if this agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination. Failure to comply with this license condition will result in a prohibition from further lixiviant injection.

(7) The applicant commits to providing final (detailed) reclamation plans for land (soil) to the NRC for review and approval at least 12 months before the planned commencement of reclamation of a well field or licensed area. The final decommissioning plan includes a description of the areas to be reclaimed, a description of planned reclamation activities, a description of methods to be used to ensure protection of workers and the environment against radiation hazards.

(8) The decommissioning plan addresses the non-radiological hazardous constituents associated with the wastes according to 10 CFR Part 40, Appendix A, Criterion 6(7). Any unusual or extenuating circumstances related to such constituents should be discussed in the reclamation plan or decommissioning plan in relation to protection of public health and the environment and should be evaluated by staff.

(9) The quality assurance and quality control programs address all aspects of decommissioning. The programs should indicate a confidence interval or that one will be specified before collection of samples. The data to be used to demonstrate compliance and the quality assurance procedures to confirm that compliance data are precise and accurate are identified. Management will ensure that approved procedures are followed.

6.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the plans for reclaiming disturbed lands, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans for reclaiming disturbed lands proposed for use at the ______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the reclamation of disturbed lands program using the review procedures in standard review plan Section 6.2.2 and the acceptance criteria outlined in standard review plan Section 6.2.3.

The applicant has acceptable plans for a pre-reclamation radiation survey that use instrumentation and techniques similar to the pre-operational survey used to establish baseline site conditions, if these are still acceptable methods. The applicant has acceptably considered results from operational monitoring and other information relative to areas of expected contamination in its reclamation plans. Areas to be evaluated include diversion ditches, surface impoundments, well field surfaces, and structures in process and storage areas, on-site transportation routes, and other areas likely to be contaminated. The applicant has proposed acceptable methodology to determine areas to be resampled or sampled with higher than normal densities. The applicant has defined appropriate procedures for the pre-reclamation survey and the means used to identify areas for cleanup using the acquired data. Methods proposed for reclamation and an acceptable plan for surface restoration, including identification of any irreversible changes, have been provided. The applicant has assured NRC that any required changes to the radiation safety program identified as a result of the reclamation work will be implemented before commencing the work.

Based on the information provided in the application and the detailed review conducted of the plans for reclaiming disturbed lands for the _____________ *in situ* leach facility, the staff concludes that the proposed plans are acceptable and are in compliance with 10 CFR 40.32(c), which requires applicant proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.42(g)(4), which provides requirements for final decommissioning plans; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate non-proliferation of waste disposal sites; 10 CFR Part 40, Appendix A, Criterion 6(6), which identifies cleanup criteria requirements; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis.

The reclamation plan specifies the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and meets the criteria of 10 CFR 40.42(g)(4) and (5). The plan sufficiently demonstrates that the proposed reclamation activities will result in compliance with 10 CFR 40.42(j)(2) requirements to conduct a radiation survey. The plan complies with the 10 CFR 40.42(k)(1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination. The plan demonstrates the proposed reclamation activities will result in compliance with 10 CFR Part 40, Appendix A, Criterion 6(7) requirements to prevent threats to human health and the environment from non-radiological hazards.

6.2.5 Reference

NRC. NUREG–1575, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).” Revision 1. Washington, DC: NRC. 2000.

6.3 Removal and Disposal of Structures, Waste Materials, and Equipment

6.3.1 Areas of Review

The staff should review methodologies proposed for removal and disposal of contaminated structures and equipment used during *in situ* leach operations, as well as techniques for managing toxic and radioactive waste materials. The reviewers should also evaluate approaches for identifying radiological hazards before initiating dismantlement of structures and equipment and for detection and cleanup of removable contamination from such structures and equipment. The staff should also review plans for ensuring that all contaminated facilities and equipment are addressed and are either planned to be disposed of in a licensed facility, will meet the contamination levels for unrestricted use, or are designated for re-use at another *in situ* leach facility. The staff should also review provisions made for the removal and disposal of byproduct material to an existing uranium mill or licensed disposal site.

6.3.2 Review Procedures

The staff should determine whether the techniques proposed for removing and disposing of structures and equipment used during *in situ* leach operations and approaches for managing toxic and radioactive waste materials are consistent with regulatory guidance and sufficient to meet the applicable regulatory requirements in 10 CFR 40.42. Plans for structures and equipment to be released for unrestricted use should be reviewed using standard review plan Section 5.7.6, "Contamination Control Program." The staff should confirm that plans for dismantlement of structures and equipment include a preliminary assessment of anticipated hazards that should be considered before dismantlement. This should include the use of appropriate survey methods to determine the extent of contamination of equipment and structures before starting decommissioning and reclamation work. Particular attention should be focused on those parts of the processing system that are likely to have accumulated contamination over long time periods such as pipes, ventilation equipment, effluent control systems, and facilities and equipment used in or near the yellowcake dryer area. The staff should also review provisions made for the removal and disposal of byproduct material to an existing uranium mill or licensed disposal site to ensure that they meet requirements of 10 CFR Part 40, Appendix A, Criterion 2.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.3.3 Acceptance Criteria

The procedures for removing and disposing of structures, waste materials, and equipment are acceptable if they meet the following criteria:

(1) A program is in place to control residual contamination on structures and equipment.

(2) Measurements of radioactivity on the interior surfaces of pipes, drain lines, and duct work will be determined by making measurements at all traps and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, and ductwork.

(3) Surfaces of premises, equipment, or scrap that are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement are presumed to be contaminated in excess of the limits.

(4) Before release of structures for unrestricted use, the licensee makes a comprehensive radiation survey to establish that contamination is within the limits specified in standard review plan Section 5.7.6, “Contamination Control Program” and obtain NRC approval.

(5) A contract between the licensee and a waste disposal operator exists to dispose of 11e.(2) byproduct material.

(6) The applicant commits to providing final (detailed) decommissioning plans for structures and equipment to the NRC for review and approval at least 12 months before the planned commencement of decommissioning of such structures and equipment. The final decommissioning plan includes a description of structures and equipment to be decommissioned, a description of planned decommissioning activities, a description of methods to be used to ensure protection of workers and the environment against radiation hazards, a description of the planned final radiation survey, and an updated detailed cost estimate. A license condition will be established to this effect.

6.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the methodologies for removal and disposal of structures, waste materials, and equipment, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the methodologies for removal and disposal of structures and equipment used at the _______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the procedures for removal and disposal of structures, waste materials, and equipment using the review procedures in standard review plan Section 6.3.2 and the acceptance criteria outlined in standard review plan Section 6.3.3.

The applicant has established an acceptable program for the measurement and control of residual contamination on structures and equipment. The applicant has made acceptable plans for measurements of radioactivity on the interior surfaces of pipes, drain lines, and ductwork by making appropriate measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination. All premises, equipment, or scrap likely to be contaminated but that cannot be measured, will be assumed by the applicant to be contaminated in excess of limits and will be treated accordingly. For all premises, equipment, or scrap contaminated in excess of specified limits, the applicant will provide detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination. The applicant will provide a detailed health and safety analysis that reflects that the contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public nor the environment. The applicant plans to conduct a comprehensive radiation survey to establish that any contamination is within limits specified before the release of the premises, equipment, or scrap. A contract exists between the licensee and a licensed waste disposal site operator to dispose 11e.(2) byproduct material.

Based on the information provided in the application and the detailed review conducted of the methodologies for removal and disposal of structures, waste materials, and equipment for the _______________ *in situ* leach facility, the staff concludes that the methodologies are acceptable and are in compliance with 10 CFR 40.32(c), which provides requirements for final decommissioning plans; 10 CFR 40.42(g)(4), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; and 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate non-proliferation of waste disposal sites.

6.3.5 References

None.

6.4 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

6.4.1 Areas of Review

The staff should review methodologies for conducting post-reclamation and decommissioning radiological surveys. The staff should review the radiological verification survey program that will serve as a basis for determining compliance with NRC concentration limits. The staff should evaluate the measurement techniques and sampling procedures proposed.

6.4.2 Review Procedures

The staff should determine whether the methodologies for conducting post-reclamation and decommissioning radiological surveys are acceptable to verify that concentration limits of 10 CFR Part 40, Appendix A, Criterion 6(6) are met. The staff should ensure that sampling and locations are acceptable and representative of conditions at the site. The staff should consider the survey methods provided in NUREG–1575 (NRC, 2000) along with the applicable site conditions to determine the acceptability of the licensee proposed sampling techniques. The staff should confirm that the determination of background concentrations of radium-226 and other radionuclides is based upon sampling in uncontaminated areas near the site. Other radionuclides that should be sampled if suspected to be present include thorium-230, thorium-232, uranium; and lead-210.

The radium benchmark dose applies for cleanup of residual radionuclides other than radium in soil and for surface activity on structures. If appropriate, the reviewer should refer to Appendix E of this standard review plan for guidance on the benchmark approach.

For license renewals and amendment application, Appendix A to this standard review plan provide guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.4.3 Acceptance Criteria

The procedures for conducting post-reclamation and decommissioning radiological surveys are acceptable if they meet the following criteria:

(1) The cleanup criteria for radium in soils are met as provided in 10 CFR Part 40, Appendix A, Criterion 6(6).

This criterion states that the design requirements for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 m^2, which as a result of byproduct material, does not exceed the background level by more than

(i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 cm [5.9 in.] below the surface,

(ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm [5.9-in.] thick layers more than 15 cm [5.9 in.] below the surface

(2) Background radionuclide concentrations are determined using appropriate methods as described in Section 2.9, “Background Radiological Characteristics,” of this standard review plan. If there are large variations in the background radionuclide concentrations within a given site, the licensee may assign different background radionuclide concentrations to different areas of the site, provided that the licensee properly justifies the background concentrations selected for each area.

(3) Acceptable cleanup criteria for uranium in soil, such as those in Appendix E of this standard review plan, are proposed by the applicant. This is the radium benchmark dose approach of 10 CFR Part 40, Appendix A, Criterion 6(6).

(4) For areas that already meet the radium cleanup criteria, but that still have elevated thorium levels, the applicant proposes an acceptable cleanup criterion for thorium-230. One acceptable criterion is a concentration that, combined with the residual concentration of radium-226, would result in the radium concentration (residual and from thorium decay) that would be present in 1,000 years meeting the radium cleanup standard.

(5) The survey method for verification of soil cleanup is designed to provide 95-percent confidence that the survey units meet the cleanup guidelines. Appropriate statistical tests for analysis of survey data are described in NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (NRC, 2000).

6.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the methodologies for conducting post-reclamation and decommissioning radiological surveys, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the methodologies for conducting post-reclamation and decommissioning radiological surveys proposed for use at the ______________*in situ* leach facility. This review included an evaluation of the methods that will be used for the post-reclamation and decommissioning radiological surveys using the review procedures in standard review plan Section 6.4.2 and the acceptance criteria outlined in standard review plan Section 6.4.3.

The applicant has developed acceptable methodologies for verification of cleanup (final status survey plan) that demonstrate that the radium concentration in the upper 15 cm [5.9 in.] of soil will not exceed 5 pCi/g and in subsequent 15 cm [5.9 in.] layers will not exceed 15 pCi/g. Also, the cleanup of other residual radionuclides in soil will meet the criteria developed with the radium benchmark dose approach (Appendix E), including a demonstration of as low as is reasonably achievable and application of the unity test of 10 CFR Part 40, Appendix A, Criterion 6(6) where applicable. For cases in which the licensee has proposed an alternative to the requirements of Criterion 6(6) or the approved guidance, the staff determines that the resulting level of protection is equivalent to that required by this criterion.

Based on the information provided in the application and the detailed review conducted of the methodologies for conducting post-reclamation and decommissioning radiological surveys for the _________________ *in situ* leach facility, the staff concludes that the methodologies are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; 10 CFR Part 40, Appendix A, Criterion 6(6), which provides standards for cleanup of radium; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data in an environmental report for the Commission to conduct an independent analysis.

6.4.5 Reference

NRC. "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)." Revision 1. Washington, DC: NRC. 2000.

6.5 Financial Assurance

6.5.1 Areas of Review

The staff should review financial assessments (cost estimates) provided by the applicant for the costs of ground-water restoration (standard review plan Section 6.1); reclamation (standard review plan Section 6.2); and decommissioning and waste disposal (standard review plan Section 6.3). These assessments may be provided as an appendix. The staff should review provisions for a financial surety that is consistent with Criteria 9 of 10 CFR Part 40, Appendix A, and the guidance in Appendix C of this standard review plan.

6.5.2 Review Procedures

The staff should review the proposed surety amount provided to ensure that it is sufficient to fund all decommissioning activities documented in the license application, that the methods used to establish the surety amount are acceptable, and that the forecast costs are reasonable. Activities to be covered by the surety include reclamation, off-site disposal of 11e.(2) byproduct material, ground-water restoration, structure and equipment removal, and closure. The purpose of the financial surety is to provide sufficient resources for completion of reclamation of the facility including building decommissioning and well field restoration and soil reclamation, by a third party, if necessary.

The reviewer should determine whether the assumptions for the financial surety analysis are consistent with what is known about the site (standard review plan Section 2.0) and the design and operations of the facility and its effluent control system (standard review plan Sections 3.0, 4.0, and 5.0). To the extent possible, the applicant should base these assumptions on experience from generally accepted industry practices, from research and development activities at the site, or from previous operating experience in the case of a license renewal. The values used in the analysis should be based on current dollars (or adjusted for inflation) and reasonable values for the costs of various activities. The reviewer should also examine the type of financial instrument(s) proposed for the surety to ensure that it is consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.5.3 Acceptance Criteria

The cost estimate for ground-water restoration, decommissioning, reclamation, and waste disposal is acceptable if it meets the following criteria:

(1) The bases for establishing a financial surety in 10 CFR Part 40, Appendix A, Criterion 9 are satisfied. The surety for well fields is usually established as they go into production. Once accepted, the surety will be reviewed annually by NRC to assure that sufficient

funds would be available for completion of the reclamation plan by a third party. Detailed guidance on reviewing financial assessments for *in situ* leach operations is found in Appendix C of this standard review plan .

The reviewer shall examine licensee commitments and proposed schedules for surety updates in response to facility changes, annual updates, and changes in closure or decommissioning plans. Additional guidance to reviewers is contained in NMSS Decommissioning Standard Review Plan, NUREG–1727 (NRC, 2000).

(2) All activities included in the cost estimate are activities that are included either in the reclamation plan or in the operations review completed using Sections 6.1 through 6.4 of this standard review plan.

(3) All activities included either in the reclamation plan or in Sections 6.1 through 6.4 of this standard review plan are included in the financial analysis.

(4) The assumptions used for the proposed surety are consistent with what is known about the site (standard review plan Section 2.0) and the design and operations of the facility and its effluent control system (standard review plan Sections 3.0, 4.0, and 5.0). To the extent possible, the applicant has based these assumptions on experience from generally accepted industry practices, any research and development at the site, or previous operating experience in the case of a license renewal.

(5) Surety values are based on current dollars (or are adjusted for inflation), and reasonable costs for the required reclamation activities are defined.

(6) The applicant commits to funding the approved financial surety through one of the mechanisms described in 10 CFR Part 40, Appendix A, Criterion 9, including a (i) surety bond, (ii) cash deposit, (iii) certificate of deposit, (iv) deposit of a government security, (v) irrevocable letters or lines of credit, or (vi) combinations of the above that meet the total surety requirements.

(7) The applicant commits to updating the surety value annually, in response to changes in closure or decommissioning plans, and as necessitated by changes in the facility and its operations. The annual update will be submitted ninety (90) days prior to the surety anniversary date each year.

(8) The applicant commits to extending the surety for an additional year if NRC has not approved a proposed revision thirty (30) days prior to the surety expiration date.

(9) The applicant commits to revising the surety arrangement within three (3) months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing financial surety. This revised surety instrument will take effect within thirty (30) days of NRC written approval of the surety documents.

(10) Surety documentation includes a breakdown of costs; the basis for cost estimates with adjustments for inflation; a minimum 15-percent contingency; and changes in engineering plans, activities performed, and any other conditions affecting estimated costs for site closure.

(11) The licensee commits to submitting for NRC approval an updated surety to cover any planned expansion or operational change not included in the annual surety update at least ninety (90) days prior to beginning associated construction.

(12) The licensee commits to providing NRC with copies of surety-related correspondence submitted to a state, a copy of the state's surety review, and the final approved surety arrangement. The licensee also commits that, where the surety is authorized to be held by the state, the surety covers all appropriate costs

(13) Reclamation/decommissioning plan cost estimates, and annual updates should follow the outline in Appendix C to this standard review plan.

6.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the financial assurance cost estimate, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the financial assurance cost estimate for the ______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the procedures using the review procedures in standard review plan Section 6.5.2 and the acceptance criteria outlined in standard review plan Section 6.5.3.

The applicant has established an acceptable financial assurance cost estimate based on the requirements in 10 CFR Part 40, Appendix A, Criterion 9. The applicant has assured that sufficient funds would be available for completion of the reclamation plan by an independent contractor. The applicant has included in the financial analyses all the activities in the reclamation plan or in Sections 6.1–6.4 of the standard review plan. The applicant has based the assumptions for financial surety analysis on site conditions, including experiences with generally accepted industry practices, research and development at the site, and previous operating experience (in the case of a license renewal). The values used in the financial surety analysis are based on current dollars (or are adjusted for inflation) and reasonable costs for the required reclamation activities are defined. The financial instrument(s) proposed are acceptable to NRC and meet the total surety requirements (select appropriate description).

Based on the information provided in the application and the detailed review conducted of the financial assurance cost estimate for the ______________ *in situ* leach facility, the staff concludes that the amount of the proposed financial surety and its methods of estimation are acceptable and are consistent with 10 CFR Part 40, Appendix A, Criterion 9, which that requires financial surety arrangements be established by each operator.

6.5.5 Reference

NRC. NUREG–1727, NMSS Decommissioning Standard Review Plan." Washington, DC: NRC. 2000.

7.0 ENVIRONMENTAL EFFECTS

7.1 Site Preparation and Construction

7.1.1 Areas of Review

The staff should review how construction activities may disturb the existing terrain and wildlife habitats, including the effects of such activities as building temporary or permanent roads, bridges, or service lines; disposing of trash; excavating; and land filling. The staff should also review information on how much land will be disturbed and for how long and whether there will be dust or smoke problems. The staff should review data indicating the proximity of human populations and identifying undesirable impacts on their environment arising from noise; disruption of stock grazing patterns; and inconvenience from the movement of men, material, or machines, including activities associated with any provision of housing, transportation, and educational facilities for workers and their families. Descriptions of any expected changes in accessibility to historic and archeological sites in the region should be assessed. Discussions of measures designed to mitigate or reverse undesirable effects such as erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats should be reviewed. The staff should also evaluate the beneficial effects of site preparation construction activities, if applicable.

The staff should review the impact of site preparation and construction activities on area water sources and the effects of these activities on fish and wildlife resources, water quality, water supply, aesthetics, as applicable. Reviewers should evaluate measures such as pollution control and other procedures for habitat improvement to mitigate undesirable effects. Staff should consult NUREG–1748 (NRC, 2001) for general procedures for environmental reviews and the environmental assessment process.

The staff should review the resources and ecosystem components cumulatively affected by the proposed action and other past, present, and reasonably foreseeable future actions. The reviewer should examine cumulative impacts by considering whether:

(1) A given resource is especially vulnerable to incremental effects

(2) The proposed action is one of several similar actions in the same geographic area

(3) Other activities in the area have similar effects on the resource

(4) Effects have been historically significant for this resource

(5) Other analyses in the area have identified a cumulative effects concern

7.1.2 Review Procedures

The staff should determine if the application adequately addresses how site preparation and construction activities may disturb the existing terrain, wildlife habitats, and area water sources in compliance with National Environmental Policy Act Requirements in 10 CFR 51.45 and 51.60. The consequences of these activities to both human and wildlife populations should be considered. The descriptions should be adequately supported by site-specific data, well-documented calculations, and accepted modeling studies, as appropriate. The discussion should include those impacts that are unavoidable as well as those that are irreversible. The staff should ensure that the applicant provides information pertaining to how much land will be disturbed and for how long. The staff should confirm that the effects of the following activities and circumstances, where applicable, are addressed: the building of temporary or permanent roads, bridges, or service lines; disposing of trash; excavating and land filling; and the likelihood of dust and smoke problems. The proximity of site activities to nearby human populations should be addressed, as well as anticipated impacts on their environment including noise; disruption of grazing patterns; inconvenience from movement of material and machines; effects arising from additional housing, transportation, and educational facilities for workers and families; and any disruption in access to historic or archeological sites. The staff should ensure that mitigation measures that are adequate to alleviate or significantly reduce environmental impacts are discussed. Examples of mitigation measures include erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats.

The staff should consider the adequacy of the cumulative impact analysis with respect to past, present, and reasonably foreseeable actions. The staff should determine if the cumulative analysis adequately considered whether and to what extent the environment has been degraded, whether ongoing activities in the area are causing impacts, and trends for activities and impacts in the area. The Council on Environmental Quality has developed guidance (Council on Environmental Quality, 1997) on considering cumulative impacts in the context of National Environmental Policy Act requirements.

The staff should also evaluate any discussion of likely beneficial effects from site preparation and construction to the extent that such might counteract detrimental effects.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.1.3 Acceptance Criteria

The applicant’s assessment of the environmental impacts of site preparation and construction is acceptable if it meets the following criteria:

(1) All environmental impacts from construction activities are adequately described and supported with site-specific data and, where applicable, modeling studies and calculations.

A thorough discussion of all construction activities is provided with associated impacts including the generation and control of wastes; dusts; smoke; noise; traffic congestion; disruption of local public services, routines, and property; and aesthetic impacts.

(2) The applicant adequately describes all unavoidable and irreversible impacts to both the natural environment and nearby human populations.

(3) The applicant adequately describes the amount of land to be disturbed and the length of time it will be disturbed.

(4) The applicant has provided an adequate evaluation of the environmental resources that are vulnerable to the incremented effects from the cumulative impacts of the proposed action and other past, present, and reasonably foreseeable action.

(5) The applicant recommends reasonable mitigation measures for all significant adverse impacts.

(6) The applicant demonstrates that land can be restored.

7.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the environmental assessment of the site preparation and construction plans, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans for site preparation and construction proposed for use at the ______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to conduct the site preparation and construction using the review procedures in standard review plan Section 7.1.2 and the acceptance criteria outlined in standard review plan Section 7.1.3.

The applicant has acceptably identified all environmental impacts from construction activities including waste generation; dusts; smoke; noise; traffic congestion; disruption of public services, routines, and property; and aesthetic impacts. Applicant plans are supported with site-specific data and modeling studies or calculations, where applicable. Identification and assessment of the effects of all unavoidable and irreversible impacts on the natural environment and humans are acceptable. Disturbance of land and the length and nature of the disturbance are acceptably described. The applicant has recommended appropriate mitigation measures for all significant adverse impacts. The applicant has determined that the land can be returned to its original use after cessation of *in situ* leach operations.

Based on the information provided in the application and the detailed review conducted of the site preparation and construction plans for the ________________ *in situ* leach facility, the staff concludes that the environmental impacts of the proposed site preparation and construction are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security nor to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent environmental analysis.

7.1.5 References

Council on Environmental Quality. "Considering Cumulative Effects Under the National Environmental Policy Act." Washington, DC: Council on Environmental Quality, Executive Office of the President. 1997.

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.2 Effects of Operations

7.2.1 Areas of Review

The staff should review discussions in the application that address the impact of facility operations on the environment, including surface-water bodies, ground water, air, land, land use, ecological systems, and important plants and animals, as discussed in Section 2.0 of this standard review plan. Staff should consult NUREG–1748 (NRC, 2001) for general procedures for environmental reviews and the environmental assessment process.

7.2.2 Review Procedures

The staff should determine whether the application addresses the impacts of facility operations on the environment, including surface-water bodies, ground water, air, land, land use, ecological systems, and important plants and animals. The staff should determine whether the supporting evidence is based on, and supported by, theoretical, laboratory, onsite, or field studies undertaken for this, or for previous operations.

The staff should determine whether the proposed facility provides for the protection of ground water from the environmental effects of operations. In conducting the review, the staff should focus on (i) characteristics of the hydrological system, (ii) effluent control systems, (iii) spill detection and containment systems in the processing facilities and storage areas, (iv) ground-water monitoring and surface-water monitoring programs, and (v) the ground-water restoration program provided in the application. This information should provide a strong basis for determining the likely overall effects of any impacts to the ground-water system, such as lixiviant excursions, infiltration from spills, or ruptures of wells.

The staff should ensure that, if surface water exists onsite or is connected to off-site surface-water systems, the likely consequences of impacts of operations on surface water are assessed, and mitigation measures are provided. Likely consequences of impacts might include siltation from disruption of surface ground cover or changes to surface drainage patterns. The staff should also determine whether the applicant has assessed the likelihood for decreased air quality resulting from dust loading from truck traffic on dirt roads and exposure of disturbed surface soils to wind. Radiological impacts to air from operations are assessed in other sections of this standard review plan.

In conducting the review, the staff should consider the applicant's ecological information as reviewed in Section 2.8 of this standard review plan to determine if any endangered or sensitive species of plants and animals exist on site. The level of concern for ecological impacts of operations will be affected by the presence of any such sensitive or endangered species. For most facilities, the ecological impacts are expected to be minimal during this period because of the lack of surface disruption during operations. The staff review should ensure that measures have been taken to restrict terrestrial animals from entering facility grounds by use of fencing and other means. In areas used by migrating waterfowl, additional measures may need to be taken to ensure that any surface impoundments are not used by waterfowl. Local ecological conditions may be such that the facility grounds provide favorable habitat for local wildlife, and efforts to minimize contact between wildlife and contaminated areas should be considered. These efforts will serve to mitigate immediate impacts on local species, but will also serve to limit introduction of contamination into the food chain.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.2.3 Acceptance Criteria

The environmental impacts from operations are acceptable if they meet the following criteria:

(1) All anticipated significant environmental impacts from facility operations are identified and the applicant provides (i) mitigation measures for these impacts, (ii) justification for why impacts cannot be mitigated, or (iii) justification for why it is not necessary to mitigate these impacts to protect the local environment.

(2) At a minimum, the applicant demonstrates that the anticipated impacts on terrestrial and aquatic ecology, air quality, surface- and ground-water systems, land, and land use are environmentally acceptable.

7.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the environmental effects of operations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the effects of operations proposed at the ______________ *in situ* leach facility. This review included an evaluation of the effects of operations using the review procedures in standard review plan Section 7.2.2 and the acceptance criteria outlined in standard review plan Section 7.2.3.

The applicant has acceptably described all anticipated significant environmental impacts from facility operations. The applicant has provided acceptable (i) plans to mitigate such impacts, (ii) justification of why impacts cannot be mitigated, or (iii) justification of why it is not necessary to mitigate the impacts to protect the local environment. The applicant has demonstrated that anticipated impacts to terrestrial ecology, air quality, surface- and ground-water systems, and land use are environmentally acceptable.

Based on the information provided in the application and the detailed review conducted of the effects of operations on the _______________ *in situ* leach facility, the staff concludes that the anticipated effects of operations are acceptable and are in compliance with 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis.

7.2.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.3 Radiological Effects

7.3.1 Exposure Pathways

The staff should review information on the radiological effects of operations on humans, including estimates of the radiological impacts from all exposure pathways. The staff should evaluate descriptions of the plant operations with special attention to the likely pathways for radiation exposure of humans. The staff should review information on accumulation of radioactive material in specific internal compartments and should ensure that both internal and external doses are included in the analysis. This information can be tabulated using the outline provided in Appendix A of the Standard Format and Content Guide (NRC, 1982).

7.3.1.1 Exposures from Water Pathways

7.3.1.1.1 Areas of Review

The staff should review the estimates of annual average concentrations of radioactive nuclides in receiving water at the site boundary and at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains. The review should include the data presented in support of these estimates, including details of models and assumptions used in supporting calculations of total annual whole body and organ doses to individuals in the off-site population from all receiving water exposure pathways as well as any dilution factors used in these calculations. Additionally, the staff should review estimates of radionuclide concentration in aquatic and terrestrial food chains and associated bioaccumulation factors. The staff should evaluate calculations of internal and external doses. If there are no waterborne effluents from the facility, then these analyses are not needed. Details of models and assumptions used in calculations may be provided in an appendix to the application.

7.3.1.1.2 Review Procedures

The staff should determine whether the concentration estimates at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) which specifies limits for annual average concentrations of radionuclides in liquid effluents. The staff should also check to ensure that calculations of concentrations have been done for receiving water at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains, to meet public dose limits in 10 CFR 20.1301. If the liquid effluent dose is calculated separately from the air pathway dose, the staff should ensure that the results can be summed with the air pathway dose for the total dose comparison to the limit in 10 CFR 20.1301. The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. The staff should review the parameter selections including the justifications provided for important parameters used in the dose calculation. The staff should check the input data for modeling results, to ensure the parameters discussed in the application are the same as those used in the modeling. Code outputs should be spot-checked to ensure that the results are correctly reported in the application. For simple hand calculations, spot calculations can be used to verify that they were done correctly.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.1.3 Acceptance Criteria

The exposures from water pathways are acceptable if they meet the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i), which specify limits for annual average concentrations of radioactive nuclides in liquid effluents, or the dose limit in 10 CFR 20.1301.

(2) Calculations of concentrations of radionuclides in receiving water at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains are included in the compliance demonstration for public dose limits in 10 CFR 20.1301.

(3) For facilities that generate liquid effluents, the relevant exposure pathways are included in a pathway diagram provided by the applicant.

(4) The conceptual model (scenarios and exposure pathways) is similar to and consistent with the methodology for liquid effluent exposure pathways in Regulatory Guide 1.109, “Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50," Appendix I (NRC, 1977).

(5) The conceptual model used for calculating the source term and individual exposures (and/or concentrations of radionuclides) from liquid effluents at the facility boundary is

representative of conditions described at the site, as reviewed in Section 2.0 of this standard review plan.

(6) The parameters used to estimate the source term, environmental concentrations, and exposures are applicable to conditions at the site, as reviewed in Section 2.0 of this standard review plan.

7.3.1.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the exposure estimates from water pathways, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from water pathways at the ________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.1.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.1.3.

Applicant estimates of individual exposure to radionuclides from water pathways at the site boundary are acceptable since they are less than the requirements in 10 CFR 20.1302 (b)(2)(i) with regard to annual average concentrations in liquid effluents, or they are less than the dose limit in 10 CFR 20.1301. The applicant has demonstrated that the concentrations of radionuclides in receiving water where it is consumed or otherwise used by humans, or where it is inhabited by biota significant to the human food chain are in compliance with the public dose limits in 10 CFR 20.1301. The applicant has included the relevant pathway diagrams in the application. The applicant has used an acceptable representation of the conditions at the site in the determination of the source term for the model calculations. The applicant has acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures, and the parameters are representative of the ______________ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from water pathways for the ______________________ *in situ* leach facility, the staff concludes that the exposures from water pathways are acceptable and are in compliance with 10 CFR 20.1302(b)(2)(i), which specifies limits for annual average concentrations of radionuclides in liquid effluents and 10 CFR 20.1301, which specifies dose limits for individual members of the public.

7.3.1.1.5 References

NRC. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

———. Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50, Appendix I." Washington, DC: NRC, Office of Standards Development. 1977.

7.3.1.2 Exposures from Air Pathways

7.3.1.2.1 Areas of Review

The staff should review estimated release rates of airborne radioactivity from facility operations and the atmospheric dispersal of such radioactivity considering applicable meteorological data as reviewed in Section 2.0 of this standard review plan. The staff should then review the estimates of annual total body and organ doses to individuals including (i) at the point of maximum ground level concentration offsite, (ii) at the site boundary in the direction of the prevailing wind, (iii) at the site boundary nearest the emission source, and (iv) at the nearest residence in the direction of the prevailing wind. The applicant can choose to show compliance with a concentration limit or with individual dose limits. Therefore, the staff should initially determine the method of compliance chosen by the applicant and focus the review accordingly. Regardless of which compliance method is chosen, the reviewer should also evaluate an individual dose to the public to verify compliance with the requirements in 10 CFR 20.1301. The staff should review data, models, calculations, and assumptions used in support of these estimates. The review should consider both the source term and exposure pathway components of the calculation and should include deposition of radioactive material on food crops and pasture grass.

7.3.1.2.2 Review Procedures

The staff should determine whether the estimates of annual total body and organ doses to individuals at the point of maximum ground level concentrations offsite; individuals exposed at the site boundary in the direction of prevailing wind; individuals exposed at the site boundary nearest to the sources of emissions; and individuals exposed at the nearest residence in the direction of the prevailing wind, meet the regulatory requirements in 10 CFR 20.1301. The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions.

An acceptable computer code that calculates off-site doses to individuals from airborne emissions from *in situ* leach facilities is MILDOS-AREA (Yuan, et al., 1989). This code does not calculate the source term. Therefore, the applicant must provide documentation of the source term calculation that is used as input to MILDOS-AREA (Yuan, et al., 1989), if this code is used. The staff should review the source term equation to ensure that it is an accurate estimation of all significant airborne releases from the facility including, where applicable, yellowcake dust from the dryer stack and radon emissions from processing tank venting and well field releases. If a closed processing loop is used, then radon release from processing is expected to be negligible. If a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible. The staff should focus attention on the values used for the production flow and the fraction of this flow that is expected to be released during operations. A reasonable estimate of well field radon release is about 25 percent. The staff should also ensure that the source term calculation accounts for all material released during startup, production, and restoration activities.

The review of the MILDOS-AREA (Yuan, et al., 1989) calculation should focus on the code input provided by the applicant. The applicant should have provided a list of the relevant parameter information that was used. The information from this list should be compared with the input from the code run to ensure that the correct values have been used. Dose results from the code output should be checked against the tabulated results in the application to ensure that the values have been correctly reported. The staff should also evaluate warning messages that the code provides in the output to identify anomalies in the input data or problems with the run. If reported results appear anomalous, the staff may conduct confirmatory analyses using MILDOS-AREA (Yuan, et al., 1989).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.2.3 Acceptance Criteria

The exposures from air pathways are acceptable if they meet the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) with regard to annual average concentrations of radionuclides in airborne effluents or the dose limit in 10 CFR 20.1301. The estimates of individual exposure to radionuclides (not including radon) indicate that the as low as is reasonably achievable constraint on air emissions in 10 CFR 20.1101(d) will be met.

(2) Calculations of concentrations of radionuclides in air at locations downwind where residents live or where biota of significance to human food chains exist are included in the compliance demonstration for public dose limits in 10 CFR 20.1301. The estimates of individual exposures to radionuclides (not including radon) indicate that the as low as is reasonably achievable constraint on air emissions, in 10 CFR 20.1101(d), will be met.

(3) Relevant airborne exposure pathways are included in the pathway diagram provided by the applicant.

(4) The conceptual model used for calculating the source term and individual exposures (and/or concentrations of radionuclides) from airborne effluents at the facility boundary is representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan. The conceptual model is consistent with the methodologies described in Regulatory Guide 3.51, Sections 1–3, “Calculational Models for Estimating Radiation Doses to Man From Airborne Radioactive Materials Resulting From Uranium Mill Operations” (NRC, 1982). The conceptual model for the MILDOS-AREA code (Yuan, et al., 1989) is one acceptable method for performing these exposure calculations. Other methods are acceptable if the applicant is able to satisfactorily demonstrate that the model includes the criteria discussed above.

(5) The parameters used to estimate the source term, environmental concentrations, and exposures are applicable to conditions at the site as reviewed in Section 2.0 of this standard review plan. Guidance on source term calculations is available in Regulatory Guide 3.59, Sections 1–3, “Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations” (NRC, 1987). Additionally, an example source term calculation specifically applicable to *in situ* leach facilities is described in Appendix D.

7.3.1.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from air pathways, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from air pathways at the ________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.2.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.2.3.

Applicant demonstrations of individual exposure to radionuclides from air pathways are acceptable since they are less than the limits in 10 CFR 20.1302 (b)(2)(i) with regard to annual average concentrations in airborne effluents or they are less than the dose limit in 10 CFR 20.1301. The applicant has acceptably demonstrated that the concentrations of radionuclides in air at locations where residents live or where biota of significance to human food chains exist are in compliance with the public dose limits in 10 CFR 20.1301 and the as low as is reasonably achievable constraint on air emissions in 10 CFR 20.1101(d). The applicant has included the relevant airborne exposure pathway diagrams in the application. The applicant has used an acceptable representation of the atmospheric conditions at the site in the determination of the source term and individual exposures for model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the ______________ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from air pathways for the ___________________ *in situ* leach facility, the staff concludes that the exposures from air pathways are acceptable and are in compliance with 10 CFR 20.1302(b)(2)(i), which specifies limits for annual average concentrations of radionuclides in airborne effluents; 10 CFR 20.1301, which specifies dose limits for individual members of the public; and the as low as is reasonably achievable constraint on airborne emissions in 10 CFR 20.1101(d).

7.3.1.2.5 References

NRC. Regulatory Guide 3.59, “Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations.” Washington, DC: NRC, Office of Standards Development. 1987.

———. Regulatory Guide 3.51, “Calculational Models for Estimating Radiation Doses to Man From Airborne Radioactive Materials Resulting From Uranium Milling Operations.” Washington, DC: NRC, Office of Standards Development. 1982.

Yuan, Y.C., J.H.C. Wang,, and A. Zielen. “MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources.” Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.3.1.3 Exposures from External Radiation

7.3.1.3.1 Areas of Review

The staff should review estimates of maximum annual external dose that would be received by an individual from direct radiation at the nearest site boundary and in off-site populations. The staff should also review data, models, calculations, and assumptions used in support of these estimates.

7.3.1.3.2 Review Procedures

The staff should determine whether the estimates of maximum annual external dose that would be received by an individual from direct radiation at the nearest site boundary meet the limits specified in 10 CFR 20.1301(a)(2). The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. Staff should confirm that the input parameters used for the external dose calculation are consistent with the information provided in the application. The staff should also confirm that the selected parameter values are representative of conditions at the site as reviewed in Section 2.0 of this standard review plan. Staff should check the source term conceptual model and selected parameter values to ensure that they are appropriate for the site conditions described in the application.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.3.3 Acceptance Criteria

The exposures from external radiation are acceptable if they meet the following criteria:

(1) The estimates of external radiation exposure at the site boundary meet the regulatory limits in 10 CFR 20.1301(a)(2), in accordance with 10 CFR 20.1302(b).

(2) The applicant provides an exposure pathway diagram that includes the relevant external exposure pathways.

(3) The model(s) used for calculating the source term, environmental concentrations, and external exposures at the facility boundary are representative of site conditions reviewed in Section 2.0 of this standard review plan.

(4) The parameters used to estimate the source term, environmental concentrations, and external exposure are applicable to site conditions as reviewed in Section 2.0 of this standard review plan.

7.3.1.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects of exposures from external radiation, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from external radiation at the ________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.3.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.3.3.

Applicant demonstration of individual exposure to radionuclides from external radiation is acceptable and meets the limits in 10 CFR 20.1301(a)(2) in accordance with the requirements of 10 CFR 20.1302 (b). The applicant has provided an acceptable exposure pathway diagram that includes all relevant external pathways. The applicant has used an acceptable representation of the external exposures at the site in the determination of the source term, environmental concentrations, and individual exposures for the model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the ________________ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from external radiation for the _____________________ *in situ* leach facility, the staff concludes that the exposures from external radiation are acceptable and are in compliance with 10 CFR 20.1301(a)(2), which specifies limits for radiation doses in unrestricted areas from external sources in accordance with the methods contained in 10 CFR 20.1302(b).

7.3.1.3.5 References

None.

7.3.1.4 Total Human Exposures

7.3.1.4.1 Areas of Review

The staff should review estimates of the maximum annual dose that could be received via all pathways described above by an individual at the site boundary and at the nearest residence. The staff should also review data, models, calculations, and assumptions used in support of these estimates. Much of this review will already have been completed for the pathway-specific calculations, and the total dose will be the sum of these results.

7.3.1.4.2 Review Procedures

The staff should determine whether estimates of the maximum annual dose that could be received via all pathways described above by an individual at the site boundary and at the nearest residence meet regulatory requirements in 10 CFR 20.1301. These calculations can be effectively executed by the MILDOS-AREA code (Yuan, et al., 1989). The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. After the pathway-specific calculations have been reviewed, staff should check to ensure that the doses have been correctly summed to determine the total dose. Also, staff should ensure the population dose is compared with a meaningful reference dose, such as that which is expected for the exposure to the same population from background radiation sources.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.4.3 Acceptance Criteria

The total human exposure is acceptable if it meets the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) with regard to annual average concentrations of radioactive nuclides in airborne and liquid effluents or the dose limit in 10 CFR 20.1301.

(2) Calculations of the maximum individual whole body and organ doses at the site boundary and for the nearest downwind resident and where biota of significance to human food chains exist are included in the compliance demonstration for public dose limits in 10 CFR 20.1301.

(3) The exposure pathway diagram provided by the applicant includes pathways relevant to all effluents expected from facility operations.

(4) The models used for calculating the source terms and individual exposures (and/or concentrations of radionuclides) from all effluents at the facility boundary are representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan. The conceptual models are acceptable as described in Sections 7.3.1.1, 7.3.1.2, and 7.3.1.3 of this standard review plan.

(5) The parameters used to estimate source terms, concentrations, and exposures are representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan.

7.3.1.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from total human exposures, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of total human exposures at the _______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.4.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.4.3.

Applicant determination of total human exposure to radionuclides at the site boundary is acceptable since it meets the requirements in 10 CFR 20.1301. The applicant has provided an exposure pathway diagram that includes all relevant external pathways. The applicant has used an acceptable representation of the external exposures at the site in the determination of the source term, environmental concentrations, and individual exposures for the model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the __________________ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of total human exposures for the ______________________ *in situ* leach facility, the staff concludes that the total human exposures are acceptable and are in compliance with 10 CFR 20.1301 which specifies dose limits for individual members of the public.

7.3.1.4.5 Reference

Yuan, Y.C., J.H.C. Wang, and A. Zielen. “MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources.” Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.3.1.5 Exposures to Flora and Fauna

7.3.1.5.1 Areas of Review

The staff should review estimates of maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna. The staff should also review data, bioaccumulation factors, models, calculations, and assumptions used in support of these estimates.

7.3.1.5.2 Review Procedures

The staff should determine whether estimates of maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna are calculated such that environmental impacts from facility operations can be assessed to address the requirements of 10 CFR Part 51. Particular attention should be paid to impacts to threatened and endangered species. The staff should also determine whether these estimates are supported by properly interpreted data, reasonable bioaccumulation factors, approved calculations, and model results using reasonable assumptions. Detailed biosphere modeling is not necessary for these calculations. Output from MILDOS-AREA (Yuan, et al., 1989) provides ground level concentrations of radionuclides that can then be converted to plant and animal concentrations by use of simple conversion equations that include deposition, uptake factors, plant interception fractions, and animal consumption rates obtained from the literature. The staff should spot-check parameter values against known sources to ensure that they are within expected ranges. The tabulation of bioaccumulation factors and their sources can be presented in an appendix to the application. Provided these concentrations are protective of human health, they would not be expected to adversely affect native plants and animals (Barnthouse, 1995).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.5.3 Acceptance Criteria

The exposures to flora and fauna are acceptable if they meet the following criterion:

(1) The model and parameter values used for calculation of concentrations of radionuclides in important local flora and fauna are consistent with generally accepted health physics practice and are applicable to the species identified at the site, as reviewed in Section 2.0 of this standard review plan.

7.3.1.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from exposures to flora and fauna, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposures to flora and fauna at the _________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.5.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.5.3.

The applicant forecasts that the off-site radiological impacts of operation will be minimal. Flora and fauna in the areas surrounding the project site are similar to those onsite and are common in the region. Since calculated human exposures are protective of human health, they would not be expected to adversely affect the native plants and animals, and as such, are acceptable.

Based on the information provided in the application and the detailed review conducted of exposures to flora and fauna for the _____________________ *in situ* leach facility, the staff concludes that the exposures to flora and fauna are acceptable and are in compliance with 10 CFR Part 51 which requires that environmental impacts from facility operations be assessed.

7.3.1.5.5 References

Barnthouse, L.W. “Effects of Ionizing Radiation on Terrestrial Plants and Animals, A Workshop Report.” ORNL/TN–13141. Oak Ridge, Tennessee: Oak Ridge National Laboratory. 1995.

Yuan, Y.C., J.H.C. Wang, and A. Zielen. “MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources.” Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.4 Non-Radiological Effects

7.4.1 Areas of Review

The staff should review estimates of concentrations of nonradioactive constituents in effluents at the points of discharge as compared with natural ambient concentrations and with applicable discharge standards. The review should include the projected effects of the effluents for both acute and chronic exposure of the biota (including any long-term buildup in soils and sediments and in the biota). The staff should evaluate discussions of dilution and mixing of discharge into the receiving environs, and estimates of concentrations at various distances from the point of discharge. The effects on terrestrial and aquatic environments from chemical wastes that contaminate ground water should also be examined.

The staff should also review discussions of any likely consequences of the proposed operation that do not clearly fall under any specific topic previously addressed. These may include changes in land and water use at the project site; sanitary and other recovery plant waste systems; interaction of the facility with other existing or projected neighboring facilities; effects of ground-water withdrawal on ground-water resources in the vicinity of the well field(s) and recovery plant(s); effects of construction and operation of roads, transmission corridors, railroads, et cetera; effects of changes in surface-water availability on biotic populations; and disposal of other solid and liquid wastes.

7.4.2 Review Procedures

The staff should determine whether the estimated concentrations of nonradioactive constituents in effluents at the point of discharge and the projected effects for both acute and chronic exposure of the biota are adequately quantified in accordance with the National Environmental Policy Act requirements in 10 CFR 51.45 and 51.60. Where applicable, the staff should determine whether these estimates are supported by properly interpreted data, reasonable bioaccumulation factors, calculations, and model results using reasonable assumptions.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.4.3 Acceptance Criteria

The non-radiological effects are acceptable if they meet the following criteria:

(1) The estimated concentrations of nonradioactive wastes in effluents at the point of discharge and the projected effects for both acute and chronic exposure of the biota are adequately quantified in accordance with the National Environmental Policy Act of 1969 requirements in 10 CFR 51.45 and 51.60.

7.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the nonradiological effects, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the nonradiological effects at the _______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate nonradiological effects using the review procedures in standard review plan Section 7.4.2 and the acceptance criteria outlined in standard review plan Section 7.4.3.

The applicant has acceptably described anticipated significant nonradiological environmental impacts from facility operations. The estimated effects of nonradioactive wastes in effluents at the point of discharge and the projected effects for both acute and chronic exposure of biota are acceptable.

Based on the information provided in the application and the detailed review conducted of nonradiological effects for the ______________________ *in situ* leach facility, the staff concludes that the nonradiological effects are acceptable and are in compliance with 10 CFR Part 51.45 which specifies the content of environmental reports.

7.4.5 References

None.

7.5 Effects of Accidents

7.5.1 Areas of Review

The NRC has evaluated the effects of accidents at *in situ* leach facilities [NUREG–0706 (NRC, 1980); Center for Nuclear Waste Regulatory Analyses, 2001]. These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. Specific areas where NRC (1980) and Center for Nuclear Waste Regulatory Analyses (2001) indicated that consequences could be significant are (i) radon releases from process streams, (ii) yellowcake dryer explosions, (iii) lixiviant leaks in buried piping between the well fields and the processing facility, and (iv) chemical accidents.

Applicants whose facilities are consistent with the operating assumptions, site features, and designs examined in these NRC analyses need not conduct independent accident analyses. For these applicants, the staff review should focus on accident response procedures and personnel training in their use. Personnel training is evaluated using Section 5.5 of this standard review plan. If an applicant's operating assumptions, site features, and designs are not consistent with these analyses, the applicant must conduct independent accident analyses. In that case, the staff review should evaluate the adequacy of these independent analyses. The scope of this review includes radiological, nonradiological, and transportation accidents. This review should verify that the accident analyses address a spectrum of accidents ranging in severity from trivial to significant, including a characterization of the occurrence rate or probability and likely consequences.

For all applicants, the reviewers should examine standard operating and accident procedures and the training programs for ensuring that personnel can execute them properly. *In situ* leach facility training programs are reviewed using Section 5.5 of this standard review plan.

7.5.2 Review Procedures

For applications that contain independent accident analyses, the staff should determine whether accident scenarios described in the application are reasonable based on descriptions of the facility and operations reviewed in Sections 3.0, 4.0, and 5.0 of this standard review plan and are sufficiently complete to determine environmental impacts of operations pursuant to National Environmental Policy Act requirements. The staff should determine whether these scenarios and estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. If consequences cannot be quantified, a qualitative description of the impacts should be reviewed for adequacy. The staff should confirm that uranium extraction industry experience is used to support any accident analyses, including consideration of plant design and specific components that are prone to failure or are known to have failed at other facilities.

For independent analyses of transportation accidents, the staff need not review all operational aspects of transportation activities, as these will be addressed through inspections relevant to the general transportation license requirements.

The staff should ensure the applicant has procedures in place to detect and respond to postulated accident conditions and to mitigate consequences. The reviewers should pay particular attention to procedures related to monitoring, identification, and response to accidents related to (i) radon release, (ii) yellowcake dryer operations, (iii) leaks in buried lixiviant piping, and (iv) chemical releases as they might affect radiological accidents.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.5.3 Acceptance Criteria

The independent analyses of consequences of accidents are acceptable if they meet the following criteria:

(1) The applicant has provided analyses of credible accident consequences that are consistent with the facility design and planned operations and are sufficient to identify likely environmental impacts from operations.

(2) Analyses of accident consequences include mitigation measures, as appropriate.

(3) Analyses of accidents include results from operating experience at similar facilities.

(4) For radiological accidents, the applicant's response program provides for notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

Adequate procedures to respond to and mitigate or remediate the likely consequences of accidents are identified or referenced in the application.

7.5.4 Evaluation Findings

If the staff's review, as described in this section, results in acceptance of the applicant's description of the effects of accidents, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the applicant's description of the effects of accidents for the _________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate the effects of accidents using the review procedures in standard review plan Section 7.5.2 and the acceptance criteria outlined in standard review plan Section 7.5.3.

The applicant has acceptably described all likely significant effects of accidents from facility operations. The applicant has provided an acceptable analysis of probable accidents and their consequences, if necessary, consistent with facility design, site features, and planned operations. If appropriate, the applicant has confirmed that facility design, site features, and planned operations are consistent with previous NRC accident analyses. The applicant has identified likely environmental impacts from such accidents and has included mitigation measures. Any accident analyses have considered past operating experience from similar facilities. Adequate response and remediation procedures have been identified or referenced, and the facility personnel will be qualified to implement them. The applicant's response program for radiological accidents will comply with the notification requirements of 10 CFR 20.2202 and 20.2203.

Based on the information provided in the application and the detailed review conducted of the effects of accidents for the __________________ *in situ* leach facility, the staff concludes that the effects of accidents are acceptable and are in compliance with 10 CFR Part 51.45, which specifies the content of environmental reports; 10 CFR 40.32(c), which requires that the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; and 10 CFR 20.2202 and 20.2203, which define response program requirements for radiological accidents.

7.5.5 References

Center for Nuclear Waste Regulatory Analyses. NUREG/CR–6733, "A Baseline Risk-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licenses." San Antonio, Texas: Center for Nuclear Waste Regulatory Analyses. 2001.

NRC. NUREG–0706, "Final Generic Environmental Impact Statement on Uranium Milling—Project M–25." Washington, DC: NRC. September 1980.

7.6 Economic and Social Effects of Construction and Operation

The staff should review descriptions in the application related to the likely economic and social effects of construction and operation of the proposed facility. These impacts should be discussed in separate sections covering benefits, costs, and resources committed.

7.6.1 Benefits

7.6.1.1 Areas of Review

The staff should review social and economic benefits from the proposed *in situ* leach operations that affect various political jurisdictions or public and private interests. Some of these reflect transfer payments or other values that may partially, if not fully, compensate for certain services as well as external or environmental costs, and this fact should be reflected in the designation of the benefit. Some examples of benefits to be reviewed include

(1) Tax revenues to be received by local, state, and federal governments

(2) Temporary and permanent new jobs created and the associated payroll (value-added concept)

(3) Incremental increases in regional productivity of goods and services

(4) Enhancement of recreational values

(5) Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats

(6) Creation and improvement of local roads, waterways, or other transportation facilities

(7) Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with plant operation and technological improvements from applicant research programs

The staff should also review discussions of significant benefits that may be realized from construction and operation of the proposed facility, including expressions in monetary terms, discounted to present worth, of who is likely to be affected and for how long. In the case of aesthetic impacts that are difficult to quantify, the staff should review photographs or pictorial drawings of structures or environmental modifications visible to the public.

7.6.1.2 Review Procedures

The staff should determine whether sufficient detail is presented to evaluate significant economic and social benefits that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility. The staff should determine whether the likely benefits are reasonable and supported by properly interpreted data, calculations, and model results, using reasonable assumptions. The staff should determine to what extent likely benefits can serve to offset adverse effects and costs of construction and operation of the facility. The Standard Format and Contents of License Applications, Including Environmental Reports (NRC, 1982) provides a list of the types of benefits to be included in the application. The NRC has also provided guidance in NUREG–1748 (NRC, 2001) for compliance with requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.6.1.3 Acceptance Criteria

The economic and social effects of construction and operation are acceptable if they meet the following criteria:

(1) The applicant’s analyses of economic and social benefits that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility are supported by properly interpreted data, calculations, and model results.

(2) For each benefit identified, the applicant identifies who is affected and the duration of the impact.

(3) For special case environmental assessments (e.g., those that have substantial public interest, decommissioning costs involving on-site disposal, decommissioning/ decontamination cases that allow radioactivity in excess of release criteria, or cases where environmental justice issues have been previously raised) the applicant has provided sufficient data to assess environmental justice issues in accordance with NUREG–1748 (NRC, 2001).

7.6.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effects of the economic and social benefits of construction and operation, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the economic and social benefits of construction and operation proposed at the _________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate effects of economic and social benefits of construction and operation using the review procedures in standard review plan Section 7.6.1.2 and the acceptance criteria outlined in standard review plan Section 7.6.1.3.

The applicant has acceptably described anticipated economic and social benefits of construction and operation of the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of the standard review plan. The applicant has provided an acceptable analysis of probable benefits consistent with the facility design and industrywide experience. The applicant has included analyses of (i) tax revenues, (ii) creation of temporary and permanent jobs and accrued payroll, (iii) incremental increases in regional productivity of goods and services, (iv) enhancement of recreational values, (v) environmental enhancement and increased knowledge of the environment through ecological research and environmental monitoring programs, and (vi) creation and improvement of infrastructure (e.g., roads, waterways, water and power supply, and other transportation facilities). The applicant has acceptably identified for each benefit who is affected and the expected duration of the beneficial effect. Overall, the applicant has demonstrated that the analysis of the economic and social benefits from the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility are supported by properly interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of economic and social benefits of construction and operation for the __________________ *in situ* leach facility, the staff concludes that the economic and social benefits of construction and operation are acceptable and are in compliance with 10 CFR Part 51.45(c) which requires an analysis that balances the impacts of proposed actions.

7.6.1.5 References

NRC. Regulatory Guide 3.46, “Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining.” Washington, DC: NRC, Office of Standards Development. 1982.

———. NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs.” Washington, DC: NRC. 2001.

7.6.2 Socioeconomic Costs

7.6.2.1 Areas of Review

The staff should review information presented concerning the ground-water quality restoration, surface reclamation, and plant decommissioning costs; and research and development costs, including postoperational monitoring requirements. The applicant should discount these costs to present worth. Resource commitments are addressed in Section 7.6.3 of this standard review plan.

The staff should also review information on external costs, including the probable number and location of the population group is adversely affected, the estimated economic and social impact, and any special measures taken to alleviate the impact. Environmental justice considerations are presented in NUREG–1748 (NRC, 2001).

Temporary external costs should also be evaluated including housing shortages; inflationary rentals or prices; congestion of local streets and highways; noise and temporary aesthetic disturbances; overloading of utilities, water supply, and sewage treatment facilities; crowding of local schools, hospitals, or other public facilities; overtaxing of community services; and disruption of people’s lives or of the local community caused by acquisition of land for the proposed site.

Finally, the staff should review information regarding long-term external costs including: (i) impairment of recreational values (e.g., reduced availability of desired species of wildlife and sport animals, or restrictions on access to land or water areas preferred for recreational use); (ii) deterioration of aesthetic and scenic values; (iii) restrictions on access to areas of scenic, historic, or cultural interest; (iv) degradation of areas having historic, cultural, natural, or archeological value; (v) removal of land from present or contemplated alternate uses; (vi) reduction in quantities of regional products because of displacement of persons from the land proposed for the site; (vii) lost income from recreation or tourism that may be impaired by environmental disturbances; (viii) lost income attributable to environmental degradation; (ix) decrease in real estate values in areas adjacent to the proposed facility; and (x) increased costs to local governments for the services required by the permanently employed workers and their families. In discussing these costs, the applicant should indicate, to the extent practical, who is likely to be affected, to what degree, and for how long.

7.6.2.2 Review Procedures

The staff should determine whether sufficient detail is presented to evaluate significant economic and social internal and external costs that may be incurred during construction, operation, restoration, reclamation, and decommissioning of the proposed facility. The assessment of costs should be reviewed in the context of the information provided in other chapters of the application as reviewed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan to ensure consistency and completeness. The staff should review any data, models, calculations, and assumptions used in support of these projections. The staff should ensure the applicant has identified who it is that will bear the cost, the number of such people, the duration of the impacts, and what measures will be taken to mitigate the impacts. Costs should be discounted to present worth. The NRC has provided guidance in NUREG–1748 (NRC, 2001) for compliance with the socioeconomic requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.6.2.3 Acceptance Criteria

The costs of the *in situ* leach operations are acceptable if they meet the following criteria:

(1) The analyses of economic and social costs that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility are supported by properly interpreted data, calculations, and model results.

(2) For each cost identified, the applicant identifies who is affected, the duration of impacts, and any mitigation measures necessary to alleviate or reduce impacts.

(3) Costs are discounted to present worth.

7.6.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effects of the economic and social costs of construction and operation, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the effects of economic and social costs of construction, operation, restoration, reclamation, and decommissioning operations proposed at the ________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate effects of economic and social costs of construction and operation using the review procedures in standard review plan Section 7.6.2.2 and the acceptance criteria outlined in standard review plan Section 7.6.2.3.

The applicant has acceptably described all anticipated economic and social costs of construction and operation of the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan. The applicant has provided an acceptable analysis of probable costs consistent with the facility design and industrywide experience. The applicant has included analyses of (i) impairment of recreational values; (ii) restriction on access to water or land for recreational use; (iii) restriction on access to areas of scenic, historic, or cultural interest; (iv) deterioration of aesthetic and scenic values; (v) degradation of areas having historic, cultural, natural, or archeological values; (vi) removal of land from present or contemplated alternative uses; (vii) reductions in quantities of regional products; (viii) lost income from recreation or tourism that may be impaired by environmental disturbances; (ix) lost income attributable to environmental degradation;

(x) decrease in real estate values adjacent to the proposed facility; and (xi) increased costs to local governments for increased services and infrastructure. The applicant has identified for each cost who is affected, to what extent, and the expected duration of the effect. Overall, the applicant has demonstrated that the analysis of the economic and social costs from the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility is supported by acceptably interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of economic and social costs of construction and operation for the __________________ *in situ* leach facility, the staff concludes that the economic and social costs of construction and operation are acceptable and are in compliance with 10 CFR Part 51.45(c) which requires an analysis that balances the impacts of proposed actions.

7.6.2.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

8.0 ALTERNATIVES TO PROPOSED ACTION

8.1 Areas of Review

The staff will review comparative reconnaissance level evaluations of available alternatives to the licensing action proposed in the *in situ* leach facility application in accordance with the requirements of National Environmental Policy Act of 1969 including realistic alternatives for the various processing stages. As part of this review, the staff should consider the no-action alternative. Alternative designs do not have to be described in as great detail as the proposed action. The purpose of these evaluations is to determine that alternatives that provide a significant reduction in impacts to human health and the environment have not been overlooked. The reviews should include descriptions of the ground-water quality restoration programs to be applied for each alternative other than the no-action alternative. The staff should evaluate alternatives that may reduce or avoid significant adverse environmental, social, and economic effects expected to result from construction and operation of the proposed facility. The staff should also review the bases and rationales for the choices in regard to number, availability, suitability, and factors limiting the range of alternatives that might avoid some or all of the environmental effects identified in Section 7.0 of this standard review plan. The preferred alternative need not be the one with the least adverse impact. For commercial-scale operations, the review should include the comparative evaluation of available alternatives using results obtained from research and development operations, if applicable.

The staff should also review waste management alternatives considering siting, design, and operational performance objectives developed by NRC staff, in addition to the plans for final disposal discussed in Section 6.0 of this standard review plan.

The review should include discussions regarding locating the liquid impoundment areas at sites where disruption and dispersion by natural forces are eliminated or reduced to acceptable levels, and designing the impoundment areas so that seepage of materials into the ground-water system would be eliminated or reduced to acceptable levels.

8.2 Review Procedures

The staff should determine that the applicant has justified the choice of particular economic recovery processes for the mineralized zone by considering and choosing among techniques and processes that affect the environment in minimal ways. The justification should include a comparative evaluation of the available practicable alternatives. Strengths and weaknesses associated with the likely effects of the use of each technique or process, including the ground-water quality restoration program, should be presented. The staff should determine whether the applicant has considered and chosen those alternatives that may reduce or avoid significant adverse environmental, social, and economic effects expected to result from the construction and operation of the proposed facility. The staff should evaluate the basis and rationale the applicant used for the consideration and rating of the alternatives. The staff should determine that, for commercial-scale operations, the comparative evaluation of available alternatives includes results from research and development operations or similar production-scale sites, if appropriate. The preferred alternative need not be the one with the least adverse environmental impact, and the staff shall evaluate whether the proposed action would meet the requirements of 10 CFR Part 40, Appendix A.

Alternatives to Proposed Action

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

8.3 Acceptance Criteria

The evaluation of alternatives to the proposed action is acceptable if it meets the following criteria:

(1) The applicant considers process alternatives to the proposed action. The applicant identifies alternatives to the operation of the proposed facility in the manner reviewed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan that may mitigate adverse environmental, social, and economic effects reviewed in Section 7.0 of this standard review plan. These alternatives may include, but are not limited to

- (a) The no-action alternative (must be included)
- (b) Alternative ore extraction processes such as traditional open-pit and underground mining
- (c) Alternative lixiviant chemistry
- (d) Alternative ground-water restoration and long-term monitoring techniques
- (e) Alternative monitoring and waste management practices
- (f) Uranium recovery process alternatives
- (g) Construction of a central processing facility versus use of satellite facilities

(2) The alternatives are compared with the proposed actions considering the site characteristics as reviewed in Section 2.0 of this standard review plan and consistent with existing uranium extraction standards and practices.

The rationale for selecting the proposed method should be provided, and the proposed action should be shown to be at least as effective as the considered alternatives in meeting all regulatory requirements. If the application is for a new commercial-scale license, the consideration should be based on the results of the research and development site, if applicable.

(3) The applicant considers the environmental, social, and economic effects of a no-action alternative. Presumably, the applicant will provide information to demonstrate that the proposed action will provide social and economic benefits that outweigh the environmental impact of operating the facility.

(4) The applicant clearly identifies the preferred alternative and demonstrates that it would meet the requirements of 10 CFR Part 40, Appendix A.

8.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the alternatives to the proposed action, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the alternatives to the proposed action at the ________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the alternatives to the proposed action using the review procedures in standard review plan Section 8.2 and the acceptance criteria outlined in standard review plan Section 8.3.

The applicant has considered other alternatives to its proposed *in situ* leach facility such as open-pit or underground mining. Alternatives to the proposed facility operations that might mitigate environmental, social, and economic effects identified in standard review plan Section 7.0 are presented in a form similar to that required in Sections 2.0, 3.0, 4.0, 5.0, and 6.0, of this standard review plan. Alternatives were acceptably considered for lixiviant chemistry, ground-water restoration techniques, waste management practices, and uranium recovery processes. The applicant has demonstrated that the choice of alternative is effective in meeting the applicable requirements of 10 CFR Part 40, Appendix A. Data from past operations or considerations based on results of research and development site were included in the evaluation of the alternatives, as appropriate. The applicant has considered a no-licensing alternative and has demonstrated that the social and economic benefits of the proposed _________________ *in situ* leach facility outweigh any adverse environmental impact of the facility.

Based on the information provided in the application and the detailed review conducted of alternatives to the proposed action for the ___________________ *in situ* leach facility, the staff concludes that the assessment of alternatives to the proposed action is acceptable and is in compliance with 10 CFR Part 51.45(b)(3) which requires that alternatives to the proposed action be analyzed and applicable portions of 10 CFR Part 40, Appendix A, which provides the requirements for extracting source material from ores and for disposal of the associated wastes.

8.5 References

None.

9.0 COST- BENEFIT ANALYSIS

9.1 Areas of Review

The benefit-cost analysis proposed in this section is intended to be a summary of the benefits and costs of the proposed facility. The staff should review the discussion provided and any accompanying illustrations and tables that explain the important benefits and costs of the proposed facility and operations to determine that the issuance of a license is justified. It is important that both quantitative and qualitative justifications be supported with acceptable data and appropriate rationale.

The review should include evaluation against criteria for assessing and comparing benefits and costs where these are expressed in nonmonetary or qualitative terms and rationales for the selection of process alternatives as well as subsystem alternatives. The staff should also evaluate descriptions of any likely cumulative effects, and the rationale for omitting apparent benefits or costs.

The staff should review irreversible and irretrievable commitments of resources caused by the construction, operation, restoration, reclamation, and decommissioning of the proposed facility. This review should include both relative impacts and long-term net effects. Such resources should include permanent land withdrawal, irreversible or irretrievable commitments of mineral resources, water resource needs and ground-water consumption, permanent vegetation and wildlife losses (e.g., unique habitat, species), and consumption of material resources during operation such as processing chemicals and power or energy needs. The staff should review information presented concerning the percentage terms in which the expected resource loss is related to the total resource in the immediate region and in which the immediate region is related to the surrounding regions in terms of affected areas and distances from the site.

9.2 Review Procedures

The reviewer should determine that the benefit-cost statement has been summarized in the form of a narrative and accompanying tables and charts. The important benefits and costs should be contrasted and discussed appropriately to justify the issuance of the license.

The reviewer should determine that the applicant has developed criteria for assessing and comparing benefits and costs where they are expressed in nonmonetary or qualitative terms. Among the criteria that should be considered are (i) ground-water quality or quantity effects, (ii) radiological impact, and (iii) disturbance of the land. The applicant should present the rationales for the selection of process alternatives as well as subsystem alternatives. The reviewer should ascertain that any likely cumulative and symbiotic effects have been detailed along with appropriate rationales for any tradeoffs. If any apparent benefits or costs have been omitted by the applicant, the reviewer should determine that the applicant has presented the rationale for such omissions. The staff should determine that the applicant has related all the terms used in the benefit-cost analysis to the relevant sections of the application. Overall, the benefit-cost section should demonstrate to reviewer satisfaction that the proposed project is a positive economic and social activity.

Cost-Benefit Analysis

The staff should determine whether sufficient detail is presented to evaluate irreversible and irretrievable commitments of resources because of the construction, operation, restoration, reclamation, and decommissioning of the proposed facility. These commitments should be reviewed considering the facility description and operations discussed in other sections of this SRP to ensure consistency and completeness. Resource needs previously identified in existing environmental reports for similar facilities that are currently operating can be used in the staff's review for comparison.

NUREG–1748 (NRC, 2001) provides guidance for compliance with the socioeconomic and cost-benefit considerations required by the National Environmental Protection Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

9.3 Acceptance Criteria

The benefit-cost analysis is acceptable if it meets the following criteria:

(1) The economic benefits of the construction and operation of the proposed facility are acceptably summarized. These may include, but are not limited to

- (a) Tax revenues to be received by federal, state, and local governments
- (b) Temporary and permanent jobs
- (c) Incremental increases in regional productivity of goods and service
- (d) Enhancement of recreational values
- (e) Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats
- (f) Creation and improvement of local roads, waterways, or other transportation facilities
- (g) Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with plant operation and technological improvements from the applicant's research program

(2) Economic benefits are estimated based on realistic assumptions and objective sources such as census data, tax information, and other site characteristics reviewed in Section 2.0 of this standard review plan.

(3) The applicant provides a summary of the costs of plant decommissioning and site reclamation costs, and ground-water restoration.

(4) The applicant summarizes short-term external costs as they affect the interests of people other than the owners and operators of the proposed facility. These may include, but are not limited to

(a) Housing shortages

(b) Local inflation

(c) Noise and congestion

(d) Overloading of the water supply, water treatment facilities, and disposal landfills

(e) Crowding of schools, hospitals, recreational facilities, or other public facilities

(f) Disruption of people's lives (e.g., ranching, farming) through the acquisition of land

(5) The applicant summarizes long-term external costs as they affect the interests of people other than the owners and operators of the proposed facility. These may include, but are not limited to

(a) Impairment of recreational values through reduction in wildlife and sport animals

(b) Restrictions on access to land or water

(c) Aesthetic impacts

(d) Degradation or limited access to areas of historical, scenic, or cultural interests

(e) Lost income related to limitations on access to land and facilities

(f) Decreased real estate values

(g) Increased cost to provide government services for increased populations

(6) The applicant identifies who is most likely to be affected by the construction and operation of the proposed facility, and to the extent possible, identifies how long the disturbance is expected. This information should be consistent with the population information reviewed in Section 2.3 of this standard review plan.

(7) If the application is for a renewal, the applicant provides a summary of the actual economic benefits and costs of the facility since the last licensing action.

(8) A comparison of the benefits and costs is presented that acceptably justifies proceeding with the *in situ* leach operations.

(9) For special case environmental assessments (e.g., those that have substantial public interest, decommissioning cases involving on-site disposal, decommissioning/ decontamination cases that allow radioactivity in excess of release criteria, or cases where environmental justice issues have been previously raised) the applicant has provided sufficient data to assess environmental justice issues in accordance with NUREG–1748 (NRC, 2001).

(10) The irreversible and irretrievable commitments of resources for the construction, operation, restoration, reclamation, and decommissioning of the proposed facility are appropriate considering the following:

- (a) Permanent land withdrawal
- (b) Permanent commitment of mineral resources
- (c) Permanent commitment of water resources

  Post ground-water restoration impacts at public water supply wells are acceptable if the water quality at town wells is consistent with EPA primary and secondary drinking water standards and NRC standards for uranium

- (d) Irreversible loss of surface vegetation
- (e) Irreversible loss of wildlife or wildlife habitat
- (f) Irreversible commitments of material resources including processing chemicals and energy needs

(11) For each resource area, the applicant identifies who is affected, the duration of impacts, and any mitigation measures proposed as necessary to alleviate or reduce impacts

9.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the cost-benefit analysis, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the cost-benefit analysis for the _______________ *in situ* leach facility. This review included an evaluation of the methods that will be used to conduct the benefit-cost analysis and the results using the review procedures in standard review plan Section 9.2 and the acceptance criteria outlined in standard review plan Section 9.3.

The applicant has acceptably summarized the social and economic benefits of the construction and operation of the proposed _______________ *in situ* leach facility including (i) additional tax revenues, (ii) temporary and permanent jobs, (iii) incremental increases in regional product, (iv) enhancement of recreational values, (v) environmental enhancement including protection or propagation of wildlife, (vi) creation and improvements in local infrastructure, and (vii) increased awareness of the environment resulting from ecological research and monitoring and any technological improvements resulting from the applicant's program. The applicant has determined economic benefits from objective sources including (i) census data, (ii) tax information, and (iii) other data as evaluated in Section 2.0 of this standard review plan. The applicant has acceptably summarized costs including plant decommissioning, site reclamation, and ground water restoration. The costs for ground-water restoration, decommissioning, and reclamation, as considered in the financial assessment for surety reviewed in Section 6.5 of this standard review plan, are acceptable. The applicant has identified all short-term *in situ* leach facility-driven external costs including (i) housing shortages, (ii) local inflation, (iii) noise and congestion, (iv) overloading of infrastructure (e.g., schools, water supply, transportation links), and (v) disruption of people's lives as a result of land acquisition. The applicant has acceptably determined all facility-driven long-term external costs including (i) impacts on recreation through reduction in wildlife or sport animals; (ii) restrictions to access to land or water; (iii) aesthetic impacts; (iv) degradation or limited access to historic, scenic, or cultural interests; (v) lost income related to limitations on access to land or recreational facilities; (vi) decreased real estate values; and (vii) increased costs to provide government services for any additional population. The applicant has acceptably identified and considered the extent and longevity of the effect of construction and operation on individuals. The applicant has presented a comparison of the societal benefits and costs to society that acceptably justifies the proposed *in situ* leach facility and operations.

The applicant has acceptably described all anticipated economic and social effects of resources committed at the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan. The applicant has provided an acceptable analysis of probable effects consistent with the facility design and industry-wide experience. The applicant has included analyses of (i) permanent land withdrawal; (ii) permanent commitment of mineral resources; (iii) permanent commitment of water resources; (iv) irreversible loss of surface vegetation; (v) irreversible loss of wildlife or wildlife habitat; and (vi) irreversible commitments of material resources, such as processing chemicals and energy needs. The applicant has acceptably identified, for each resource committed, who is affected, to what extent, and the expected duration of the effect. Overall, the applicant has demonstrated that its analysis of resources committed as a result of the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility is supported by properly interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of the benefit-cost analysis for the _____________________ *in situ* leach facility, the staff concludes that the benefit-cost analysis is acceptable and is in compliance with 10 CFR Part 51.45(c) which requires that economic, technical, and other benefits and costs of the proposed action and alternatives be considered.

9.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 Areas of Review

The staff should review all licenses, permits, and other approvals of construction and operations required by federal, state, local, and regional authorities for the protection of the environment including a list of those federal and state approvals that have already been received, and the status of those pending approvals. The staff should also review similar information regarding approvals, licenses, and contacts with tribal authorities. The staff should examine previously submitted environmental assessments or environmental impact statements, if appropriate.

The staff should evaluate discussions of the status of efforts to obtain a water quality certification under Section 401 and discharge permits under Section 402 of the Federal Water Pollution Control Act, as amended, if required, including the rationale if certification is not required. The staff should also note the state, local, and regional planning authorities that have been contacted or consulted.

Finally, the staff should review descriptions and records of public meetings and of meetings held with environmental and other citizen's groups with reference to specific instances of the compliance with citizens' group recommendations.

10.2 Review Procedures

The reviewer should determine that the applicant has satisfied all license, permit, and other approvals of construction and operations that are required by federal, state, local, and regional authorities with jurisdiction for the protection of the environment. Types of licenses or permits may include but are not limited to (i) source materials, (ii) underground injection, (iii) surface impoundment construction, (iv) surface discharge, (v) industrial ground-water, (vi) aquifer exemption, (vii) air quality, (viii) disposal well, and (ix) a state *in situ* leach mining permit. The federal and state approvals that have already been received should be listed, and those pending approval should be appropriately identified. The reviewer should determine that the applicant has presented the appropriate environmental assessment or full environmental impact statement for the proposed *in situ* leach site and surrounding area, regardless of whether the assessments are preexisting or prepared especially for this application. This section is intended to cover licensing and permitting of the process as a whole or parts of the process, and does not require a listing of certifications that may be required for equipment or personnel. Copies of associated documentation may be provided as an appendix to the application. NUREG–1748 (NRC, 2001) provides guidance for evaluating compliance with the consultation requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

10.3 Acceptance Criteria

The status of environmental approvals and consultations is acceptable if it meets the following criteria:

(1) The applicant provides a summary of all permits or licenses obtained for the proposed facility. These should clearly identify

(a) the type of permit or license

(b) The granting authority (local, state, regional, tribal authorities, or federal)

(c) The permit or license number (if appropriate)

(d) The current status, with expiration date, if appropriate

(2) For permits not yet granted, the applicant provides a discussion of the current status of the application and objective evidence that the applicant has applied for, but has not yet received, the permit from the granting authority. Such evidence may include copies of documents such as letters from the granting authority or the permit application.

(3) For permits and licenses not yet granted, the applicant indicates when approval is expected. Consultations with the granting authority can be summarized.

(4) The granting authority is clearly defined and appropriate to the area being permitted or licensed. If permits are granted under Agreement State status, this should be identified in the application.

(5) For licenses renewals and amendments, the applicant summarizes public meetings and meetings held with environmental and other citizens' groups since the last licensing application, and responses to the concerns expressed at these meetings.

10.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the environmental approvals and consultations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the environmental approvals and consultations for the _____________________ *in situ* leach facility. This review included an evaluation of the methods that will be used to acquire the environmental approvals and consultations using the review procedures in standard review plan Section 10.2 and the acceptance criteria outlined in standard review plan Section 10.3.

The applicant has acceptably identified the environmental approvals and consultations obtained or required for the proposed ____________________ *in situ* leach facility. The applicant has provided a summary of all permits and licenses obtained for the proposed facility that identifies the type of permit (license), the granting authority, the assigned number, and the current status with expiration date (if appropriate). For permits not yet received, the applicant has provided a discussion of the status of the application and evidence that the applicant has requested the appropriate permits, and an indication of when the approval is expected. The applicant has identified all permits issued under Agreement State status and demonstrated that the granting authority is appropriate for all permits. Any meetings held with environmental and citizens' groups are acceptably documented.

Based on the information provided in the application and the detailed review conducted of the environmental approvals and consultations for the ____________________ *in situ* leach facility, the staff concludes that the environmental approvals and consultations are acceptable and are in compliance with 10 CFR 51.45(d) which requires that the environmental report list all federal permits licenses, approvals and other entitlements that must be obtained in connection with the proposed action and describe the status of compliance with these requirements.

10.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

APPENDIX A

GUIDANCE FOR REVIEWING HISTORICAL ASPECTS OF SITE PERFORMANCE FOR LICENSE RENEWALS AND AMENDMENTS

For license renewals and amendments, the historical record of site operations, including air and ground-water quality monitoring, provides valuable information for evaluating the licensing actions. Following are specific areas where a compliance history or record of site operations and changes should be provided for review:

- For license renewals, U.S. Nuclear Regulatory Commission (NRC) inspection reports and license performance reports
- Amendments and changes to operating practices or procedures
- License violations identified during NRC or Agreement State site inspections
- Excursions, incident investigations or root cause analyses, and resultant cleanup histories or status
- Exceedences of any regulatory standard or license condition pertaining to radiation exposure, contamination, or release limits
- Exceedences of any non-radiation contaminant exposure or release limits
- Updates and changes to any site characterization information important to the evaluation of exposure pathways and doses including site location and layout; uses of adjacent lands and waters; population distributions; meteorology; the geologic or hydrologic setting; ecology; background radiological or non-radiological characteristics; and other environmental features
- Environmental effects of site operations including data on radiological and non-radiological effects, accidents, and the economic and social effects of operations
- Updates and changes to factors that may cause reconsideration of alternatives to the proposed action
- For license renewals, updates and changes to the economic costs and benefits for the facility since the last application
- For license renewals, the results and effectiveness of any mitigation proposed and implemented in the original license

If, after a review of these historical aspects of site operations, the staff concludes that the site has been operated so as to protect health and safety and the environment and that no unreviewed safety-related concerns have been identified, then only those changes proposed by the license renewal or amendment application should be reviewed using the appropriate sections of this standard review plan. Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined.

APPENDIX B

RELATIONSHIP OF 10 CFR PART 40, APPENDIX A REQUIREMENTS TO STANDARD REVIEW PLAN SECTIONS

The criteria in 10 CFR Part 40, Appendix A were written specifically for conventional uranium recovery facilities. Therefore, they are not all applicable to *in situ* leach facilities. This appendix identifies the specific standard review plan sections where the applicable criteria are addressed.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
Criterion 1: Optimize site selection to achieve permanent isolation of tailings without maintenance.	Not applicable.
Criterion 2: Avoid proliferation of small waste disposal sites.	3.1.4, 4.2.4, 6.2.4, 6.3.4
Criterion 3: Dispose of tailings below grade or provide equivalent isolation.	Not applicable.
Criterion 4: Adhere to siting and design criteria.	
(a) Minimize upstream rainfall catchment areas.	Not applicable to *in situ* leach facilities.
(b) Select topographic features that provide good wind protection.	Not applicable to *in situ* leach facilities.
(c) Provide relatively flat embankment and cover slopes.	Not applicable to *in situ* leach facilities.
(d) Establish a self-sustaining vegetative cover or rock cover considering stability, erosion potential, and geomorphology.	Not applicable to *in situ* leach facilities.
(e) Locate away from faults capable of causing impoundment failure.	2.6.4
(f) Design to promote deposition, where feasible.	Not applicable to *in situ* leach facilities.
Criterion 5A: Meet the primary ground-water protection standard.	
(1) Design, construct, and install an impoundment liner that prevents migration of wastes to subsurface soil, groundwater, or surface water.	3.1.4, 4.2.4
(2) Construct liner of suitable materials, place it on an adequate base, and install it to cover surrounding earth likely to be in contact with wastes or leachate.	3.1.4, 4.2.4

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(3) Apply alternate design or operating practices that will prevent migration of hazardous constituents into ground water or surface water.	3.1.4, 4.2.4
(4) Design, construct, maintain, and operate impoundments to prevent overtopping.	3.1.4, 4.2.4
(5) Design, construct, and maintain dikes to prevent massive failure.	3.1.4, 4.2.4
Criterion 5B: Conform to the secondary ground-water protection standards.	
(1) Prevent hazardous constituents from exceeding specified concentration limits in the uppermost aquifer beyond the point of compliance.	3.1.4, 5.7.8.4
(2) Define hazardous constituents as those expected to be in or derived from the byproduct material, those detected in the uppermost aquifer, and those listed in Criterion 13.	3.1.4
(3) Exclude hazardous constituents if they are not capable of posing a substantial present or potential hazards to human health or the environment.	3.1.4
(4) Consider identification of underground sources of drinking water and exempted aquifers.	2.2.4, 3.1.4
(5) Ensure hazardous constituents at the point of compliance do not exceed the background concentration, the value in Paragraph 5C, or an approved alternate concentration limit.	3.1.4, 5.7.8.4
(6) Establish alternate concentration limits, if necessary, after considering practical corrective actions, as low as is reasonably achievable requirements, and potential hazard to human health or the environment.	3.1.4
Criterion 5C: Comply with maximum values for ground-water protection.	3.1.4, 5.7.8.4
Criterion 5D: Implement a ground-water corrective action program if secondary ground-water protection standards are exceeded.	5.7.8.4
Criterion 5E: Consider appropriate measures when developing and conducting a ground-water protection program.	

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(1) Incorporate leak detection systems for synthetic liners and conduct appropriate testing for clay/soil liners.	4.2.4
(2) Use process designs that maximize solution recycling and water conservation.	4.2.4
(3) Dewater tailings by process devices or properly designed and installed drainage systems.	4.2.4
(4) Neutralize hazardous constituents to promote immobilization.	4.2.4
Criterion 5F: Alleviate seepage impacts where they are occurring and restore ground-water quality.	4.2.4
Criterion 5G: Provide appropriate information for a disposal system.	
(1) Define the chemical and radioactive characteristics of waste solutions.	4.1.4, 4.2.4
(2) Describe the characteristics of the underlying soil and geologic formations.	2.6.4
(3) Define the location, extent, quality, capacity, and current uses of ground water.	2.2.4
Criterion 5H: Minimize penetration of radionuclides into underlying soils when stockpiling.	Not applicable.
Criterion 6: Install an appropriate cover and close the waste disposal area.	
(1) Ensure the cover meets lifetime and radioactive material release specifications.	Not applicable to *in situ* leach facilities.
(2) Demonstrate the effectiveness of the final radon barrier prior to placement of erosion protection barriers or other features.	Not applicable to *in situ* leach facilities.
(3) Demonstrate the effectiveness of phased emplacement of radon barriers as each section is completed.	Not applicable to *in situ* leach facilities.
(4) Document verification of radon barrier effectiveness to the U.S. Nuclear Regulatory Commission (NRC) and maintain records of this verification.	Not applicable to *in situ* leach facilities.
(5) Ensure that radon exhalation is not significantly above background because of the cover material.	Not applicable to *in situ* leach facilities.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(6) Cleanup residual contamination from byproduct material consistent with the radium benchmark dose. (7) Prevent threats to human health and the environment from non-radiological hazards.	4.2.4, 6.2.4, 6.4.4 2.11.4, 6.2.4
Criterion 6A: Ensure expeditious completion of the final radon barrier. (1) Complete the radon barrier as expeditiously as practical after ceasing operations in accordance with a written, Commission-approved reclamation plan. (2) Extend milestone completion dates if justified by radon release levels, cost considerations consistent with available technology. (3) Authorize disposal of byproduct materials or similar materials from other sources if appropriate criteria are met.	Not applicable.
Criterion 7: Conduct pre-operational and operational monitoring programs.	2.5.4, 5.7.8.4, 5.7.9.4
Criterion 7A: Establish a detection monitoring program to set site-specific ground-water protection standards, a compliance monitoring system once groundwater protection standards have been established, and a corrective action monitoring program in conjunction with a corrective action program.	5.7.8.4, 5.7.9.4
Criterion 8: Conduct milling operations, including ore storage, tailings placement, and yellowcake drying and packaging operations so that airborne releases are as low as is reasonably achievable.	Partially applicable: 4.1.4, 5.3.1.4, 5.3.2.4, 5.7.1.4, 5.7.3.4
Criterion 8A: Conduct and record daily inspections of tailings or waste retention systems and report failures or unusual conditions to NRC.	5.3.1.4, 5.3.2.4
Criterion 9: Establish appropriate financial surety arrangements for decontamination, decommissioning, and reclamation.	6.2.4, 6.5.4
Criterion 10: Establish sufficient funds to cover the costs of long-term surveillance and control.	Not applicable

10 CFR Part 40, Appendix A Criterion		Locations in NUREG–1569 Where the Criterion is Addressed
Criterion 11A:	Comply with effectivity dates for site and byproduct material ownership requirements.	Applies to Commission—not addressed in NUREG–1569.
Criterion 11B:	Establish license conditions or terms to ensure that licensees comply with ownership requirements prior to license termination for sites used for tailings disposal.	Applies to Commission—not addressed in NUREG–1569.
Criterion 11C:	Transfer title to byproduct material and land to the United States or the state in which the land is located.	Not applicable.
Criterion 11D:	Permit use of surface and subsurface estates if the public health, safety, welfare, or environment will not be endangered.	Applies to the Commission—not addressed in NUREG–1569.
Criterion 11E:	Transfer material and land to the United States or a state without cost other than administrative a legal costs.	Not applicable.
Criterion 11F:	Follow specific requirements for land held in trust for or owned by Indian tribes.	Not applicable.
Criterion 12:	Minimize or avoid long-term active maintenance and conduct and report on annual inspections.	Applicable to the long-term custodian—not addressed in NUREG–1569.
Criterion 13:	Establish standards for constituents reasonably expected to be in or derived from byproduct materials and detected in ground water.	3.1.4

APPENDIX C

RECOMMENDED OUTLINE FOR SITE-SPECIFIC *IN SITU* LEACH FACILITY RECLAMATION AND STABILIZATION COST ESTIMATES

As required under Criterion 9 of 10 CFR Part 40, Appendix A, the licensee shall supply sufficient information for the U.S. Nuclear Regulatory Commission (NRC) to verify that the amount of coverage provided by the financial assurance will permit the completion of all decontamination, decommissioning, and reclamation of sites, structures, and equipment used in conjunction with facility operation. Cost estimates for the following activities (where applicable) should be submitted to NRC with the initial license application or reclamation plan and should be updated annually; as specified in the license. Cost estimates must be calculated on the basis of completion of all activities by a third party (a third party is an independent contractor or operator who is not financially affiliated with the licensee). Unit costs, calculations, references, assumptions, equipment and operator efficiencies, *et cetera*, must be provided. The annual surety estimate must be prospective of all work to be performed at the site. The licensee must provide estimated costs for all decommissioning, reclamation, and ground-water restoration work remaining to be performed at the site, and not simply deduct the cost of work already performed from the previous surety estimate [see NRC Generic Letter 97-03 (NRC, 1997)].

The detailed cost information necessary to verify the cost estimates for the above categories of closure work is summarized in the following recommended outline. For each area, estimates should include costs for equipment; materials; labor and overhead; licenses, permits and miscellaneous site-specific costs; and any other activity or resource that will require expenditure of funds.

(I) FACILITY DECOMMISSIONING

This includes decommissioning, free release, or disposal of all structures and equipment. This may be accomplished in two phases. In the first phase, only the equipment not used for ground-water restoration (including the stability monitoring period) might be decontaminated, surveyed and released for unrestricted use. Well plugging and removal of the remaining equipment would be performed in a second phase, after the of ground-water restoration has been completed and approved. The buildings used for the *in situ* leach operations may be decontaminated and released for unrestricted use.

(A) Salvageable building and equipment decontamination (list). For each building or piece of equipment listed, the following cost data should be provided:

(1) Decontamination

(2) Refurbishment

(3) Removal of equipment

(4) Repairs

(B) Nonsalvageable building and equipment disposal:

(1) List of major categories of buildings and equipment to be disposed of and their corresponding quantities:

(a) Structures (list each major) [tons of material and building volume cubic meters (cubic feet)]

(b) Foundation concrete [cubic meters (cubic yards)]

(c) Process equipment (tons)

(d) Piping and insulation (lump sum)

(e) Electrical and instrumentation (lump sum)

(2) Disposal of chemical solutions within the facility

(C) Restoration of contaminated areas (process area, affected ground water, surface impoundment residues, etc.)

Removal and Disposal of 11(e).2 byproduct material—Criterion 2 of 10 CFR Part 40, Appendix A, requires that these materials be transported and disposed of at a licensed tailings area or licensed disposal site. The quantity of material to be removed, the distance to the disposal site, and the fees charged by the receiving facility are important considerations in determining the costs of disposal.

Reclamation—This entails recontouring the well fields and surface impoundments and placing top soil or other materials acceptable to the NRC. This may also include revegetation.

(1) Removal:

(a) Area, depth, and quantity of material to be removed

(b) Excavation, loading, transportation, and deposition

(2) Revegetation:

(a) Area to be revegetated (acre)

(b) Obtaining fill material, replacing topsoil, and revegetating

(c) Erosion protection

(II) GROUND-WATER RESTORATION AND WELL PLUGGING

In most cases, ground-water restoration consists of ground-water sweeping and water treatment with partial reinjection. The water treatment equipment used during the uranium recovery phase of the operation is generally suitable for the restoration phase. The capital cost of this equipment is usually absorbed during the initial stages of the operation, leaving only the costs of operation, maintenance, and replacement filters for the restoration phase. However, if additional equipment will be required for restoration, associated costs should be detailed here. Replacement costs of some water treatment equipment may need to be included in the surety if the equipment used for restoration is near the end of its serviceable life.

(A) Method of restoration

(B) Volume of aquifer required to be restored, area and thickness of aquifer, number of required pumping cycles, and cycling time. The aquifer volume should include the volume of the exploited ore zone, the flow factor, and any contaminated ground water outside the well field (vertical and horizontal excursions)

(C) Equipment associated with aquifer restoration (e.g., reverse osmosis unit)

(D) Verification sample analysis

(E) Well plugging:

(1) Number of wells to be plugged

(2) Depth and size of each well

(3) Material to be used for plugging including acquisition, transportation, and plugging

(III) RADIOLOGICAL SURVEY AND ENVIRONMENTAL MONITORING

Radiological Survey—Surveys and soil samples for radium are required in areas to be released for restricted use. Soils around the well fields, surface impoundments, and process buildings should be analyzed for radium content. A gamma survey of all areas should be made before release for unrestricted use. All equipment released for unrestricted use should be surveyed and the records should be maintained.

(A) Soil samples

(B) Decommissioning equipment and building smear samples

(C) Gamma survey

(D) Environmental monitoring

(IV) PROJECT MANAGEMENT COSTS AND MISCELLANEOUS

Itemize estimated costs associated with project management; engineering design, review, and change; mobilization; power during reclamation; quality control; radiological safety; and any other costs not included in other estimation categories.

(V) LABOR AND EQUIPMENT OVERHEAD, CONTRACTOR PROFIT

Overhead costs for labor and equipment and contractor profit may be calculated as separate items or loaded into hourly rates. If included in hourly rates, the unit costs must identify the percentages applied for each area.

(VI) CONTINGENCY

The licensee should include a contingency amount to the total cost estimate for the final site closure. The staff considers a 15-percent contingency to be an acceptable minimum amount.

(VIII) ADJUSTMENTS TO SURETY AMOUNTS

The licensee is required by 10 CFR Part 40, Appendix A, Criterion 9 to adjust cost estimates annually to account for inflation and changes in reclamation plans. The submission should be in the form of a request for amendment to the license.

(A) Adjustments for inflation:

The licensee should submit a revised surety incorporating adjustments to the cost estimates for inflation 90 days before each anniversary of the date on which the first reclamation plan and cost estimate were approved. The adjustment should be made using the inflation rule indicated by the change in the Urban Consumer Price Index published by the U.S. Department of Labor, Bureau of Labor Statistics (http://stats.bls.gov).

(B) Changes in Plans:

(1) Changes in the process such as size or method of operation

(2) Licensee initiated changes in reclamation plans or reclamation/ decommissioning activities performed

(3) Adjustments to reclamation plans required by NRC

(4) Proposed revisions to reclamation plans with cost estimates and the basis for cost estimates detailed for NRC review and approval.

To avoid unnecessary duplication and expense, NRC shall take into account surety arrangements required by other federal agencies, state agencies, or other local governing bodies. However, the Commission is not required to accept such sureties if they are not sufficient. Similarly, no reduction to surety amounts established with other agencies shall be effected without NRC approval. Copies of all correspondence relating to the surety between the licensee and the state should be provided to NRC. If authorized by NRC to maintain a surety with a state as the beneficiary, it is the responsibility of the licensee to provide NRC with verification of same and ensure that the agreement with the state specifically identifies the financial surety's application, *in situ* leach facility, and decommissioning/ reclamation requirements.

All costs (unit and total) are to be estimated on the basis of third party, independent contractor costs (include overhead and profit in unit costs or as a percentage of the total). Equipment owned by the licensee and the availability of licensee staff should not be considered in the estimate, to reduce cost calculations. All costs should be based on current-year dollars. Credit for salvage value is generally not acceptable in the estimated costs.

NRC staff review may include a comparison of unit cost estimates with standard construction cost guides (e.g., Dodge Guide, Data Quest) and discussions with appropriate state or local authorities (e.g., highway cost construction). The licensee should provide supporting information or the basis for selection of the unit cost figures used in estimates. The staff may elect to use a publicly available computer code such as RACER™ (Talisman Partners, Ltd., 2000) or spreadsheet to assess these costs.

References

NRC. "Annual Financial Surety Update Requirements for Uranium Recovery Licensees." Generic Letter 97-03. Washington, DC: NRC. July 1997.

Talisman Partners, Ltd. "Introduction to RACER 2000™ (Version 2.1.0)—A Quick Reference." Englewood, Colorado: Talisman Partners, Ltd. 2000.

APPENDIX D

MILDOS-AREA: AN UPDATE WITH INCORPORATION OF *IN SITU* LEACH URANIUM RECOVERY TECHNOLOGY

Letter Report

MILDOS-AREA: An Update with Incorporation of *In Situ* Leach Uranium Recovery Technology*

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1.0 INTRODUCTION

The MILDOS-AREA computer code was developed at Argonne National Laboratory in 1989 (Yuan, et al, 1989) for evaluating radiological impacts of uranium processing facilities. The code was modified from the original MILDOS code (Strenge and Bander, 1984) to include large-area sources and to incorporate changes in methods for dosimetry calculations. MILDOS-AREA estimates the radiological impacts of airborne emissions of radioisotopes of the uranium-238 series. Two different measures are calculated: dose commitments to human receptors and annual average air concentrations.

MILDOS-AREA incorporated dose conversion factors derived by the International Commission on Radiological Protection (ICRP) recommendations of 1978. The annual average air concentrations were compared with the maximum permissible concentrations (MPCs) in the U.S. Nuclear Regulatory Commission's *Standards for Protection against Radiation* (10 CFR Part 20). On January 1, 1994, a revision to 10 CFR Part 20 (revised Part 20) went into effect. The revised Part 20 updated its dosimetry to the ICRP 1978 recommendations. The dose limit to the general public also changed. The changes led to a revision of the calculated allowable concentrations for unrestricted areas, with MPC being replaced by the term "effluent concentrations." Therefore, the calculations performed by MILDOS–AREA were not consistent with the current terminology and data contained in the revised Part 20.

In addition, a new method of recovering uranium gained popularity in the late 1980s, and now the majority of operating licensees use the *in situ* leach (ISL) method. In a typical ISL mining site (Hunter, 1996), a licensee uses a series of injection wells that introduce dissolved oxygen and sodium carbonate/bicarbonate into the ore zone. The uranium is mobilized and is extracted through a series of pumping wells. The uranium-rich water is routed through a processing building, where the uranium is removed from the water by ion-exchange (IX) columns. The loaded IX resin is then processed to remove the uranium (elution). The eluted uranium is further processed into a concentrated uranium slurry. The slurry is then dried into yellow cake (U_3O_8). The dried U_3O_8 is packaged and shipped for further processing into enriched uranium and reactor fuel.

Some ISL facilities have smaller processing plants remote from the main processing plant. These plants, called satellite facilities, generally will collect the uranium in resin tanks and then ship the loaded resin to the main processing plant for elution, drying, and packaging. The satellite facilities allow the licensee to economically mine uranium a distance away from the main processing plant.

2.0 PROJECT OBJECTIVES

The overall objective of this project is to update the MILDOS-AREA code data structures and terminology to be consistent with revised 10 CFR Part 20. Another objective is the creation of an example problem for ISL facilities. Finally, the above objectives result in the creation of a patch program that will update current versions of MILDOS-AREA to the new version.

This report consists of three components: (1) modification of the data structure of the MILDOS-AREA code, (2) source term derivation for the ISL mining technology, and (3) application of this methodology in the sample problem. Finally, a computer patch program containing this updated information is described. This patch program is to be attached to MILDOS-AREA as an update for the particular application.

3.0 MODIFICATIONS TO THE MILDOS-AREA CODE

Two sets of modifications are made to the MILDOS-AREA code. These changes reflect both the semantic and the dosimetric revisions implemented in the revised 10 CFR Part 20.

The first modification consists of replacing all occurrences of MPC with allowable concentration (ALC). These changes affect the last page(s) of output for each time step, where the concentrations of radionuclides in air at each receptor location are reported. These pages are now referred to as the "Results of the ALC Check at this Location."

The second modification consists of replacing the old MPC values in the MILDOS-AREA database with the numbers currently tabulated under Effluent Concentrations (Air - Column 1) in Table 2 of Appendix B to the revised 10 CFR Part 20. An exception is radon-222 (Rn-222), where the ALC is expressed in units of working level (WL). The value for Rn-222 is derived as specified in the text of Appendix B; to revised Part 20; the occupational derived air concentration of 1/3 WL has been divided by 300. Table 3-1 lists the radionuclides and the ALCs used in MILDOS-AREA.

TABLE 3-1 Allowable Concentrations Used in MILDOS-AREA

Radionuclide	AC (Inhalation Class) (pCi/m^3)	Default Inhalation Class
Uranium-238	3(D), 1(W), 0.06(Y)	Y
Uranium-234	3(D), 1(W), 0.05(Y)	Y
Thorium-230	0.02(W), 0.03(Y)	W
Radium-226	0.9 (W)	W
Radon-222	1/900 (*)	(*)
Lead-210	0.6 (D)	D
Bismuth-210	500 (D), 40 (W)	W
Polonium-210	0.9 (D), 0.9 (W)	W

(*) Radon-222 is gaseous; the AC is reported in Wls.

4.0 SOURCE TERM ESTIMATION FOR A SAMPLE ISL FACILITY

The sources of radioactive effluent from an operating ISL uranium recovery facility include (1) the drilling operation at new well fields, (2) uranium extraction operations at production well fields, (3) drying and packaging of yellow cake, (4) restoration operations at old well fields, and (5) land application areas. The following sections describe a methodology for source term derivation for ISL sites that may be used instead of the methodology presented in NUREG/CR-4088 (Hartley, et al, 1985). *Other methodologies may be more appropriate for a particular operating site.*

4.1 New Well Field

Conventional rotary rigs are commonly employed for all drilling activities at an ISL facility. Because all exploration drill holes are sealed with high-viscosity bentonitic mud to maintain aquifer isolation, no particulates are expected to be released during drilling operations. The only source of radioactive release is the Rn-222 from radium-containing ore cuttings temporarily stored in the mud pit. During the period when the ore cuttings are awaiting disposal while stored in a mud pit, radioactive decay of radium-226 (Ra-226) is producing radon continuously. The amount of Rn-222 available for release, or the maximum release rate, in a year as a result of Ra-226 decay from ore cuttings in storage is assumed to be given by the following expression:

$$Rn_{nw} = 10^{-12}\ E\ L\ [Ra]\ T\ M\ N \qquad \textbf{(1)}$$

where

Rn_{nw} = Rn-226 release rate from new well field (Ci/yr),

10^{-12} = unit conversion factor (Ci/pCi),

[Ra] = concentration of Ra-226 in ore (pCi/g),

E = emanating power (dimensionless),

L = decay constant of Rn-222 (0.181/d),

T = storage time in mud pit (d),

M = average mass of ore material in the pit (g), and

N = number of mud pits generated per year.

4.2 Production Well Field

No particulate materials are expected to be released from the production well field because its process streams, from production and injection wells to IX columns in the satellite facility, are all in a closed-loop circuit. The primary radioactive emission from the process streams of the production well field is Rn-222 gas. In the natural environment, radon emanates continuously in the ground and migrates through the rock or soil by both diffusion and convection. The movement of radon in ground water in most cases is governed by water transport, rather than by diffusion (Hess, et al, 1985; Mueller Associates, Inc., 1986). In an ISL production well field, the radon released from the ore body is readily removed by the process water ("lixiviant") moving through the well field by injection and production wells. The 3.8-day half-life of Rn-222 allows it to circulate along with the process water in the well field over a long time before it decays.

The general equation describing the change in Rn-222 concentration over time in the process water of a well field can be expressed as:

$$V \frac{dC_{Rn}}{dT} = f\, S - (L + v)\, V\, C_{Rn} - (F_p + F_i)\, C_{Rn} \qquad \textbf{(2)}$$

where

V = volume of water in circulation (L),

C_{Rn} = Rn-222 concentration in process water (pCi/L),

f = fraction of radon source carried by circulating water (dimensionless),

S = radon source (pCi/d),

L = decay constant of Rn-222 (0.181/d),

v = rate of radon venting from piping and valves during circulation (1/d),

F_p = "purge" rate of treated water (L/d), and

F_i = water discharge rate from resin unloading of IX columns (L/d).

The balance of the fraction of radon source carried by circulating water accounts for any radon in the mined area that is not swept into the injection-production well loop and remains trapped in the ore zone. The "purge" or "bleed" in the production well field is necessary to maintain a hydraulic cone of depression around each well field to prevent leakage of mining solutions outside the production zone.

The radon source term, *S*, can be expressed as

$$S = 10^6 \times L\, E\, [Ra]\, A\, D\, P \qquad \textbf{(3)}$$

where

10^6 = unit conversion factor (cm^3/m^3),

E = emanating power of active ore zone (dimensionless),

[Ra] = Ra-226 concentration in ore zone (pCi/g),

A = active area of ore zone (m^2),

D = average thickness of ore zone (m), and

P = bulk density of ore material (g/cm^3).

The water discharge rate from resin unloading, F_i, can be calculated by

$$F_i = N_i \ V_i \ P_i \tag{4}$$

where

V_i = volume content of IX column (L),

N_i = number of IX column unloadings per day, and

P_i = porosity of resin material.

Under steady-state conditions, the Rn-222 concentration in the process water, C_{Rn}, can be written as

$$C_{Rn} = \frac{10^6 \ [Ra] \ A \ D \ P \ E \ L \ f}{(L+v) \ V + F_p + F_i} \tag{5}$$

When pressure is reduced during purging or when water is aerated during irrigation, radon is readily released to the atmosphere. The amount of Rn-222 available for release from the "purge" is dependent on the water volume purge rate, F_p, and on the Rn-222 concentration in the purged liquid, C_{Rn}. By conservatively assuming that all available radon in the purge water is released, the annual Rn-222 emission is

$$Rn_w = 3.65 \times 10^{-10} \ C_{Rn} \ F_p \tag{6}$$

where

3.65×10^{-10} = unit conversion factor (Ci/pCi)(d/yr), and

Rn_w = Rn-222 release rate from purge water (Ci/yr).

The annual Rn-222 releases from occasional venting from wellheads and leaking transport piping are

$$Rn_v = 3.65 \times 10^{-10} \ v \ C_{Rn} \ V \qquad \textbf{(7)}$$

where Rn_v is the annual Rn-222 release from venting (Ci/yr).

The annual radon-222 discharge from the unloading of the IX column contents is

$$Rn_x = 3.65 \times 10^{-10} \ F_i \ C_{Rn} \qquad \textbf{(8)}$$

where Rn_x annual Rn-222 release from unloading of IX column content (Ci/yr).

The total annual Rn-222 release from the production well field is the sum of Rn_w, $Rn_{v,}$ and Rn_x.

The occurrence of radon in water is controlled by the chemical concentration of radium in the host soil or rock and the emissivity of radon into water. Radon enters air-filled pores in the soil mainly because of the recoil of radon atoms on the decay of Ra-226. The fraction of radon formed in the soil which enters the pores is called the emanating power; reported values range from about 1% to 80%, with an average of 20%, depending on soil type, pore space, and water content (Mueller Associates, Inc., 1986). Varying environmental conditions have been found to affect the rate of radon emanation. In particular, moisture has been found to have significant effects on the radon emanation rate. For purposes of conservatively estimating the radon release from ISL well fields, the emanating power is assumed to be 0.25.

4.3 Drying and Packaging of Yellow Cake

For facilities using rotary vacuum dryers for processing yellow cake, no particulate emissions are expected under normal operating conditions. For facilities using thermal drying, stack releases may be estimated on the basis of information provided by a number of operating ISL uranium recovery facilities. Although more data are needed, the stack release of yellow cake has been estimated to be about 0.05% of the amount produced; however, because the day-to-day variations of particulate release rates can vary by several times, the assumption is that 0.1% of the uranium produced escapes as particulates into the atmosphere, as suggested in the *Final Generic Environmental Impact Statement on Uranium Milling* (U.S. Nuclear Regulatory Commission, 1980).

The particulate release of nuclides other than uranium isotopes is estimated by grab samples reported by ISL facilities (e.g., Semiannual Reports for Highland Uranium Project, Irigary and Christensen Ranch Projects, Crownpoint, and others). On the basis of the field measurements, the conservative assumption is that the activities of thorium (0.15-0.4% of measured values), radium (0.2-0.3%), lead, polonium, and its decay progeny are 0.5% of the U-238 activity in the yellow cake. Furthermore, it may be assumed that the fraction of this activity that is released is the same as the fraction of uranium (0.1%) that is released.

4.4 Restoration Well Field

The basic operating processes of the restoration well field are similar to those of the production well field. Ground water affected by leaching processes in the production well fields is restored to its premining levels (1) by the “pump and treat" (ground-water sweep) method and by flushing with fresh water injection, and (2) by using the permeative stream from reverse-osmosis treatment units. Like the production well field, no particulate materials are expected to be released from the restoration well field operations. The primary source of radioactive release is the Rn-222 gas in the process water circulating within and discharged from the restoration operations. The annual Rn-222 releases from the restoration well field therefore can be calculated by Equations 6 and 7.

4.5 Releases from Land Application Areas

Radionuclide-containing water, either from purge water from production well fields or from restoration wastewater from restoration well fields, is treated to unrestricted release levels and disposed of by irrigation. Release onto the soil surface will contaminate the soil at the land application areas. The radionuclides adsorbed by the soil will become a source term for radioactive release through wind erosion processes. To estimate this wind-generated source term by using MILDOS-AREA, the radionuclide concentration in the soil needs to be estimated first. The radionuclide concentration in the contaminated surface soil region of the land application area, C_s, is calculated by

$$C_s = \frac{10^{-3}\ C_{tw}\ V_o\ R_s}{A_s\ S_d\ P_s} \qquad \textbf{(9)}$$

where

C_s	=	radionuclide concentration in the surface soil (pCi/g),
10^{-3}	=	unit conversion factor (L/cm^3),
V_o	=	total volume of water released onto the land application area (m^3),
C_{tw}	=	radionuclide concentration in treated water (pCi/L),
A_s	=	area of land application (m^2),
S_d	=	assumed depth of contaminated area (m),
P_s	=	bulk density of surface soil (g/cm^3), and
R_s	=	fraction of radionuclide in irrigation water retained in the soil particles (dimensionless).

The fraction of radionuclides in irrigation water retained in the soil particles, R_s, can be calculated with the following formula:

$$R_s = (1 - \frac{1}{R_d}) \qquad \textbf{(10)}$$

The retardation factor, R_d, can be calculated with the following formula:

$$R_d = 1 + \frac{P_s\ K_d}{w} \qquad \textbf{(11)}$$

where

K_d	=	radionuclide distribution coefficient (cm^3/g), and
w	=	soil volume water content (dimensionless).

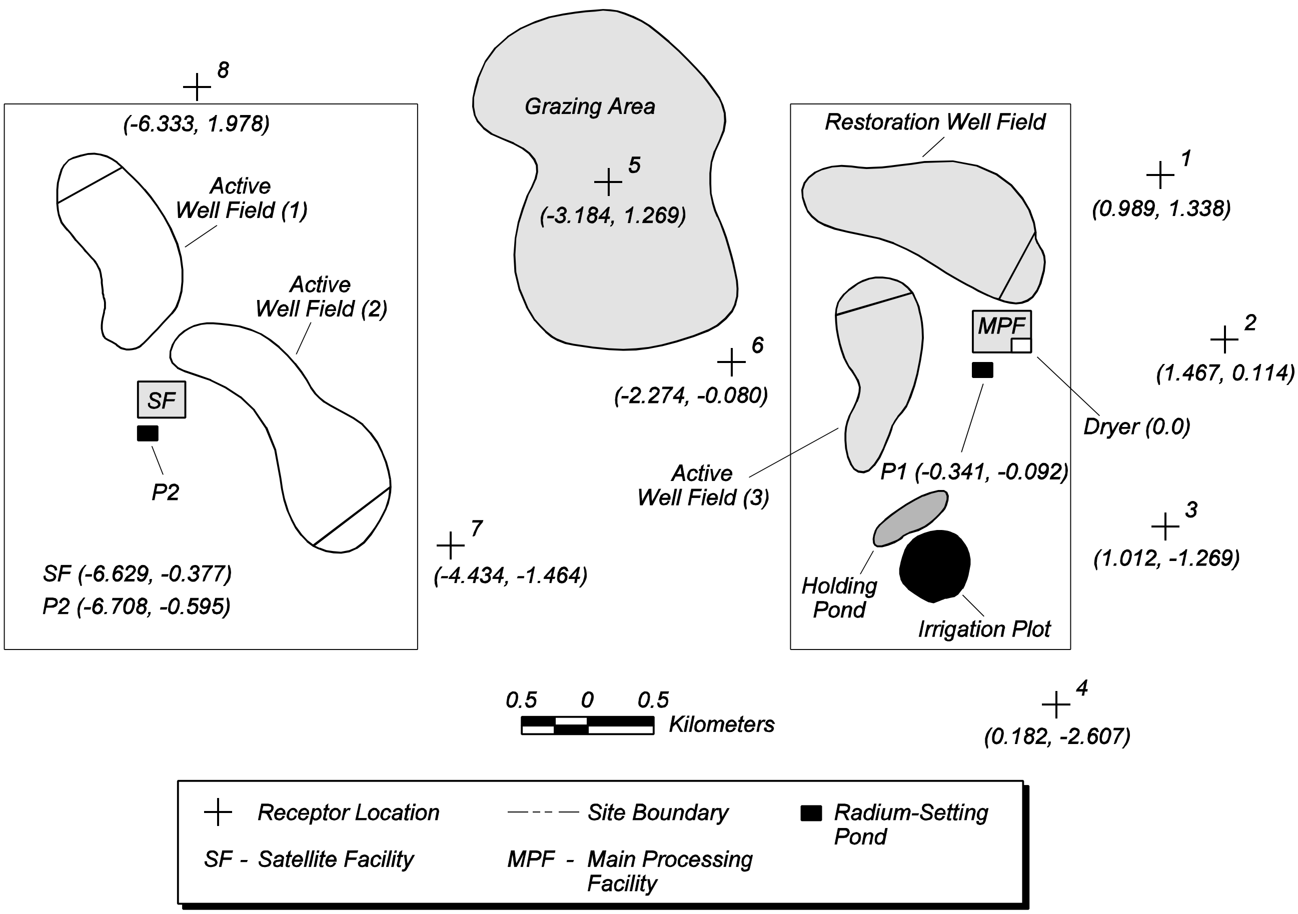
The volumetric water content of the soil, w, is the fraction of the total porosity of the soil material occupied by water. The radionuclide distribution coefficient is the ratio of the radionuclide equilibrium concentration of the adsorbed radionuclide in soil to the desorbed radionuclide in water. Representative distribution coefficients can be found in the report by Yu, et al, 1993.

5.0 EXAMPLE OF SOURCE TERM CALCULATION FOR SAMPLE ISL FACILITY

The following example illustrates some typical calculations that may be used to derive the source term at a hypothetical operating ISL uranium recovery facility. The example covers the potential operations that may result in radionuclide releases to the air from a typical facility. Note that reasonable assumptions for input parameters have been used for this hypothetical site, *but these input data are not intended to serve as substitutes for data collected at actual operating facilities*.

The layout of the hypothetical site is shown in Figure 5-1. It consists of a main processing facility, a satellite facility, one well field under development (active well field 1, two production well fields (active well fields 2 and 3), a restoration well field, two radium-settling ponds (P1 and P2), a holding pond, and an irrigation plot. Only small portions of the well fields are assumed to be active over any one-year period of operations. Eight receptor locations are identified. Of these, location 5 is included within a cattle grazing area to estimate the dose from consumption of livestock products that may become contaminated from site releases. Source and receptor locations are reported in kilometers east (x coordinate) and north (*y* coordinate) of the dryer stack in the main processing facility. Negative values of *x* and *y* coordinates indicate west and south directions, respectively. Table 5-1 lists the coordinates, used in the input data file for each source and receptor. The meteorology for the site is assumed to be the generic file provided with the code.

Figure 5-1. Layout of Hypothetical ISL Facility



5.1 Summary of Principal Operating Characteristics of the Sample ISL Facility

The following parameters apply to the entire facility:

Yellow cake production rate = 520 metric ton (MT)/yr

Average ore activity, U-238 and each progeny in secular equilibrium = 280 pCi/g

Ore porosity = 0.28

Ore density = 1.8 g/cm^3

5.2 New Well Field Drilling/Construction Area (Well Field 1):

A portion of well field 1, located north of the satellite facility, is under development, as follows:

Number of new wells per peak year = 600

Number of new wells per mud pit = 12

Number of mud pits = 600/12 = 50

Ore zone thickness = 5 m

Drill hole diameter = 8 in.

Average ore material per well (g)=$3.14 \times (8 \text{ in} / 2 \times 2.54 \text{ cm/in})^2 \times 500 \text{ cm} \times 1.8 \text{ g/cm}^3 = 2.9 \times 10^5$

Total ore material in mud pit per year (g) = 3.5×10^6

Average storage time of ore grade material in mud pits = 12d

Radon emanating power = 0.25

TABLE 5-1 Source and Receptor Coordinates

Source		East (km)	North (km)	Receptor	East (km)	North (km)
1.	Yellow Cake Dryer Stack	0.000	0.000	Receptor 1 (Individual)	0.989	1.338
2.	Main Processing Facility IX Columns	0.000	0.000	Receptor 2 (Individual)	1.467	0.114
3.	Satellite-Facility	−6.629	−0.377	Receptor 3 (Individual)	1.012	−1.269
4.	Radium-Setting Pond 1	−0.341	−0.092	Receptor 4 (Individual)	0.182	−2.607
5.	Radium-Setting Pond 2	−6.708	−0.595	Receptor 5 (Grazing)	−3.184	1.269
6.	Active Well Field 1 (Area Source)	−7.363	1.162	Receptor 6 (Individual)	−2.274	−0.08
		−7.380	1.313	Receptor 7 (Individual)	−4.434	−1.464
		−7.145	1.464	Receptor 8 (Individual)	−6.333	1.978
		−6.893	1.380			
7.	Active Well Field 2 (Area Source)	−5.449	−1.489			
		−4.879	−1.053			
		−5.080	−1.438			
		−5.282	−1.556			
8.	Active Well Field 3 (Area Source)	−1.423	0.307			
		−1.305	0.525			
		−1.104	0.575			
		−0.886	0.441			
9.	Restoration Well Field (Area Source)	−0.248	0.407			
		0.054	0.927			
		0.137	0.575			
		−0.014	0.374			
10.	Irrigation Plot (Area Source)	−0.669	−1.825			
		−0.830	−1.704			
		−0.952	−1.448			
		−0.911	−1.448			

For this location, on the basis of an average Ra-226 concentration of 280 pCi/g, the annual Rn-222 emission from the mud pit can be estimated by using Equation 1:

$$
\begin{aligned}
Rn_{nw} &= 10^{-12}\text{ Ci/pCi} \times 0.25 \times 0.181\text{/d} \times 280\text{ pCi/g} \times 12\text{ d} \times 3.5 \times 10^{6}\text{ g} \times 50\text{/yr} \\
&= 0.027\text{ Ci/yr}
\end{aligned}
$$

The radon flux can then be estimated by dividing the total emission rate by the area under development as follows:

Area of active drilling per year = 60,000 m^2

Average Rn-222 flux rate = (10^{12} pCi/Ci × 0.027 Ci/yr) / [60,000 m^2 × (3.15 × 10^7 s/yr)]

= 0.0143 pCi/m^2/s

5.3 Production Well Field 2

The following assumptions are used for the production well field located just to the east of the satellite facility:

Operating days per year = 365

Dimensions of the active ore body:

Peak area per year to be mined = 50,000 m^2

Average thickness of ore bodies = 3 m

Total flow volume in circulation in well field = 50,000 × 3 × 0.28 = 42,000 m^3

= 4.2 × 10^7 L

The following assumptions are made for the satellite facility:

Dimensions or capacity of resin column = 3,500 gal

Resin porosity = 0.4

Number of loaded resin unloadings per day = 3

Water discharge rate from unloading of IX column

= 3,500 gal × 0.4 × 3.785 L/gal × 3/d = 1.6 × 10^4 L/d

Total wastewater "purge" rate = 100 gallons per minute (gpm)

= 100 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 5.5 × 10^5 L/d

Fraction of radon source carried by circulating water = 0.8

Rate of radon venting during circulation = 0.01/d

The radon concentration in circulating water is derived by using Equation 5[*] :

$$C_{rn} = [(10^6 \times 280 \times 50{,}000 \times 3 \times 1.8 \times 0.25 \times 0.181) \times 0.8] \,/$$
$$\{[0.191 \times (4.2 \times 10^7)] + [(5.5 \times 10^5) + (1.6 \times 10^4)]\}$$
$$= [(3.4 \times 10^{12}) \times 0.8] \,/\, (8.6 \times 10^6) = 3.2 \times 10^5 \text{ pCi/L}$$

The radon release rate from purge water into settling pond P2 is derived by using Equation 6:

$$Rn_w = (3.65 \times 10^{-10}) \quad (3.2 \times 10^5) \quad (5.5 \times 10^5)$$
$$= 64 \text{ Ci/yr}$$

The radon release rate from gas venting and leaking during circulation is derived by using Equation 7:

$$Rn_v = (3.65 \times 10^{-10}) \times 0.01 \times (3.2 \times 10^5) \times (4.2 \times 10^7)$$
$$= 49 \text{ Ci/yr}$$

The radon release rate from IX unloading is derived by using Equation 8:

$$Rn_x = (3.65 \times 10^{-10}) \times (3.2 \times 10^5) \times (1.6 \times 10^4)$$
$$= 1.9 \text{ Ci/yr}$$

The total radon release from production well field 2 = 115 Ci/yr.

5.4 Production Well Field 3

The following assumptions are used for the production well field located just to the west of the main processing facility:

Operating days per year = 365

Dimensions of the active ore body:

Peak area per year to be mined = 55,000 m^2

Average thickness of ore bodies = 5 m

Total flow volume in circulation in well field

= 55,000 × 5 × 0.28 = 77,000 m^3 = 7.7 × 10^7 L

The same parameters used for the satellite facility servicing well field 2 apply to the IX facility used for well field 3. The following source terms have been derived by using Equations 5 to 8.

[*]To reduce the length of this and other calculations, most of the units have been omitted. The reader is referred back to the equations in Chapter 4 for details on parameter descriptions and units.

The radon concentration in circulating water for well field 3 is given by

$$C_{rn} = [(10^6 \times 280 \times 55{,}000 \times 5 \times 1.8 \times 0.25 \times 0.181) \times 0.8] \,/$$

$$\{[0.191 \times (7.7 \times 10^7)] + [(5.5 \times 10^5) + (1.6 \times 10^4)]\}$$

$$= [(6.3 \times 10^{12}) \times 0.8] \,/\, (1.53 \times 10^7) \;= 3.3 \times 10^5 \text{ pCi/L}$$

The radon release rate from purge water into settling pond P1 is given by

$$Rn_w = (3.65 \times 10^{-10}) \times (3.3 \times 10^5) \times (5.5 \times 10^5)$$

$$= 66 \text{ Ci/yr}$$

The radon release rate from gas venting and leaking during circulation is given by

$$Rn_v = (3.65 \times 10^{-10}) \times 0.01 \times (3.3 \times 10^5) \times (7.7 \times 10^7)$$

$$= 93 \text{ Ci/yr}$$

The radon release rate from IX unloading is given by

$$Rn_x = (3.65 \times 10^{-10}) \times (3.3 \times 10^5) \times (1.6 \times 10^4)$$

$$= 1.9 \text{ Ci/yr}$$

The total radon release from production well field 3 = 161 Ci/yr.

5.5 Restoration Well Field

The following assumptions were used for the restoration well field north of the main processing facility:

Expected restoration operation time = 7 yr

Operating days per year = 240

Dimensions of restoration ore body:

Area per year to be restored = 100,000 m^2

Average thickness of ore bodies = 5 m

Total flow volume in circulation in well field

= 100,000 × 5 × 0.28 = 140,000 m^3 = 1.4 × 10^8 l

Total treated water "purge" rate = 200 gpm

= 200 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 1.1×10^6 L/d

Fraction of radon source carried by circulating water = 0.8

Rate of radon venting during circulation = 0.01/d

The following source terms have been derived by using Equations 5 to 7.

The radon concentration in circulating water for the restoration well field is given by

C_{rn} = [(10^6 × 280 × 100,000 × 5 × 1.8 × 0.25 × 0.181) × 0.8] /

{[0.191 × (1.4 ×10^8)] + (1.1m ×10^6)]}

= [(1.1 ×10^{13}) × 0.8] / (2.8 ×10^7) = 3.3 ×10^5 pCi/L

The radon release rate from purge water into settling pond P1 is given by

Rn_w = (240/365) × (3.65 ×10^{-10}) × (3.3 ×10^5) × (1.1 ×10^6)

= 87 Ci/yr

The radon release rate from gas venting and leaking during circulation is given by

Rn_v = (240/365) × (3.65 × 10^{-10}) × 0.01 × (3.3 × 10^5) × (1.4 × 10^8)

= 110 Ci/yr

The total radon release from the restoration well field = 197 Ci/yr.

5.6 Land Application (Irrigation) Area

The following assumptions are made for the irrigation plot:

Radionuclide concentrations in the holding pond:

U-238 = 1,200 pCi/L

Th-230 = 5 pCi/L

Ra-226 and all progeny = 30 pCi/L

Land irrigation operation water flow rate = 400 gpm

= 400 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 2.2 × 10^6 L/d

Land irrigation operation = 122 d/yr

Land irrigation operation lifetime = 7 yr

Total volume water released over operation lifetime

= (2.2 ×10^6 L/d) × 122 d/yr × 7 yr × 10^{-3} m^3/L =1.9 × 10^6 m^3

Total area of clean wastewater land application = 185,000 m^2

Assumed depth of contaminated area = 0.15 m

Density of soil = 1.6 g/cm^3

Soil volume water content = 0.25

Distribution coefficient of soil (cm^3/g):

Uranium = 50

Thorium = 60,000

Radium = 70

Lead = 100

The retardation factors of surface soil, calculated by using Equation 11, are

Uranium = 320

Thorium = 380,000

Radium = 450

Lead = 640

The fraction of radionuclides in irrigation water that is retained in the surface soil, calculated by using Equation 10, is

Uranium = 1

Thorium = 1

Radium = 1

Lead = 1

The land application area peak surface soil radionuclide concentrations, calculated by using Equation 9, are

U-238 = (10^{-3} × 1,200 × 1.9 × 10^6 × 1) / (185,000 × 0.15 × 1.6)

= 0.043   1,200 = 51 pCi/g

Th-230 = 0.043   5 = 0.21 pCi/g

Ra-226 = 0.043   30 = 1.3 pCi/g

Pb-210 = 0.043   30 = 1.3 pCi/g

Radon flux = 1.3 pCi/g   1.0 ($pCi/m^2/s$)/(pCi/g) = 1.3 ($pCi/m^2/s$)

5.7 Main Processing Facility

The following assumptions apply to the main processing facility:

Yellow cake (U_3O_8) production = 520 MT/yr

Stack release rate:

U-238

$= 520$ MT/yr × 0.001 × 10^6 g/MT × 0.85 g U-nat/g U_3O_8 × (3.3 × 10^{-7} Ci U-238/g U-nat)

= 0.146 Ci/yr

Th-230

= 0.146 × 0.005 = 0.00073 Ci/yr

Ra-226, Pb-210, and Po-210

= 0.146 × 0.005 = 0.00073 Ci/yr

6.0 DESCRIPTION OF PATCH PROGRAM

The revisions to the MILDOS-AREA code are incorporated in the following files:

MILMAIN.EXE. This file is the FORTRAN executable file containing the revisions discussed in Chapter 3. It replaces the old MILMAIN.EXE.

SAMPISL.DAT. This file is the input data file for the example ISL facility described in Chapter 5. A copy of the input data file and output file can be obtained upon request to the U.S. Nuclear Regulatry Commission.

MILDOS.UPD. This data file contains the updated allowable concentration levels for the radionuclides listed in Table 3-1.

README.TXT. This text file contains instructions to MILDOS-AREA on how to replace the old MILMAIN.EXE with the new version and how to copy the other two files to the user's MILDOS directory.

7.0 REFERENCES

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APPENDIX E

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF ON THE RADIUM BENCHMARK DOSE APPROACH

E1.0 BACKGROUND

In 10 CFR 40.4, byproduct material is defined as the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Uranium milling is defined as any activity resulting in byproduct material. Therefore, 10 CFR Part 40, Appendix A, applies to *in situ* leach, heap leach, and ion-exchange facilities that produce byproduct material, as well as to conventional uranium and thorium recovery facilities. This guidance only addresses uranium recovery facilities because there are no currently licensed or planned thorium recovery facilities.

The final rule,"Radiological Criteria for License Termination of Uranium Recovery Facilities," became effective on June 11, 1999, and added the following paragraph after the "radium in soil" criteria in Appendix A, Criterion 6(6):

Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more than one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide, of concentration present to the concentration limit, will not exceed 1 (unity). A calculation of the peak potential annual total effective dose equivalent within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site, must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 100 mrem/yr, before application of as low as is reasonably achievable, requires the approval of the Commission after consideration of the recommendation of the U.S. Nuclear Regulatory Commission (NRC) staff. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before June 11, 1999.

E2.0 RADIUM BENCHMARK DOSE APPROACH

The general requirements for a decommissioning plan, including verification of soil contamination cleanup, are addressed in Chapter 6.0 of the standard review plan. This appendix discusses the NRC staff evaluation of the radium benchmark dose approach, specifically dose modeling and its application to site cleanup activities that should be addressed in the decommissioning plan for those uranium recovery facilities licensed by the NRC and subject to the new requirements for cleanup of contaminated soil and buildings under 10 CFR Part 40, Appendix A, Criterion 6(6), as amended in 1999. The facilities that did not have an approved decommissioning plan at the time the rule became final are required to reduce residual radioactivity, that is, byproduct material, as defined by 10 CFR Part 40, to levels based on the potential dose, excluding radon, resulting from the application of the radium (Ra-226) standard at the site. This is referred to as the radium benchmark dose approach.

This guidance also applies to any revised decommissioning plan submitted for NRC review and approval, after the final rule is effective. However, if a subject licensee can demonstrate that no contaminated buildings will remain, and that soil thorium-230 (Th-230) does not exceed 5 pCi/g (above background) in the surface and 15 pCi/g in subsurface soil in any 100-square-meter area that meets the radium standard, and the natural uranium (U-nat, i.e., U-238, U-234, and U-235) level is less than 5 pCi/g above background, radium benchmark dose modeling is not required. If future modeling with site-specific parameters for uranium recovery sites indicates that this is not a protective approach, the guidance will be revised. Therefore, it would be prudent for a uranium recovery licensee to consider the potential dose from any residual thorium and uranium.

The unity “rule” mentioned in the new paragraph of Criterion 6(6) applies to all licensed residual radionuclides. Therefore, if the ore (processed by the facility), tailings, or process fluid analyses indicate that elevated levels of Th-232 could exist in certain areas after cleanup for Ra-226, some verification samples in those areas should be analyzed for Th-232 or Ra-228. The thorium (Th-232) chain radionuclides (above local background levels) in milling waste would have soil cleanup criteria similar to the uranium chain radionuclides. The staff considers the EPA memorandum of February 12, 1998, (Directive No. 9200.4–25) concerning use of 40 CFR Part 192 soil criteria for Comprehensive Environmental Response, Compensation and Liability Act sites, an acceptable approach. This means that the Th-230 and Th-232 should be limited to the same concentration as their radium progeny with the 5 pCi/g (0.19 Bq/g) criterion applying to the sum of the radium (Ra-226 plus Ra-228) as well as the sum of the thorium (Th-230 plus Th-232) above background.

E2.1 Radium Benchmark Dose Modeling

E2.1.1 Areas of Review

The radium benchmark dose approach involves calculation of the peak potential dose for the site resulting from the 5 pCi/g [0.19 Bq/g] concentration of radium in the surface 15 cm [6 in.] of soil. The dose from the 15 pCi/g [0.56 Bq/g] subsurface radium would also be calculated for any area where the criterion is applied. The dose modeling review involves examining of the computer code or other calculations employed for the dose estimates, the code or calculation input values and assumptions, and the modeling results (data presentation).

Evaluation of the radium benchmark dose modeling as proposed in the decommissioning plan, requires an understanding of the site conditions and site operations. The relevant site information presented in the plan or portions of previously submitted documents (e.g., environmental reports, license renewal applications, reclamation plan, and characterization survey report) should be reviewed.

E2.1.2 Review Procedures

The radium benchmark dose modeling review consists of ascertaining that an acceptable dose modeling computer code or other type of calculation has been used, that input parameter values appropriate (reasonable considering long-term conditions and representative of the application) for the site have been used in the modeling, that a realistic (overly conservative is not acceptable as it would result in higher allowable levels of uranium or thorium which would not be as low as is reasonably achievable) dose estimate is provided, and that the data presentation is clear and complete.

E2.1.3 Acceptance Criteria

The radium benchmark dose modeling results will be acceptable if the dose assessment (modeling) meets the following criteria:

(1) Dose Modeling Codes and Calculations

The assumptions are considered reasonable for the site analysis, and the calculations employed are adequate. Reference to documentation concerning the code or calculations is provided [e.g., the RESRAD Handbook and Manual (Argonne, 1993a,b)].

The RESRAD code developed by the U.S. Department of Energy (Version 6.1, 2001) may be acceptable for dose calculations because, although the RESRAD ground-water calculations have limitations, this does not affect the uranium recovery sites that have deep aquifers (ground-water exposure pathway is insignificant). The DandD code developed by the NRC (see website ftp://nwerftp.nwer.sandia.gov/nrc/DandD/; also see http://techconf.llnl.gov/radcri/ then dose assessment) provides conservative default values, but does not, at this time, allow for modeling subsurface soil contamination and does not allow calculation of source removal due to soil erosion. Neither the RESRAD nor the DandD code would be adequate to model the dose from off-site contamination, but codes such as GENII are acceptable. See Appendix C of NUREG–1727 (NRC, 2000) for additional information.

If the code or calculations assumptions are not compatible with site conditions, adjustments have been made in the input to adequately reflect site conditions. For example, the RESRAD code assumes a circular contaminated zone. The shape factor (external gamma, code screen R017) must be adjusted for an area that is not circular.

The code and/or calculation provides an estimated annual dose as total effective dose equivalent in mrem/yr. The DandD code provides the annual dose, but RESRAD calculates the highest instantaneous dose. However, RESRAD results are acceptable for long-lived radionuclides that do not move rapidly out of surface soils.

(2) Input Parameter Values

The code/calculation input data are appropriate for the site and represent current or long-term conditions, whichever is more applicable to the time of maximum dose. When code default values are used, they are justified as appropriate (representative) for the site. Excessive conservatism (i.e., upper bound value) is not used, as this would result in a higher dose and thus higher levels of uranium and thorium could be allowed to remain on site.

Previously approved MILDOS code input parameter values may not be appropriate, because derived operational doses in the restricted area may be an order of magnitude higher than acceptable doses for areas to be released for unrestricted use.

Site-specific input values are demonstrated to be average values of an adequate sample size. Confidence limits are provided for important parameters so that the level of uncertainty can be estimated for that input value. Alteration of input values considers that some values are interrelated [see draft NUREG–1549, Appendix C (NRC, 1998)], and relevant parameters are modified accordingly. The preponderance of important parameter values are based on site measurements and not on conservative estimates. One or more models consider the annual average range of parameter values likely to occur within the next 200 years, for important parameters that can reasonably be estimated. Some other considerations for the input parameter values follow:

(a) Scenarios for the Critical Group and Exposure Pathways

The scenario(s) chosen to model the potential dose to the average member of the critical group[1] from residual radionuclides at the site reflect reasonable probable future land use. The licensee has considered ranching, mining, home-based business, light industry, and residential farmer scenarios, and has justified the scenarios modeled.

On the basis of one or more of these projected (within 200 years is reasonably foreseeable) land uses to define the critical group(s), the licensee has determined and justified what exposure pathways are probable for potential exposure of the critical group to residual radionuclides at the site. Dairies are not likely to be established in the area of former uranium recovery facilities because the climate and soil restrict feed production. Even if some dairy cows were to graze in contaminated areas, the milk would probably be sent for processing (thus diluted), and not be consumed directly at the site. Therefore, milk consumption is not a likely ingestion exposure pathway. Also, a pond in the contaminated area providing a significant quantity of fish for the resident's diet is not likely, so the aquatic exposure pathway may not have to be modeled. However, the external gamma, plant ingestion, and inhalation pathways are likely to be important.

The radon pathway is excluded from the benchmark dose calculation as defined in Criterion 6(6) of Appendix A to 10 CFR Part 40. This also reflects the approach in the decommissioning rule (radiological criteria for license termination, 10 CFR Part 20, Subpart E).

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[1]As defined in 10 CFR Part 20, "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

(b) Source Term

If the RESRAD code is used, the input includes lead-210 (Pb-210) at the same input value as for Ra-226. The other radium progeny are automatically included in the code calculations. The chemical form of the contamination in the environment is considered in determining input values related to transport, or inhalation class (retention in the lung) for dose conversion factors.

(c) Time Periods

The time periods for calculation of the dose from soil Ra-226 include the 1,000-year time frame. The calculated maximum annual dose and the year of occurrence are presented in the results.

(d) Cover and Contaminated Zone

A cover depth of zero is used in the surface contamination model, and a depth of at least 15 cm [6 in.] is used for the subsurface model. The values for area and depth of contamination are derived from site characterization data. The erosion rate value for the contaminated zone is less than the RESRAD default value because in regions drier than normal, the erosion rate is less, as discussed in the RESRAD Data Collection Handbook (Argonne, 1993a), and the proposed value is justified. The soil properties are based on site data (sandy loam or sandy silty loam are typical for uranium recovery sites), and other input parameters are based on this demonstration of site soil type [see RESRAD handbook, pp., 23, 29, 77, and 105 (Argonne, 1993a)].

The evapotranspiration coefficient for the semi-arid uranium recovery sites is between 0.6 and 0.99. The precipitation value is based on annual values averaged over at least 20 years, obtained from the site or from a nearby meteorological station.

The irrigation rate value may be zero, or less than a code's default value, if supported by data on county or regional irrigation practices (e.g., zero is acceptable if irrigation water is obtained from a river not a well). The runoff coefficient value is based on the site's soil type, expected land use, and regional morphology.

(e) Saturated Zone

The dry bulk density, porosity, "b" parameter, and hydraulic conductivity values are based on local soil properties. The hydraulic gradient for an unconfined aquifer is approximately the slope of the water table. For a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.

If the RESRAD code is used, the non-dispersion model parameter is chosen for areas greater than 1,000 square meters (code screen R014), and the well pump rate is based on irrigation, stock, or drinking water well pump rates in the area.

(f) Uncontaminated and Unsaturated Strata

The thickness value represents the typical distance from the soil contamination to the saturated zone. Since the upper aquifer at uranium recovery sites is often of poor quality and quantity, the depth of the most shallow well used for irrigation or stock water in the region is chosen for the unsaturated zone thickness. A value of 18 m [60 ft] is typical for most sites {15 m [50 ft] for the Nebraska site}, but regional data are provided for justification. The density, porosity, and "b" parameter values are similar to those for the saturated zone, or any changes are justified.

(g) Distribution Coefficients and Leach Rates

The distribution coefficient (Kd) is based on the physical and chemical characteristics of the soil at the site. The leach rate value of zero in the RESRAD code is acceptable as it allows calculation of the value. If a value greater than zero is given, the value is justified.

(h) Inhalation

An average inhalation rate value of approximately 8,395 m^3/yr is used for the activity assumed for the rancher or farmer scenario based on a draft letter report (Sandia, 1998a). The mass loading for inhalation (air dust loading factor) value is justified based on the average level of airborne dust in the local region for similar activities as assumed in the model.

(i) External Gamma

The shielding factor for gamma is in the range of 0.4 to 0.8 (60 to 20 percent shielding) based on DandD Parameter data (NRC, 1998) (the DandD code screening default value is 0.55). The factor is influenced by the type (foundation, materials) of structures likely to be built on the site and the gamma energy of the radionuclides under consideration.

The time fractions for indoor and outdoor occupancy are similar to default values in RESRAD and draft guidance developed for the decommissioning rule [NUREG/CR–5512, Volume 3 (NRC, 1996)]. For example, the staff would consider fraction values approximating 0.7 indoors and 0.15 outdoors for a resident working at home, and 0.5 outdoors and 0.25 indoors for the farmer scenario (the remaining fraction allocated to time spent off site).

The site-specific windspeed value is based on adequate site data. The average annual windspeed for the uranium recovery sites varies from 3.1 to

5.5 meters/sec [7 to 13 mph]. The maximum and annual average windspeed are also considered when evaluating proposed erosion rates.

(j) Ingestion

Average consumption values (g/yr) for the various types of foods are based on average values as discussed in NUREG/CR–5512, Volume 3 (NRC, 1996), or the Sandia Draft Letter Reports (1998a,b), or are otherwise justified. Livestock ingestion parameters are default values, or are otherwise justified.

For sites with more than 100 acres of contamination, the fraction of diet from the contaminated area is assumed to be 0.25 for the farmer scenario (Sandia, 1998a), or is otherwise justified based on current or anticipated regional consumption practices for home-grown food. Because of the low level of precipitation in the areas in which uranium recovery facilities are located, extensive gardens or dense animal grazing is not likely, so the percentage of the diet obtained from contaminated areas would be lower than the code default value.

Note that the default plant mass loading factor in the DandD code can reasonably be reduced to 1 percent (Sandia, 1998c). The depth of roots is an important input parameter for uranium recovery licensees using the RESRAD code. The value is justified based on the type of crops likely to be grown on the site in the future. For vegetable gardens, a value of 0.3 is more appropriate than the RESRAD default value of 0.9 meters that is reasonable for alfalfa or for a similar deep-rooted plant.

(3) Presentation of Modeling Results

The radium benchmark dose modeling section of the decommissioning plan includes the code or calculation results as the maximum annual dose (total effective dose equivalent) in mrem/yr, the year that this dose would occur, and the major exposure pathways by percentage of total dose. The modeling section also includes discussion of the likelihood of the various land-use scenarios modeled (reflecting the probable critical groups), and provides the variations in dose (dose distribution) created by changing key parameter values to reflect the range of dose values that are likely to occur on the site. The section also contains the results of a sensitivity analysis (RESRAD can provide a sensitivity analysis via the graphics function) to identify the important parameters for each scenario.

E2.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radium benchmark dose modeling, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the site benchmark dose modeling for the ______________ uranium *in situ* leach facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.1 of Appendix E of the *in situ* leach standard review plan.

The licensee has provided an acceptable radium benchmark dose model, and the staff evaluation determines that (1) the computer code or set of calculations used to model the benchmark dose is appropriate for the site, (2) input parameter values used in each dose assessment model are site-specific or reasonable estimates, and (3) the dose modeling results include adequate estimates of dose uncertainty.

On the basis of the information presented in the application, and the detailed review conducted of radium benchmark dose modeling for the ______________ uranium *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which provides requirements for soil and structure cleanup.

E2.2 Implementation of the Benchmark Dose

E2.2.1 Areas of Review

The results of the radium benchmark dose calculations are used to establish a surface and subsurface soil dose limit for residual radionuclides other than radium, as well as a limit for surface activity on structures that will remain after decommissioning. The staff should review the licensee's conversion of the benchmark dose limit to soil concentration (pCi/g) or surface activity levels (dpm/100 cm^2) as a first step to determine cleanup levels. Alternatively, the licensee can derive the estimated dose from the uranium or thorium contamination (as discussed in Section 2.1.3) and compare this to the radium benchmark dose.

The reviewer should also evaluate the proposed cleanup guideline levels (derived concentration limit) in relation to the as low as is reasonably achievable requirement and the unity rule.

E2.2.2 Review Procedures

The decommissioning plan section on cleanup criteria will be evaluated for appropriate conversion of the radium standard benchmark dose to cleanup limits for soil uranium and thorium and/or surface activity. The plan will also be examined to ensure reasonable application of as low as is reasonably achievable to the cleanup guideline values and application of the unity rule where appropriate.

E2.2.3 Acceptance Criteria

(1) The soil concentration limit is derived from the site radium dose estimate. The modeling performed to estimate mrem/year per pCi/g of Th-230 and/or U-nat follows the criteria listed in Section 2.1.3. In addition, the U-nat source term input is represented as percent activity by 48.9 percent U-238, 48.9 percent U-234, and 2.2 percent U-235, or is based on analyses of the ore processed. For a soil uranium criterion

(derived concentration limit), the chemical toxicity is considered in deriving a soil concentration limit if soluble forms of uranium are present.

(2) Detailed justification for the inhalation pathway parameters is provided, such as the determination of the chemical form in the environment, to support the inhalation class.

(3) The derived Th-230 soil limit will not cause any 100 square meter (m^2) area to exceed the Ra-226 limit at 1,000 years (i.e., current concentrations of Th-230 are less than 14 pCi/g surface and 43 pCi/g subsurface, if Ra-226 is at approximately background levels).

(4) In conjunction with the activity limit, the as low as is reasonably achievable principle is considered in setting cleanup levels (derived concentration guideline levels). The as low as is reasonably achievable guidance in NUREG–1727, Appendix D (NRC, 2000) is considered. The proposed levels allow the licensee to demonstrate that the 10 CFR 40.42 (k) requirements (the premises are suitable for release, and reasonable effort has been made to eliminate residual radioactive contamination) can be met.

(5) In recent practice at mill sites, the as low as is reasonably achievable principle is implemented by removing about 2 more inches [5 cm] of soil than is estimated to achieve the radium standard (reduce any possible excess or borderline contamination). At recovery facilities, it is generally cheaper to remove more soil than to do sampling and testing that may indicate failure and require additional soil removal with additional testing.

(6) The unity rule is applied to the cleanup if more than one residual radionuclide is present in a soil verification grid (100 m^2). This means that the sum of the ratios for each radionuclide of the concentration present/concentration limit may not exceed 1 (i.e., unity).

(7) The subsurface soil standard, if it is to be used, is applied to small areas of deep excavation where at least 15 cm [6 in.] of compacted clean fill is to be placed on the surface and where that depth of cover is expected to remain in place for the foreseeable future. The long-term cover depth used in the model is justified.

(8) The surface activity limit for remaining structures is appropriately derived using an approved code or calculation. Because recent conservative dose modeling by NRC staff has indicated that more than 2,000 dpm/100 cm^2 alpha (U-nat or uranium chain radionuclides) in habitable buildings [2,000 hr/yr] could exceed an effective dose equivalent of 25 mrem/yr, the licensee proposes a total (fixed plus removable) average surface activity limit for such buildings that is lower than 2,000 dpm/100 cm^2, or a higher value is suitably justified.

(9) If the DandD code is used, data are provided to support that 10 percent or less of the activity is removable; otherwise the resuspension factor is scaled to reflect the site-specific removable fraction. Note that this code assumes that the contamination is

only on the floor, which can be overly conservative. If the RESRAD-Build code is used, the modeled distribution of contamination on walls and floor is justified.

E2.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the application of the radium benchmark dose modeling to the site cleanup criteria, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the proposed implementation of the benchmark dose modeling results for the _______________ uranium *in situ* leach facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.2 of Appendix E of the *in situ* leach standard review plan.

The licensee has provided an acceptable implementation plan of the benchmark dose modeling results to the proposed site cleanup activities, and the staff evaluation determines that (1) the cleanup criteria will allow the licensee to meet 10 CFR Part 40.42(k) and 10 CFR Part 40, Appendix A, Criterion 6(6) requirements; (2) the soil and structures of the decommissioned site will permit termination of the license because public health and the environment will not be adversely affected by any residual radionuclides.

E3.0 REFERENCES

Argonne National Laboratory. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." ANL/EAIS–8. Washington, DC: U.S. Department of Energy. April 1993a.

———. "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0." ANL/EAD/LD–2. Washington, DC: U.S. Department of Energy. September 1993b.

NRC. NUREG/CR–5512, "Residual Radioactive Contamination from Decommissioning—User's Manual." Volume 2. Washington, DC: NRC. April 2001.

———. NUREG–1727, "NMSS Decommissioning Standard Review Plan." Washington, DC: NRC. 2000.

———. Draft NUREG–1549, "Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination." Washington, DC: NRC. July 1998.

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Sandia National Laboratories. “Review of Parameter Data for the NUREG/CR–5512 Residential Farmer Scenario and Probability Distributions for the DandD Parameter Analysis.” Draft Letter Report. January 30, 1998a.

———. “Review of Parameter Data for the NUREG/CR–5512 Building Occupancy Scenario and Probability Distributions for the DandD Parameter Analysis.” Draft Letter Report. January 30, 1998b.

———. “Comparison of the Models and Assumptions Used in the DandD 1.0, RESRAD 5.61, and RESRAD-Build Computer Codes with Respect to the Residential Farmer and Industrial Occupant Scenarios Provided in NUREG/CR–5512.” Draft Report. October 15, 1998c.

ATTACHMENT 4

NUREG–1620
Rev. 1

STANDARD REVIEW PLAN
for the Review of a Reclamation Plan
for Mill Tailings Sites
Under Title II of the Uranium Mill Tailings
Radiation Control Act of 1978

FINAL REPORT

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Fuel CYCLE Safety and Safeguards
Washington, DC 20555-0001

NUREG–1620
Rev. 1

Standard Review Plan

for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978

Final Report

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U.S. Nuclear Regulatory Commission
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AVAILABILITY NOTICE

ABSTRACT

A U.S. Nuclear Regulatory Commission source and byproduct materials license is required by 10 CFR Part 40 for the operation of uranium mills and the disposal of “tailings,” wastes produced by the extraction or concentration of source material from ores processed primarily for their source material content. Appendix A to Part 40 establishes technical and other criteria relating to siting, operation, decontamination, decommissioning, and reclamation of mills and of tailings at mill sites. The licensee’s site reclamation plan documents how the proposed activities demonstrate compliance with the criteria in Appendix A to Part 40 and the information needed to prepare the environmental assessment on the effects of the proposed reclamation activities on the health and safety of the public and on the environment.

This standard review plan is prepared for the guidance of staff reviewers in the Office of Nuclear Material Safety and Safeguards in performing safety and environmental reviews of reclamation plans for uranium mill tailings sites covered by Title II of the Uranium Mill Tailings Radiation Control Act of 1978 as amended. It provides guidance for new reclamation plans, license renewals, and license amendments. The principal purpose of this standard review plan is to ensure the quality and uniformity of staff reviews and to present a well-defined base from which to evaluate changes in the scope and requirements of a review.

This standard review plan is written to cover a variety of site conditions and reclamation plans. Each section contains a description of the areas of review, review procedures, acceptance criteria, and evaluation findings.

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FIGURE

TABLES

EXECUTIVE SUMMARY

A U.S. Nuclear Regulatory Commission (NRC) source and byproduct materials license is required in accordance with the provisions of Title 10 of the U.S. Code of Federal Regulations, Part 40 (10 CFR Part 40), “Domestic Licensing of Source Material,” in conjunction with uranium or thorium milling, or with byproduct material at sites formerly associated with such milling. At the termination of a uranium mill license, the mill tailings impoundment and some adjoining land will be turned over to the U.S. Department of Energy (DOE), another Federal agency designated by the President, or the State in which the site is located for long-term care. Requirements applicable to a license consist of the regulations in 10 CFR Part 40, Appendix A to 10 CFR Part 40, and any license conditions. The specific sections in this standard review plan that address the criteria of 10 CFR Part 40, Appendix A, are shown in Appendix A of the review plan.

An application for a new license, license renewal, or an amendment to or termination of an existing license should contain, as appropriate, proposed specifications relating to the milling operations, and the information on the disposal of tailings or wastes resulting from such milling activities and information on decommissioning of the site. General guidance on (i) contents and filing of an application and (ii) producing an environmental report appears in 10 CFR 40.31, “Application for specific licenses,” and in 10 CFR 51.45, “Environmental report,” respectively. The staff uses the information in the application to determine whether the proposed activities will be protective of public health and safety and be environmentally acceptable. General provisions for issuance, amendment, transfer, and renewal of licenses are described in 10 CFR Part 2, Subpart A. Guidance on considering environmental justice issues during licensing of Title II uranium or thorium mills is presented in NUREG–1748 (NRC, 2001).

This standard review plan provides the staff in the Office of Nuclear Material Safety and Safeguards with specific guidance on the review of reclamation plans and license amendments related to reclamation plans. The reclamation plan, submitted by an applicant (in the case of a new application) or a licensee (in the case of an amendment to a previously approved reclamation plan or termination of an existing license) should demonstrate compliance with the applicable criteria in Appendix A to 10 CFR Part 40. The introduction to 10 CFR Part 40 specifically states that “In many cases, flexibility is provided in the criteria to allow achieving an optimum tailings disposal program on a site-specific basis. However, in such cases the objectives, technical alternatives and concerns which must be taken into account in developing a tailings program are identified.” The principal purpose of the standard review plan is to present guidance to the NRC staff to ensure a consistent quality and uniformity in NRC reviews of reclamation plans. Each section in this standard review plan contains guidance on what is to be reviewed, the basis for the review, how the staff review is to be done, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding compliance with the regulations in 10 CFR

Part 40. This standard review plan is intended to cover only those aspects of the NRC regulatory mission related to the reclamation of mill tailings sites, including soil and ground-water cleanup, at conventional uranium mills. As such, the standard review plan helps focus the staff review on determining if a tailings impoundment can be constructed, operated, and reclaimed in compliance with the applicable NRC regulations. The standard review plan is also intended to make information about regulatory matters widely available to improve communication, and to help interested members of the public and the uranium recovery industry gain a better understanding of the staff review process. In any of these reviews, the staff will consider licensee-proposed alternatives to Appendix A criteria as described in the Introduction in Appendix A to 10 CFR Part 40. The review would cover the level of protection to the public health and safety and the environment and the level of stabilization and containment of the site. All site-specific licensing decisions based on Appendix A criteria or proposed alternatives will consider the risk to health and safety and the environment and the economic costs involved. Staff guidance for review of environmental reports and preparing environmental assessments is found in NUREG–1748 (NRC, 2001).

For license amendments, the review should focus on the changes proposed in the amendment [see NUREG–1748 (NRC, 2001) for guidance on reviewing historical aspects of site performance]. Reviewers should not review previously accepted actions if they are not part of the proposed amendment, unless the review of the amendment package identifies an impact on previously accepted actions.

For changes to previously approved reclamation plans, the licensee need only submit information pertinent to the proposed change. The licensee need not resubmit a complete reclamation plan covering all aspects of site reclamation, but should present information on the proposed changes to the previously approved plan and its updates as identified in the current NRC license. Reviewers should also analyze the inspection history and operation of the site to see if any major problems have been identified over the course of the license term that would have an effect on reclamation. The operating history of the facility is often a valuable source of information concerning the adequacy of site characterization, the acceptability of radiation protection and monitoring programs, and the sufficiency of other data that may influence staff determination of compliance. NUREG–1757, Volume I, Section 16.2 (NRC, 2002) presents guidance for review of these historical aspects of facility performance. If the changes are found to be acceptable, the license is then amended to identify the revised reclamation plan as the required design for reclamation.

License termination usually involves a confirmation that all applicable reclamation requirements have been met. This includes ensuring completion of stabilization work for the tailings consistent with the accepted reclamation plan and a determination that the licensee has complied with all standards applicable to land structures, and ground-water cleanup. As such, the information in this review plan will be used to help make the necessary conclusions concerning license termination. The four aspects of license termination addressed in this review plan included (i) mill decommissioning, decontamination and disposal; (ii) surface soil cleanup and post cleanup verification; (iii) mill tailings surface stabilization; and (iv) ground water corrective action. Compliance with these four aspects of reclamation, taken together, forms the basis for the staff finding that the design and ground-water cleanup program meet applicable requirements, and that the design and cleanup program have been acceptably completed at the sites and that the licensee has, therefore, met the applicable requirements.

The staff will prepare the following reports to document the review: a technical evaluation report and an environmental assessment. The guidance in NUREG–1748 (NRC, 2001) will be used to prepare the environmental assessment. The provisions of 10 CFR 51.21 require preparation of an environmental assessment unless: (i) the staff finds, based on the environmental assessment, that NRC needs to prepare an environmental impact statement; (ii) another federal agency also involved in the action as a cooperating agency needs to prepare an environmental impact statement; (iii) the effects on the quality of the human environment are likely to be highly controversial; or (iv) 10 CFR 51.22 categorically excludes the necessity to prepare an environmental assessment. Applications for new mills require NRC to prepare an environmental impact statement in accordance with 10 CFR 51.20(b)(18). This standard review plan is intended to guide the preparation of the technical evaluation report.

It is important to note that the acceptance criteria noted in this standard review plan are for the guidance of the Office of Nuclear Material Safety and Safeguards staff responsible for the review of license applications. Review plans are not substitutes for the Commission's regulations, and compliance with a particular standard review plan is not required. Methods and solutions different from those set out in the standard review plan may be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a license by NRC. Use of this standard review plan does not obviate the need for professional judgement; it helps assure overall completeness and uniformity of the staff review.

GENERAL REVIEW PROCEDURE

A licensing review is not intended to be a detailed evaluation of all aspects of facility operations. Specific information about implementation of a program or construction of a design outlined in an application is obtained through the NRC review of procedures and operations done as part of the inspection function. However, some procedures may be required during review of a reclamation or decommissioning plan. The differences between licensing reviews and inspections are shown in Figure 1. For a new license application, the staff will review the proposed reclamation plan and ground water protection program for compliance with the criteria in Appendix A to 10 CFR Part 40. For a license renewal or an amendment to an existing license, the staff will only review proposed changes to the NRC-approved reclamation plan for compliance with criteria in Appendix A to 10 CFR Part 40. If the changes proposed have an adverse impact on the performance or functionality of some of the approved features at the site, then the staff will review those items for their compliance with regulations.

In the case of an amendment application concerning confirmation of site or ground-water cleanup or completion of construction, the reviewer will focus on ensuring that the applicable activities have been completed consistent with the approved review plan. Reviewers will not revisit accepted designs or plans unless the as-completed activity presents problems, such as degradation or reconformation.

Changes to existing licensed activities and conditions require the issuance of an appropriate license amendment. An application for such an amendment should describe the proposed changes in detail and should discuss the potential environmental and health and safety impacts. Amendment requests should be reviewed using the appropriate sections of this document for guidance. NUREG–1757, Volume I (NRC, 2002), contains guidance for examining the historical aspects of facility operations in connection with amendment reviews. The steps of the reclamation plan review are described in the paragraphs that follow.

Acceptance Review

The staff will conduct an acceptance review of a new reclamation plan or changes to a previously approved plan to determine the completeness of the information submitted. The reclamation plan will be considered acceptable for docketing if the information in it is sufficiently complete to initiate a detailed technical review, and reflects an adequate reconnaissance and physical examination of the regional and site conditions, and contains appropriate analyses and design information to demonstrate that the applicable regulatory criteria will be met. Completeness of the environmental report will be determined using the information requirements in 10 CFR 51.45 and the guidance in NUREG–1748 (NRC, 2001). The staff should complete the acceptance review and transmit the results to the applicant within 30 days of the receipt of the application, along with a projected schedule for the remainder of the review. In this transmittal, the staff should note any additional information needed to make the reclamation plan or environmental report complete. Detailed technical questions, although not required, can be included, if they are identified during the acceptance review. If the contents of the reclamation plan or environmental report do not clearly demonstrate compliance with applicable regulatory criteria, then the staff may decline to docket the reclamation plan and will return it to the licensee for revisions.

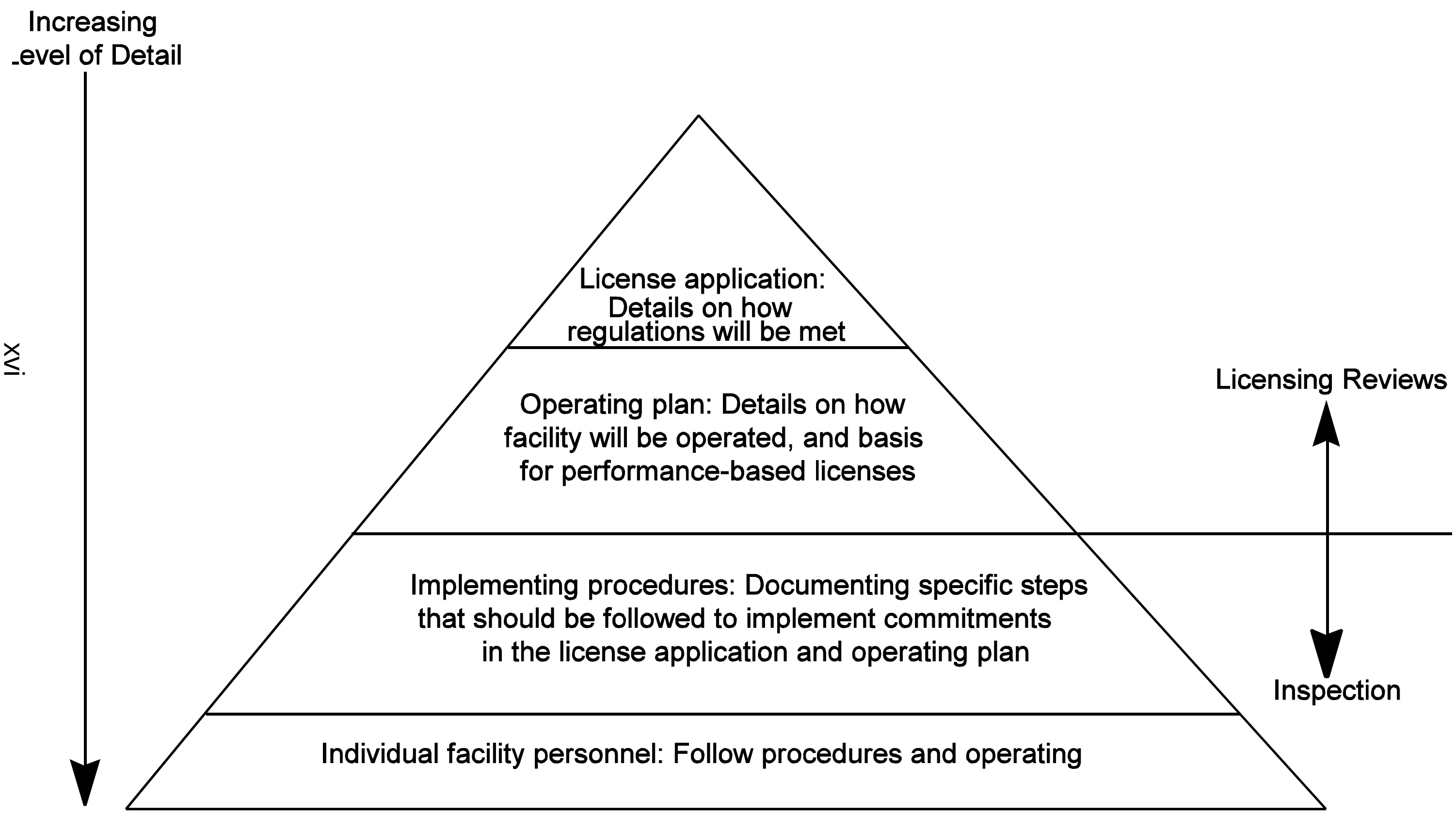

Figure 1. Schematic of NRC Licensing and Inspection Process and Applicability to Different License Documents

Detailed Review

Following completion of the acceptance review, the staff will conduct a detailed technical review of the reclamation plan. During the detailed review, if there is a need for additional information, the staff will send to the licensee a request for additional information identifying the issue or concern, basis for the concern, and the kind of information needed to resolve the concern. After the staff receives a satisfactory response to the request for additional information, the detailed review will be concluded. NRC documents the results of this review and the basis for acceptance or denial of the requested licensing action in a technical evaluation report, and in an environmental assessment (10 CFR 51.21) if there is a finding of no significant impact, or in an environmental impact statement (10 CFR 51.20) if the reclamation plan is part of an application for a new mill or if one of the other requirements for an environmental impact statement have been met (10 CFR 51.20). The detailed review should evaluate the environmental, economic, and technical evidence presented by the applicant to support the ability of the proposed facility to meet applicable regulatory requirements. In the case of amendments to an existing license as a result of changes to a previously approved reclamation plan, the need for an environmental assessment will be determined on a case-by-case basis.

In determining the acceptability of any aspect of tailings reclamation, the staff will evaluate the use of alternatives to meeting the specific requirements in 10 CFR Part 40, Appendix A. In evaluating the use of alternatives, the staff will determine if the proposed reclamation design satisfactorily demonstrates the requisite requirements of economic benefit and equivalent protection. In this standard review plan, we identify alternatives that have been found to be acceptable by the staff in previous reviews. Alternatives developed by licensees need not be limited to those discussed here. Other alternatives can be proposed, as long as the economic benefit and equivalent protection can be demonstrated.

The Standard Review Plan

The standard review plan is written to cover a variety of site conditions and reclamation designs. Each section presents the complete review procedure and acceptance criteria for all the areas of review pertinent to that section. The review plan is intended as general guidance to the NRC staff, and does not contain regulatory requirements. For any given application, the staff reviewer may select and emphasize particular aspects of each standard review plan section as appropriate for the reclamation plan. Because of this, the staff may not carry out, in detail, all of the review steps listed in each standard review plan section, in the review of every reclamation plan.

I. Areas of Review

This subsection describes the scope of the review (i.e., what is being reviewed). It contains a brief description of the specific technical information and analyses in the reclamation plan that need to be reviewed by each technical reviewer.

II. Review Procedures

This subsection discusses the appropriate review technique. It is generally a step-by-step procedure that the reviewer uses to determine whether the acceptance criteria have been met.

III. Acceptance Criteria

This subsection delineates criteria that the reviewer can apply to determine the acceptability of the applicant's compliance demonstration. Although acceptance criteria are not regulatory requirements, the technical bases for these criteria have been derived from 10 CFR Parts 20, 40, and 51, NRC regulatory guides, general design criteria, codes and standards, NRC branch technical positions, standard testing methods (e.g., American Society for Testing and Materials standards), technical papers, and other similar sources. These sources typically contain solutions and approaches previously determined by the staff to be acceptable for making compliance determinations for the specific area of review. These acceptance criteria have been defined so that staff reviewers can use consistent and well-documented approaches for review of all reclamation plans. In the absence of well-defined acceptance criteria, the staff will rely on "professional judgment" and what is normally practiced in the profession. Licensees may take approaches to demonstrating compliance that are different from those in this standard review plan. However, they should recognize that, as is the case for regulatory guides, substantial staff time and effort have gone into the development of these procedures and criteria, and a corresponding amount of time and effort may be required to review and accept new or different solutions and approaches. Thus, licensee-proposed solutions and approaches to safety problems or safety-related design areas other than those described in this standard review plan may require longer review times and NRC requests for more extensive supporting information. The staff is willing to consider proposals for other solutions and approaches on a generic basis, apart from a specific review, to avoid the impact of the additional review time for individual cases.

IV. Evaluation Findings

This subsection presents the staff's general conclusions and findings that result from review of each area of the reclamation plan, as well as identification of the applicable regulatory requirements. Conclusions and findings for a specific site and review area are dependent on the site characteristics and type of licensing action being considered. For each standard review plan section, a conclusion is included in the technical evaluation report/safety evaluation report or in the environmental assessment/environmental impact statement, in which results of the review are published. These documents contain a description of the review; the basis for the staff findings, including aspects of the review selected or emphasized; where the reclamation design or the licensee’s plans deviate from the criteria stated in the standard review plan; and the evaluation findings.

Standard Review Plan Updates

The standard review plan will be revised and updated periodically as the need arises to clarify the content or correct errors and to incorporate modifications approved by NRC management.

REFERENCES

NRC. NUREG–1757, “Consolidated NMSS Decommissioning Guidance.” Vol. I. Washington, DC: NRC. January 2002.

NRC Draft NUREG–1748, “Environmental Review guidance for Licensing Actions associated with NMSS Programs.” Washington, DC: NRC, Office of Nuclear Material Safety and Safeguards. 2001.

1.0 GEOLOGY AND SEISMOLOGY

The reclamation plan and its supporting documents must contain sufficient regional and site-specific geologic and seismologic information related to the proposed disposal site and reclamation design, including regional and site-specific stratigraphy, structure, geomorphology, and seismology. This standard review plan establishes the requirements for staff of the U.S. Nuclear Regulatory Commission (NRC) to conduct and document the review of new reclamation plans for mill tailings impoundments, or amendments to previously approved reclamation plans in the areas of geology and seismology.

1.1 Stratigraphic Features

1.1.1 Areas of Review

The staff should review information presented in the reclamation plan on the regional and site-specific stratigraphy and geology. The reclamation plans should describe surface and subsurface strata and the interpretation of their orientation, occurrence, thickness, composition, age, depositional environment, and interrelationships. The reviewer should coordinate the stratigraphic information with the evaluation of the site's geotechnical stability, surface water and erosion protection, and ground-water resources protection information as described in standard review plan Chapters 2.0, 3.0, and 4.0, respectively. The purpose of this review is to determine if there has been an acceptable characterization of site and regional stratigraphy so that sufficient information has been presented for use in the reclamation plan and design of the tailings cell.

1.1.2 Review Procedures

The reviewer should examine the description and discussion of the regional and site-specific features to determine if a thorough evaluation of the regional and site stratigraphy has been presented.

The following specific descriptive information should be reviewed to determine its adequacy for characterizing the regional and site-specific stratigraphic features:

(1) Description of regional stratigraphic units by rock classification and type.

(2) Distribution of regional stratigraphic units.

(3) Age relationships of regional and site-specific stratigraphic units.

(4) Detailed site stratigraphy based on outcrop and well borings conducted to determine rock types and their texture, composition, distribution, thickness, and environment of deposition.

The staff determination of compliance should be based in part on professional judgment, considering the complexity of the subsurface conditions at the site.

1.1.3 Acceptance Criteria

The characterization of regional and site stratigraphy will be acceptable if the information presented conforms to the following criteria:

(1) The regional and site-specific stratigraphy are described in sufficient detail to produce an adequate understanding of the site-specific subsurface characteristics, including descriptions of major stratigraphic units and their orientations, age relationships, thicknesses, environments of deposition distributions, and any stratigraphic features (e.g., facies changes) likely to affect site stability or ground-water resource protection.

(2) Stratigraphic units are described in sufficient detail to provide input to a geotechnical stability analysis.

(3) Descriptions of regional and site-specific stratigraphic units contain sufficient information for input to an analysis of ground water resources and the protection thereof.

(4) Regional stratigraphic information is discussed in sufficient detail to support site-specific information.

(5) Descriptions of the regional and site stratigraphy are based on published literature and site data and conform to standard geological classifications.

(6) Discussions of regional stratigraphy are adequately referenced and supported by published reports, maps, logs, and cross sections.

(7) Site descriptions are based on field investigations and adequate sampling to define physical and chemical properties of surface and subsurface materials such as soils and underlying geologic formations at the site.

(8) Maps are at a scale sufficient to show the locations of all site explorations such as borings, geophysical surveys, trenches, and sample locations.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. Staff determination of compliance should be based in part on professional judgment, considering the complexity of the site conditions.

1.1.4 Evaluation Findings

If the staff review, as described in standard review plan Section 1.1, results in the acceptance of the characterization of regional and site stratigraphy, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the characterization of the regional and site stratigraphy at the_______________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.1.2 and the acceptance criteria outlined in Section 1.1.3 of this standard review plan.

The licensee has provided an acceptable description of the stratigraphic features by presenting a description of the site and regional stratigraphy using published information and information collected for the specific purpose of supporting determinations of geotechnical stability and ground water analyses at the site. Data gathering, investigations, and analyses have used acceptable standards and practices. Data and interpretations of data are presented to allow effective incorporation into geotechnical and ground-water analyses.

On the basis of the information and analysis presented in the review plan on the stratigraphic features at the ________________ uranium mill facility, the NRC staff concludes that the information is sufficient to support a decision with reasonable assurance that the requirements of 10 CFR Part 40, Appendix A, Criterion 4(e) have been met. These require that tailings impoundments not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand , or that an acceptable alternate method of determination of seismic hazard has been used. If a probabilistic seismic hazard analysis is used as an alternate method, the applicant has presented sufficient information to support an analysis of the facility design for the operational and post-operational periods. The description of the physical and chemical properties of the underlying soils and geologic formations of the site is sufficient to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 5G(2) with regard to the extent to which they will control transport of contaminants and solutions. Reasonable assurance has also been provided that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met.

1.1.5 References

None.

1.2 Structural and Tectonic Features

1.2.1 Areas of Review

The staff should review information presented in the reclamation plan on the regional and site-specific structural and tectonic setting. The reclamation plan should contain a definition of surface and subsurface structural and tectonic features and an interpretation of their origin, occurrence, age, and potential impacts, if any, on the stability of the site. Review of the structural and tectonic information should be coordinated with the evaluation of the site's geotechnical stability, surface water and erosion protection, and ground-water resources protection information as described in standard review plan Chapters 2.0, 3.0,and 4.0, respectively. The reviewer will determine whether the information presented is sufficient to support an analysis of geologic features as they affect the facility.

1.2.2 Review Procedures

The reviewer should examine the description and discussion of the regional and site-specific information to determine if a thorough evaluation of structural and tectonic features has been presented. This may include analyses of photogrammetric data, results of field reconnaissance and detailed mapping, review of pertinent literature, and review of geophysical data and studies. Features that should be considered in the review include structural features such as faults and fractures, crustal deformation, and volcanic features that may affect the site stability or ground-water conditions.

The following specific descriptive information should be reviewed to determine its adequacy for characterizing the regional and site-specific structural features necessary to support the evaluations of reclamation system performance:

(1) Description and location of regional structural features based on published information and field reconnaissance, including the geologic attitude of key stratigraphic units.

(2) Description and location of site subsurface structural features from sources such as available borings, drill logs, geophysical logs and data, and existing literature.

(3) Description of any volcanic features such as flows, cones, plugs, or dikes located in the site region.

(4) Age relationships of regional and site-specific structural and tectonic features.

(5) Discussion of published literature containing interpretations of any of the information in previous Items 1, 2, 3, and 4.

Staff determination of compliance should be based in part on professional judgment, considering the complexity of the subsurface conditions at the site.

1.2.3 Acceptance Criteria

The characterization of regional and site structural features will be acceptable if the information presented in the reclamation plan conforms to the following criteria:

(1) Descriptions of regional and site-specific structural and tectonic features are based on published literature and gathered data.

(2) Regional structural and tectonic features, particularly faults, are defined in sufficient detail to present an adequate understanding of the structural geologic conditions that may have a likelihood of affecting the site stability or ground-water regime.

(3) Site-specific structural and tectonic features, particularly faults, are described in sufficient detail to present adequate information for an analysis of the site stability. Information presented adequately addresses the uncertainties and variability within the site area and the potential impacts on the disposal facility.

(4) The structural and tectonic province or provinces that influence the site seismicity are identified and described.

(5) The tectonic history of the pertinent province(s) is discussed in sufficient detail to support an analysis of the potential for disruption of the site by tectonic activity.

(6) Discussions of structural, tectonic, and volcanic features are adequately referenced and are supported by maps, logs, and cross sections showing locations of all site explorations and surveys, and depicting surface and subsurface structural and tectonic features.

(7) Descriptions contain discussions of age relationships of structural and tectonic features.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. Staff determination of compliance should be based in part on professional judgment, considering the complexity of the site conditions.

1.2.4 Evaluation Findings

If the staff review, as described in standard review plan Section 1.2, results in the acceptance of the characterization of the structural and tectonic features of the region and site, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the characterization of structural and tectonic features at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.2.2 and the acceptance criteria outlined in Section 1.2.3 of this standard review plan.

The licensee has acceptably described the regional and site-specific structural and tectonic features by presenting discussions and interpretations of pertinent data and reports that may have an impact on the site or tailings disposal system. Information presented includes descriptions of any faults capable of disrupting the site and any other information necessary to support an analysis of the geotechnical stability or ground-water conditions at the site. In addition, the staff concludes that the licensee has used acceptable methods of investigation and analysis to support its conclusions.

On the basis of the information and analysis presented in the review plan on the structural and tectonic features at the ______________ uranium mill facility, the NRC staff concludes that the information is sufficient to support a decision with reasonable assurance that the requirements of 10 CFR Part 40, Appendix A, Criterion 4(e) have been met. These require that tailings impoundments not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand, or that an acceptable alternate method of determination of seismic hazard has been used. If a probabilistic seismic hazard analysis is used as an alternate method, the applicant has presented sufficient information to support an analysis of the facility design for the operational and postoperational periods. Reasonable assurance has also been provided that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met.

1.2.5 References

None.

1.3 Geomorphic Features

1.3.1 Areas of Review

The staff should review the information presented in the reclamation plan on the regional and site-specific geomorphic features. The reclamation plan should analyze regional and local landforms to determine evidence for geomorphic processes that may impact the long-term stability of the site, including information to support an evaluation of the potential for any destructive geomorphic processes, such as mass wasting, extreme erosion, and stream encroachment. The reviewer should coordinate the geomorphic information with the evaluation of the site's geotechnical stability and surface water and erosion protection information as described in standard review plan Chapters 2.0 and 3.0, respectively. The results of this review will be used to determine the acceptability of the design during operation and long-term stabilization.

1.3.2 Review Procedures

The reviewer should examine the description and discussion of the regional and site-specific geomorphic information to determine if a thorough evaluation has been presented. Information should be detailed enough for the reviewer to make a determination regarding the geomorphic stability of the site.

The following specific descriptive information should be reviewed to determine the acceptability of the assessment of the regional and site-specific geomorphology as it relates to geomorphic stability of the site:

(1) Description of the physiographic (geomorphic) province(s) in which the site is located, including a discussion of the distinguishing characteristics such as elevation and relief.

(2) Discussion of the active processes, such as erosion, mass wasting, and stream encroachment within the site region and the nature and extent of those processes.

(3) Topographic maps depicting geomorphic surfaces, physiographic provinces, landforms, drainage networks, rivers, surficial geologic units, areas of subsidence, and geomorphic hazards.

(4) Aerial photographs of the site area.

(5) Discussion of the age, occurrence, and origin of geomorphic features, in particular those that may adversely affect site stability.

1.3.3 Acceptance Criteria

The characterization of regional and site geomorphic features and geomorphic stability will be acceptable if the information presented conforms to the following criteria:

(1) Descriptions of the regional and site-specific geomorphology and geomorphic processes include information sufficient to allow the reviewer to assess the nature and extent of major active processes that may modify the present-day topography of the geomorphic province(s) and the site area.

(2) The geomorphic features, particularly potential geomorphic hazards, are clearly delineated on topographic base maps of adequate scale to enable the reviewer to assess their occurrence and distribution.

(3) Descriptions are adequately referenced and are supported by published reports and maps or site data.

(4) The regional and site-specific geomorphology and geomorphic processes are described in sufficient detail to support an analysis of the geomorphic and geotechnical stability of the site.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. Staff determination of compliance should be based in part on professional judgment, considering the complexity of the site conditions.

1.3.4 Evaluation Findings

If the staff review, as described in standard review plan Section 1.3, results in the acceptance of the characterization of the geomorphic features of the region and site and provides information sufficient to support an assessment of the geomorphic stability, the following conclusions may be presented in the technical evaluation report.

The NRC has completed its review of the information concerning the characterization of geomorphic features at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.3.2 and the acceptance criteria outlined in Section 1.3.3. of this standard review plan.

The licensee has acceptably described the geomorphic features by presenting an adequate description of regional and site geomorphology using published information and information collected for the specific purpose of supporting determinations of the stability of site. Data gathering, investigations, and analyses have used acceptable standards and practices. Data and interpretations are presented to allow effective incorporation into other site analyses.

On the basis of the information and analysis presented in the review plan on the geomorphic features at the _______________ uranium mill facility, the NRC staff concludes that the information is sufficient to support a decision with reasonable assurance that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met.

1.3.5 References

None.

1.4 Seismicity and Ground Motion Estimates

1.4.1 Areas of Review

The staff should review information presented in the reclamation plan on the regional and site-specific seismicity and the basis for determining the vibratory ground motion (peak horizontal acceleration) at the site from seismic events. The purpose of this review is to determine the potential for seismic events to affect the site. The reviewer will determine whether the information presented is sufficient to support an analysis of the design for the operational and closure periods.

1.4.2 Review Procedures

The reviewer should examine the description and discussion of the regional and site-specific information to determine if a thorough evaluation of the potential for seismic activity has been presented. The information should be sufficient to enable the reviewer to determine the vibratory ground motion (peak horizontal acceleration) at the site from seismic events.

The following specific descriptive information should be reviewed to determine the acceptability of the characterization of the seismicity and the assessment of the stability of the site and geotechnical design:

(1) A listing of all recorded earthquakes in the tectonic province in which the site is located and in other tectonic provinces within 200 km [124 mi] of the site. This listing should contain the date of occurrence of the earthquake, its magnitude, and the location of the epicenter. Since earthquakes have at times been reported in terms of intensity at a given location, or effect on ground, structures, and people at a specific location, some of this information may have to be

estimated by use of appropriate empirical relationships.

(2) Data obtained by standard photogeologic analysis and field reconnaissance of the study area and from review of the pertinent literature. Information in the form of maps, papers, or other data, specific to the area or region, generated by state and federal agencies or published in the literature, should be utilized.

(3) An association of epicenters or locations of highest intensity of historic earthquakes with tectonic structures, where possible. Epicenters or locations of highest intensity that cannot be reasonably identified with tectonic structures should be identified with tectonic provinces.

(4) Maps on which the locations of epicenters of historic earthquakes, associated tectonic structures, and tectonic provinces have been depicted.

(5) The applicant proposed maximum earthquakes associated with each tectonic province or capable fault or structure.

(6) Deterministic and/or probabilistic seismic hazard analyses.

For a deterministic analysis, the potential ground motion at the site from capable faults that might affect the licensed area should be assessed. The term “capable fault” as used in 10 CFR Part 40, Appendix A, Criterion 4(e), has the same meaning as defined in Section III(g) of Appendix A to 10 CFR Part 100. Alternatively, the licensee may choose to use the term “capable tectonic source” as defined in Appendix A to Regulatory Guide 1.165 (NRC, 1997) to conduct its analysis.

A probabilistic seismic hazard analysis yields a curve of exceedence probability versus peak horizontal acceleration. The 10^{-4} value represents a 1 in 10 chance of the site exceeding the peak horizontal acceleration in a 1,000-year period, which is appropriate for a 1,000-year design life. The seismic hazard analysis of uranium recovery mill sites by Bernreuter, et al. (1994), contains probabilistic analyses for Title II mill sites. The study by Bernreuter, et al. (1994) is intended as a screening study; the probabilistic seismic hazard estimates are not site specific and are only calculated for random earthquakes.

(7) Seismic design ground motion (peak horizontal acceleration).

Staff determination of compliance should be based in part on professional judgment, considering the complexity of the regional and site-specific seismicity. The reviewer will focus on evaluating the maximum credible earthquake, as required by 10 CFR Part 40, Appendix A, Criterion 4(e), unless an alternate method of determining ground motion is presented as allowed in the Introduction to Appendix A. One such alternative to the maximum credible earthquake is a probabilistic seismic hazard analysis, which is presented in Section 1.4.3, below.

1.4.3 Acceptance Criteria

The regional and site-specific seismicity and ground motion estimates will be acceptable if the following criteria are met:

(1) The information presented on the regional and site-specific seismicity contains sufficient detail to allow the staff to determine the vibratory ground motion (peak horizontal acceleration) at the site caused by seismic events and to further use that determination to assess the geotechnical stability of the site. The geotechnical stability of the site is sufficient to control radiological hazards for 1,000 years to the extent reasonably achievable, and, in any case, for at least 200 years.

(2) In conducting this review, the staff will consider a deterministic and/or a probabilistic seismic hazard analysis as an acceptable method for selecting the peak horizontal acceleration for a site. An analysis of the geotechnical stability of the design proposed in the reclamation plan will be based on the resultant peak horizontal acceleration (Chapter 2.0, “Geotechnical Stability,” of this standard review plan).

   (a) Deterministic Analysis: The use of a deterministic seismic hazard analysis is acceptable if:

      (i) Capability is determined by suitable methods, such as those outlined by Slemmons (1977).

      (ii) Fault length versus magnitude relationships for determining the maximum magnitude earthquake that may be produced by each capable fault or capable tectonic source are developed using acceptable approaches such as those of Slemmons, et al. (1982); Bonilla, et al. (1984); or Wells and Coppersmith (1994).

      (iii) For each maximum magnitude earthquake, the peak horizontal acceleration at the site is determined using the applicable attenuation relationship between earthquake magnitude and distance for the site. Campbell (1997); Campbell and Bozorgnia (1994); and Boore, et al. (1993, 1997) offer examples of acceptable attenuation relationships. In applying the relationship, the site-to-source distance should be the distance between the site and the closest approach of the fault.

(iv) The peak horizontal acceleration value adopted for each capable fault or tectonic source is not less than the median value provided by the attenuation relationship. Possible soil amplification effects are considered.

(v) To assess potential ground motion at the site from earthquakes not associated with known tectonic structures (i.e., random or floating earthquakes), the largest floating earthquakes reasonably expected within the tectonic province are identified. In addition, the largest floating earthquakes characteristic of any adjacent tectonic provinces are identified, if such earthquakes cause appreciable ground motion at the site. For each of these earthquakes, the peak horizontal acceleration at the site is calculated as stated previously, with 15 km [9 mi] used as the site-to-source distance for floating earthquakes within the host tectonic province. For floating earthquakes in other tectonic provinces, the distance between the site and the closest approach of the province boundary is used as the site-to-source distance.

(vi) The peak horizontal acceleration for the site is the maximum value of the peak horizontal accelerations determined for earthquakes from all capable faults, tectonic sources, and tectonic provinces.

(b) Probabilistic Analysis: The use of a probabilistic seismic hazard analysis as an alternative to the requirements of 10 CFR Part 40, Appendix A, Criterion 4(e), is acceptable, as is stated in the Introduction to Appendix A, if:

(i) It is shown that the design proposed by the licensee will achieve a level of stabilization and containment, and a level of protection for public health and safety and the environment, which is equivalent to, to the extent practicable, or more stringent than that achieved by the requirements of 10 CFR Part 40, Appendix A.

(ii) The licensee takes into account local conditions when estimating the seismic design of the facility because peak horizontal acceleration values are often calculated for hypothetical rock foundations. The effects of local site conditions on the peak ground acceleration are reviewed in Chapter 2.0 in the standard review plan.

(3) The presentation on seismotectonic stability is acceptable if sufficient information is presented to support interpretations and conclusions. If the staff should conclude that the information presented is insufficient, it will request additional information or investigations. Staff determination of compliance should be based, in part, on professional judgment, considering the complexity of site and seismic conditions.

1.4.4 Evaluation Findings

If the staff review as described in standard review plan Section 1.4 results in the acceptance of the characterization of the seismicity of the region and site and the seismic design ground motion, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the characterization of the seismicity at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.4.2 and the acceptance criteria outlined in Section 1.4.3 of this standard review plan.

The licensee has presented information and investigations that support its conclusions about the seismic characterization of the site and the seismic design value. Information presented includes descriptions of historical earthquakes, locations of their epicenters, an analysis of the seismic hazard at the site, and the design peak horizontal acceleration. The staff concludes that the information presented is sufficient to support an analysis of the geotechnical stability. In addition, the staff concludes that the licensee has used acceptable methods of investigation and analysis to support its conclusions.

On the basis of the information and analysis presented in the review plan on the seismicity and ground motion estimates at the ______________ uranium mill facility, the NRC staff concludes that the information is sufficient to support a decision with reasonable assurance that the requirements of 10 CFR Part 40, Appendix A, Criterion 4(e), have been met. These require that tailings impoundments not be located near a capable fault that would cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand, or that an acceptable alternate method of determination of seismic hazard has been used. If a probabilistic seismic hazard analysis is used as an alternate method, the applicant has presented sufficient information to support an analysis of the facility design for the operational and postoperational periods. Reasonable assurance has also been provided that the requirements of 10 CFR Part 40, Appendix A, Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, have been met.

1.4.5 References

Bernreuter, D., E. McDermott, and J. Wagoner. “Seismic Hazard Analysis of Title II Reclamation Plans.” Livermore, California: Lawrence Livermore National Laboratory. 1994.

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Wells, D.L. and K.J. Coppersmith. “New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement.” *Bulletin of the Seismological Society of America.* Vol. 84. pp. 974–1,002. 1994.

2.0 GEOTECHNICAL STABILITY

The reclamation plan and its supporting documents must contain geotechnical information, design details, and construction considerations related to the proposed disposal site and to all materials associated with the reclamation design, including soil and rock cover, foundation materials, contaminated materials, and other materials, for any zones (liners, filters, or capillary breaks). Standard review plan Chapter 2.0 establishes the procedures for NRC staff to conduct and document the review of geotechnical stability aspects of reclamation plans for mill tailings impoundments, amendments to the approved reclamation plans, or license termination.

2.1 Site and Uranium Mill Tailings Characteristics

2.1.1 Areas of Review

The staff should review information presented in the reclamation plan on the geotechnical aspects of the regional and site geology and stratigraphy, the geotechnical characteristics of the uranium mill tailings and other materials designated for stabilization, and borrow area material characteristics. "Other materials" are contaminated soil from site cleanup operations, tailings from other sites accepted for disposal at this site, and any contaminated materials from mill decommissioning activities to be disposed of at this site. This review should cover exploration data, sampling and laboratory techniques, test results, descriptions of physical properties, and static and dynamic geotechnical engineering parameters of the materials, as well as discussions of ground-water conditions (e.g., perched, confined, or unconfined) for all critical subsurface strata at the site, including information on the fluctuations of the hydraulic head. Review of the ground-water information should be coordinated with the review of information on ground-water resources protection, as described in standard review plan Chapter 4.0. Review of geologic, stratigraphic, and seismologic information should be coordinated with the review of the geology and seismology information as described in standard review plan Chapter 1.0. Borrow area restoration plans should be evaluated.

2.1.2 Review Procedures

The information to be reviewed depends on whether the proposed tailings disposal is below grade, either in mines or specially excavated pits, or in above ground impoundments. The reviewer should focus on the appropriateness of the site characterization for the proposed tailings disposal scheme. The reviewer should examine the site stratigraphy and evaluation of engineering properties of the underlying materials at the site, uranium mill tailings, other materials, and borrow materials to determine if appropriate methods were properly used in characterizing the materials.

The reviewer should examine the following specific descriptive information to determine its adequacy for characterizing the site and for supporting the evaluations of reclamation system performance:

(1) Site stratigraphy, based on borings and other investigations conducted to determine the type, location, and thickness of underlying materials.

(2) Regional and site-specific seismologic information to determine the potential for impact on the geotechnical stability of the site and site structures.

(3) Stratigraphy specifying type, location, and thickness of borrow material and other materials designated for stabilization in the tailings disposal cell.

(4) *In situ* testing programs and procedures conducted to determine the engineering properties of underlying materials at the site, borrow area material, other materials, and tailings.

(5) Sampling programs conducted to obtain laboratory samples for determination of engineering properties of borrow materials, underlying materials at the site, other materials, and tailings.

(6) Laboratory testing used to determine the engineering properties of borrow materials, underlying materials at the site, other materials, and tailings.

(7) Physical and engineering properties of borrow materials, underlying materials at the site, other materials, and tailings.

(8) Records of historical ground-water-level fluctuations at the site, to the extent that they are available.

The reviewer should evaluate methods used to characterize the site to ensure that they comply with generally accepted standards, such as those of the American Society for Testing and Materials and those which are commonly used in the geotechnical engineering profession. Areas to be examined in this respect include the *in situ* and laboratory testing programs, sampling techniques, and analyses for determining the physical and engineering properties of materials at the site. Field investigations and laboratory testing procedures not commonly used in the geotechnical engineering profession will be reviewed in detail.

Staff determination of compliance should be based in part on professional judgment, considering the complexity of the site subsurface conditions.

2.1.3 Acceptance Criteria

The site characterization information constitutes part of the input data needed for analysis and design of the tailings impoundment facility. The site characterization will be acceptable if it provides the needed input for the design and analysis of the disposal facility and meets the following criteria:

(1) The site stratigraphy is described in sufficient detail to provide an understanding of the site-specific subsurface features, including structural features and other characteristics of underlying soil and rock.

(2) Information on regional and local faults and seismicity, as obtained from field data, published literature, and historical records is presented in sufficient detail to effectively incorporate that information into a geotechnical stability analyses. (Note: This aspect of the review should be coordinated with the geology and seismology review performed in accordance with standard review plan Chapter 1.)

(3) Sampling scope and techniques are appropriate and sufficient to ensure that samples collected are representative of the range of *in situ* soil conditions, taking into consideration variability and uncertainties in such conditions within the site.

(4) For all soils that might be unstable because of their physical or chemical properties, locations and dimensions are identified and the properties have been documented.

(5) Investigations (including laboratory and field testing) are conducted using appropriate standards published by the American Society for Testing and Materials or the International Society for Rock Mechanics and are sufficient to establish the static and dynamic engineering parameters of borrow materials, other materials, tailings, and underlying soil and rock materials at the site (NRC, 1978, 1979).

(6) A detailed discussion of laboratory sample preparation techniques is presented, when standard procedures are not used.

For critical laboratory tests, details such as how saturation of the sample was determined and maintained during testing, or how the pore pressures changed are provided. A detailed and quantitative discussion of the criteria used to verify that the samples were properly taken and tested in sufficient number to define the critical soil parameters for the site is presented. In the case of tailings material (e.g., license amendment reviews), the evaluations of its strength and settlement characteristics are presented in detail.

(7) Parameter values are presented to enable evaluation of properties of mill tailings, borrow materials, other materials, and underlying soil and rock, including the following:

(a) Compressibility and rate of consolidation

(b) Shear strength, including, for sensitive soils, possible loss of shear strength resulting from strain-softening

(c) Liquefaction potential

(d) Permeability

(e) Dispersion characteristics

(f) Swelling and shrinkage

(g) Long-term moisture content for radon barrier material

(h) Cover cracking

(8) Soil stratigraphy and relevant parameters that are used in the geotechnical evaluations (settlement, stability, liquefaction potential, etc.) are discussed in detail.

(9) Records of historical ground-water-level fluctuations at the site as obtained from monitoring local wells and springs and/or by analysis of piezometer and permeability data from tests conducted at the site are presented in sufficient detail to effectively incorporate the information into geotechnical stability analyses. (Note: This aspect of the review should be coordinated with the hydrogeologic characterization review performed according to standard review plan Chapter 4.0.)

The information should be sufficient to provide the required input for the design of the facility and to enable the reviewer to assess compliance with the regulatory requirements, such as site features contributing to waste isolation; facility location with respect to an active fault; and reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

2.1.4 Evaluation Findings

If the staff review as described in standard review plan Section 2.1 results in the acceptance of the characterization of the site and uranium mill tailings sufficient to support a conclusion regarding the geotechnical stability of the site, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the geotechnical characteristics of the site and uranium mill tailings at the _________________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.1.2 and the acceptance criteria outlined in Section 2.1.3 of this standard review plan.

The licensee has acceptably described the geotechnical characteristics of the site and uranium mill tailings based on sampling techniques that are acceptable, and will ensure that a representative range of *in situ* soil conditions will be examined. Unstable soils have been identified. Investigations and analyses have used acceptable standards and practices. Laboratory sample preparation and testing techniques are appropriately described and include: (1) compressibility and rate of consolidation, (2) shear strength, (3) liquefaction potential, (4) permeability, (5) dispersion characteristics, (6) swelling and shrinkage, and (7) physical properties. Records of historic ground-water-level fluctuations are presented to allow effective incorporation into geotechnical stability analyses.

On the basis of the information presented in the application and the detailed review conducted of geotechnical the characteristics of the site and uranium mill tailings at the _______________ uranium mill facility, the NRC staff concludes that the geotechnical characterization of the site and uranium mill tailings and associated conceptual and numerical models provide an acceptable input which, along with other information such as results of design analysis, will enable the staff to make a finding on the demonstration of compliance with the following criteria in Appendix A to 10 CFR Part 40: (1) Criterion 1, which relates to the site features that contribute to the permanent waste isolation characteristics of the site; (2) Criterion 3, which states the primary option for disposal of tailings is placement below grade, either in mines or specially excavated pits (if applicable for the site); (3) Criterion 4(e), which requires that the impoundment not be located near a capable fault on which a maximum credible earthquake, larger than one that the impoundment could reasonably be expected to withstand, might occur; (4) Criterion 5(G)(2), relating to the permeability characteristics of the site; and (5) Criterion 6(1), which requires reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.1.5 References

American Society for Testing and Materials Standards:

D 420, “Guide for Investigating and Sampling Soil and Rock.”

D 421, “Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.”

D 422, “Method for Particle-Size Analysis of Soils.”

D 653, “Terminology Relating to Soil, Rock, and Contained Fluids.”

D 854, “Test Method for Specific Gravity of Soils.”

D 1140, “Test Method for Amount of Material in Soils Finer Than the No. 200 Sieve.”

D 1452, “Practice for Soil Investigation and Sampling by Auger Borings.”

D 1586, “Method for Penetration Test and Split-Barrel Sampling of Soils.”

D 1587, “Practice for Thin-Walled Tube Sampling of Soils.”

D 2113, “Practice for Diamond Core Drilling for Site Investigation.”

D 2166, “Test Method for Unconfined Compressive Strength of Cohesive Soil.”

D 2216, “Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate Mixtures.”

D 2217, “Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.”

D 2487, “Test Method for Classification of Soils for Engineering Purposes.”

D 2488, “Practice for Description and Identification of Soils (Visual-Manual Procedure).”

D 2573, “Test Method for Field Vane Shear Test in Cohesive Soils.”

D 3441, “Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil.”

D 3550, “Practice for Ring-Lined Barrel Sampling of Soils.”

D 4221, “Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer.”

D 4318, “Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.”

D 4647, “Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test.”

D 4750, “Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).”

NRC. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Rev. 1. Washington, DC: NRC, Office of Standards Development. March 1979.

NRC Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." Washington, DC: NRC, Office of Standards Development. April 1978.

2.2 Slope Stability

2.2.1 Areas of Review

The staff should examine exploration data, test results, slope characterization data, design details, and static and dynamic analyses related to the stability of all natural and manmade earth and rock slopes whose failure, under any of the conditions to which they could be exposed throughout the period of regulatory interest, could adversely affect the integrity of the slopes or embankments. This review should also include examination of static and dynamic materials properties, test and design methods, pore pressures within and beneath the embankment, and the design seismic coefficient. Information on the design seismic event should be obtained from results of the review completed using standard review plan Chapter 1.0. The review will focus on (i) the design of the impoundment during operation when a large volume of tailings liquor would be present and (ii) the stability of the impoundment over the long term.

2.2.2 Review Procedures

The reviewer should examine data gathered from site investigations, such as borings: maps; laboratory and field tests; soil profiles; site plans; results of seismic investigations; permeability tests; and static, dynamic, or pseudostatic stability analyses to determine whether the assumptions and analyses used in the reclamation plan are conservative. The degree of conservatism required depends on the type of analysis used, the variability and uncertainty in the values of the parameters considered in the slope stability analysis, the number of borings, the sampling program, the extent of the laboratory testing program, and the resultant safety factor. For instances in which safety factors are low, the reviewer should ensure that reasonable ranges of soil properties have been considered. Other factors, such as flood conditions, pore pressure effects, possible erosion of soils, and seismic amplification effects, should be conservatively assessed. The design criteria and analyses should be reviewed to ascertain whether the techniques employed are appropriate and represent commonly accepted methods [e.g., U.S. Army Corps of Engineers (1970b)].

The reviewer should examine the spatial variability of the measured properties to ensure that it has been adequately defined. The reviewer should also examine slope characterization data to ensure that nearby slopes, the failure of which could adversely affect the stability of impoundments, have been properly characterized.

The reviewer should determine whether the static and dynamic stability analyses demonstrate that there is an adequate factor of safety against failure.

The reviewer should examine the slope stability analysis to determine that an appropriately conservative approach has been used and that adverse conditions to which the slope might be subjected have been considered. The reviewer should confirm that the static analyses include calculations using appropriate assumptions and methods to assess the following:

(1) Uncertainties and variations in the shape of the slope, the boundaries and parameters of the several types of soils within the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope.

(2) The failure surface corresponding to the lowest factor of safety.

(3) The effect of the assumptions inherent in the method of analysis used.

The reviewer should ensure that the analysis is conservative and that possible failure modes have been considered, including evaluation of the effect of the maximum credible earthquake, or the appropriate design criteria found acceptable in standard review plan Section 1.4. The reviewer will also verify that the impoundment will not be located near a capable fault on which a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand might occur.

The reviewer should be aware that no single method of analysis is applicable for all stability assessments. Therefore, no single method of analysis is recommended. If the staff review indicates that questionable assumptions have been made or that non-standard or inappropriate methods of analysis have been used, the staff may model the slope in a manner consistent with the data and perform an independent analysis.

The reviewer should verify that disposal cell slopes will be relatively flat after final stabilization to minimize the potential for erosion and to provide a conservative factor of safety. In evaluating the slope, the reviewer will focus on determining if the slopes are 5 horizontal to 1 vertical (5h:1v) as required by 10 CFR Part 40, Appendix A, Criterion 4(c). If slopes steeper than 5h:1v are proposed, the reviewer must evaluate these steeper slopes as an alternative to the requirements of Criterion 4(c). In conducting a review of steeper slopes, the reviewer must evaluate the acceptability of the steeper slope using the applicable criteria in this standard review plan and determine if there is an acceptable economic basis and an equivalent level of protection available to justify an alternative to 10 CFR Part 40, Appendix A, Criterion 4(c). The reviewer should evaluate whether a full self-sustaining vegetative cover can be placed over the tailings pile, primarily to reduce the wind and water erosion to negligible levels. If a vegetative cover is not suitable for the site conditions, the reviewer should verify that an appropriate rock cover has been provided. This verification should be coordinated with the review using standard review plan Chapter 3.0.

Because dams at operating facilities, or dams that continue to hold water after the cessation of operations, are also subject to the National Dam Safety Program Act of 1996, the reviewer should determine if the dam is classified as a structure with low hazard potential or high hazard potential. If the dam is classified as high hazard, the reviewer should evaluate the emergency action plan for the facility.

2.2.3 Acceptance Criteria

The analysis of slope stability will be acceptable if it meets the following criteria:

(1) Slope characteristics are properly evaluated.

  (a) Cross sections and profiles of natural and cut slopes whose instability would directly or indirectly affect the control of radioactive materials are presented in sufficient number and detail to enable the reviewer to select the cross sections for detailed stability evaluation.

  (b) Slope steepness is a minimum of five horizontal units (5h) to one vertical unit (1v) or less. The use of slopes steeper than 5h:1v is considered an alternative to the requirements in 10 CFR Part 40, Appendix A, Criterion 4(c). When slopes steeper than 5h:1v are proposed, a technical justification should be offered as to why a 5h:1v or flatter slope would be impractical and compensating factors and conditions are incorporated in the slope design for assuring long-term stability.

  (c) Locations selected for slope stability analysis are determined considering the location of maximum slope angle, slope height, weak foundation, piezometric level(s), the extent of rock mass fracturing (for an excavated slope in rock), and the potential for local erosion.

(2) An appropriate design static analysis is presented.

(a) The analysis includes calculations with appropriate assumptions and methods of analysis (NRC, 1977). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis. Acceptable methods for slope stability analysis include various limit equilibrium analysis or numerical modeling methods.

(b) The uncertainties and variability in the shape of the slope, the boundaries and parameters of the several types of soils and rocks within and beneath the slope, the material properties of soil and rock within and beneath the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope are considered.

(c) Appropriate failure modes during and after construction and the failure surface corresponding to the lowest factor of safety are determined. The analysis takes into account the failure surfaces within the slopes, including through the foundation, if any.

(d) Adverse conditions such as high water levels from severe rain and the probable maximum flood are evaluated.

(e) The effects of toe erosion, incision at the base of the slope, and other deleterious effects of surface runoff are assessed.

(f) The resulting safety factors for slopes analyzed are comparable to the minimum acceptable values of safety factors for slope stability analysis given in NRC Regulatory Guide 3.11 (NRC, 1977).

(3) Appropriate analyses considering the effect of seismic ground motions on slope stability are presented.

(a) Evaluation of overall seismic stability, using pseudostatic analysis or dynamic analysis, as appropriate (U.S. Army Corps of Engineers, 1977; NRC, 1977). Alternatively, a dynamic analysis following Newmark (1965) can be carried out to establish that the permanent deformation of the disposal cell from the design seismic event will not be detrimental to the disposal cell. The reviewer should verify that the yield acceleration or pseudostatic horizontal yield coefficient necessary to reduce the factor of safety against slippage of a potential sliding mass to 1.0 in a “Newmark-type” analysis has been adequately estimated (Seed and Bonaparte, 1992).

(b) An appropriate analytical method has been used. A number of different methods of analysis are available (e.g., slip circle method, method of slices, and wedge analysis) with several variants of each (Lambe and Whitman, 1979; U.S. Army Corps of Engineers, 1970b; NRC, 1977; Bromhead, 1992). Limit-equilibrium analysis methods do not provide information regarding the variation of strain within the slope and along the slip surface. Consequently, there is no assurance that the peak strength values used in the analysis can be mobilized simultaneously along the entire slip surface unless the material shows ductile behavior (Duncan, 1992). Residual strength values should be evaluated if mobilized shear strength at some points is less than the peak strength. The reviewer should ensure that appropriate conservatism has been incorporated in the analysis using the limit equilibrium methods. The limit equilibrium analysis methodologies may be replaced by other techniques, such as finite element or finite difference methods. If any important interaction effects cannot be included in an analysis, the reviewer must determine that such effects have been treated in an approximate but conservative fashion. The engineering judgment of the reviewer should be used in assessing the adequacy of the resulting safety factors (NRC, 1983a,b).

(c) For dynamic loads, the dynamic analysis includes calculations with appropriate assumptions and methods (NRC, 1977; Seed, 1967; Lowe, 1967; Department of the Navy, 1982a,b,c; U.S. Army Corps of Engineers, 1970a,b, 1971, 1972; Bureau of Reclamation, 1968). The effect of the assumptions and limitations of the methods used is discussed and accounted for in the analysis.

(d) For dynamic loads, a pseudostatic analysis is acceptable in lieu of dynamic analysis if the strength parameters used in the analysis are conservative, the materials are not subject to significant loss of strength and development of high pore pressures under dynamic loads, the design seismic coefficient is 0.20 or less, and the resulting minimum factor of safety suggests an adequate margin, as provided in NRC Regulatory Guide 3.11 (NRC, 1977).

(e) For pseudostatic analysis of slopes subjected to earthquake loads, an assumption is made that the earthquake imparts an additional horizontal force acting in the direction of the potential failure (U.S. Army Corps of Engineers, 1970b, 1977; Goodman, 1989). The critical failure surface obtained in the static analysis is used in this analysis with the added driving force. Minimum acceptable values for safety factors of slope stability analysis are given in Regulatory Guide 3.11 (NRC, 1977).

(f) The assessment of the dynamic stability considers an appropriate design level seismic event and/or strong ground motion acceleration, consistent with that identified in Chapter 1 of this review plan. Influence of local site conditions on the ground motions associated with the design level event is evaluated. The design seismic coefficient to be used in the pseudostatic analysis is either 67 percent of the peak ground acceleration at the foundation level of the tailings piles for the site or 0.1g, whichever is greater.

(g) If the design seismic coefficient is greater than 0.20g, then the dynamic stability investigation (Newmark, 1965) should be augmented by other appropriate methods (i.e., finite element method), depending on specific site conditions.

(h) In assessing the effects of seismic loads on slope stability, the effect of dynamic stresses of the design earthquake on soil strength parameters is accounted for. As in a static analysis, the parameters such as geometry, soil strength, and hydrodynamic and pore pressure forces are varied in the analysis to show that there is an adequate margin of safety.

(i) Seismically induced displacement is calculated and documented. There is no universally accepted magnitude of seismically induced displacement for determining acceptable performance of the disposal cell (Seed and Bonaparte, 1992; Goodman and Seed, 1966). Surveys of five major geotechnical consulting firms by Seed and Bonaparte (1992) indicate that the acceptable displacement is from 15 to 30 cm [6 to 12 in.] for tailings piles. The reviewer should ensure that this criterion is also augmented by provisions for periodic maintenance of the slope(s).

(j) Where there is potential for liquefaction, changes in pore pressure from cyclic loading are considered in the analysis to assess the effect of pore pressure increase on the stress-strain characteristics of the soil and the post-earthquake stability of the slopes. Liquefaction potential is reviewed using Section 2.4 of this review plan. Evaluations of dynamic properties and shear strengths for the tailings, underlying foundation material, radon barrier cover, and base liner system are based on representative materials properties obtained through appropriate field and laboratory tests (NRC, 1978, 1979).

(k) The applicant has demonstrated that impoundments will not be located near a capable fault on which a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand might occur.

(4) Provision is made to establish a vegetative cover, or other erosion prevention, to include the following considerations:

(a) The vegetative cover and its primary functions are described in detail.

This determination should be made with respect to any effect the vegetative cover may have on reducing slope erosion and should be coordinated with the reviewer of standard review plan Chapter 3.

If strength enhancement from the vegetative cover is taken into account, the methodology should be appropriate (Wu, 1984).

(b) In arid and semi-arid regions, where a vegetative cover is deemed not self-sustaining, a rock cover is employed on slopes of the mill tailings. If credit is taken for strength enhancement from rock cover, the reviewer should confirm that appropriate methodology has been presented.

The design of a rock cover, where a self-sustaining vegetative cover is not practical, is based on standard engineering practice. Standard review plan

Chapter 3 discusses this item in detail.

(5) Any dams meet the requirements of the dam safety program if the application demonstrates the following:

(a) The dam is correctly categorized as a low hazard potential or a high hazard potential structure using the definition of the U.S. Federal Emergency Management Agency.

(b) If the dam is ranked as a high hazard potential, an acceptable emergency action plan consistent with the Federal Emergency Management Agency guide (U.S. Federal Emergency Management Agency, 1998) has been developed.

(6) The use of steeper slopes as an alternative to the requirements in 10 CFR, Part 40, Appendix A, will be found acceptable if the following are met:

(a) An equivalent level of stabilization and containment and protection of public health, safety, and the environment is achieved.

(b) A site-specific need for the alternate slopes is demonstrated.

2.2.4 Evaluation Findings

If the staff review as described in standard review plan Section 2.2 results in the acceptance of the slope stability, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the slope stability at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.2.2 and the acceptance criteria outlined in Section 2.2.3 of this standard review plan.

The licensee has acceptably described the slope stability evaluation by (1) providing cross sections and profiles of natural and cut slopes in sufficient detail and number to represent significant slope and foundation conditions; (2) placing tailings below grade or in demonstrably safe above-grade disposal facilities; (3) ensuring that slope steepnesses are five horizontal (5h) to one vertical (1v) or less or by providing technical justification for a different slope ratio; (4) providing measurements of static and dynamic properties of soil and rock using standards such as those established by the American Society for Testing and Materials, International Society of Rock Mechanics, NRC, or the U.S. Army Corps of Engineers; (5) selecting locations for slope stability analyses while considering the location of maximum slope angle, slope height, weak foundation, the extent of rock mass fracturing, and the potential for local erosion; and (6) describing vegetative cover and its primary functions in detail. Where the licensee has proposed use of steeper slopes as an alternative to the requirements of 10 CFR Part 40, Appendix A, Criterion 4(c), the staff has evaluated the licensee’s demonstration that steeper slopes would result in economic savings and also ensure the long-term stabilization of the tailings with a level of protection equivalent to that required in 10 CFR Part 40, Appendix A, Criterion 4(c). Therefore, the use of steeper slopes complies with the alternates requirement in

10 CFR Part 40, Appendix A.

The static loads analysis is acceptable and includes (1) appropriate uncertainties and variabilities in important rock/soils parameters; (2) consideration of appropriate failure modes; (3) a discussion of the effect of the assumptions inherent in the method of analysis used; (4) consideration of adverse conditions, including flooding, with appropriate safety factors; and (5) the effects of toe erosion, incision of the base of the slope, and other deleterious effects of surface runoff.

The dynamic and pseudostatic analyses are acceptable and include (1) calculations with appropriate assumptions and methods; (2) treatment of important interaction effects in a conservative fashion; (3) an accounting of the dynamic stresses of the maximum credible earthquake on soil strength parameters; (4) for pseudostatic analyses of slopes subjected to earthquake loads, consideration of the added driving horizontal force acting in the direction of a potential failure; (5) determination that possible permanent deformation sustained in the slope from a maximum credible earthquake will not damage the effectiveness of the disposal cell; (6) determination that the magnitude of seismically induced displacement does not exceed 15 to 30 cm [6 to 12 in.]; (7) a selection of appropriate design-level seismic events or strong ground motion accelerations; (8) evaluations of local site conditions; (9) evaluations of the potential for liquefaction and the effect of pore pressure increase on the stress-strain characteristics of the soil and post-earthquake stability of the slopes; (10) evaluations of the dynamic properties and shear strength of the tailings, underlying foundation, radon barrier cover, and base liner system; and (11) design of a self-sustaining vegetative or rock cover that is consistent with commonly accepted engineering practice.

On the basis of the information presented in the application and the detailed review conducted of the slope stability at the ______________ uranium mill facility, the NRC staff concludes that the slope stability and associated conceptual and numerical models pertaining to design of the impoundments provide an acceptable input to demonstration of compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the long-term stability of the embankment and cover slopes for tailings; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient; Criterion 4(e), which requires that the impoundment not be located near a capable fault on which a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand might occur; Criterion 5(A)(5), which requires the structural integrity of slopes (dikes) to prevent massive failure of the dikes; and Criterion 6(1), which requires that impoundment designs providing reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.2.5 References

American Society for Testing and Materials Standards:

D 2850, “Test Method for Unconsolidated, Undrained Compressive Strength of

Cohesive Soils in Triaxial Compression."

D 3080, "Method for Direct Shear Test of Soils Under Consolidated Drained Conditions."

D 4767, "Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils."

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———. Regulatory Guide 1.138, “Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants.” Washington, DC: NRC, Office of Standards Development. April 1978.

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U.S. Army Corps of Engineers. “Earthquake Design and Analysis for Corps of Engineer Dams.” ER1110-2-1806. U.S. Department of the Army, Office of the Chief of Engineers. April 1977.

———. “Soil Sampling.” Engineering Manual EM1110-2-1907. Department of the Army, Office of the Chief of Engineers. March 1972.

———. “Instrumentation of Earth and Rockfill Dams.” Engineering Manual EM1110-2-1908, Part 1 and 2. Department of the Army, Office of the Chief of Engineers. August and November 1971.

———. “Laboratory Soil Testing.” Engineering Manual EM1110-2-1906. Department of the Army, Office of Chief Engineers. November 1970a.

———. “Engineering and Design Stability of Earth and Rock Fill Dams.” Engineering Manual EM1110-2-1902. Department of the Army, Office of the Chief of Engineers. 1970b.

U.S. Federal Emergency Management Agency. “Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners.” Washington, DC: U.S. Federal Emergency Management Agency. 1998.

Wu, T.H. “Effect of Vegetation on Slope Stability, "Soil Reinforcement and Moisture Effects on Slope Stability.” Transportation Research Record 965. National Research Council, Transportation Research Board. 1984.

2.3 Settlement

2.3.1 Areas of Review

The staff should review the methods and results of testing and analyses conducted to estimate deformation of subsurface materials and uranium mill tailings. This should include examination of material properties and thicknesses of compressible materials, factors used in stress calculations, calculated pore pressures within and beneath the embankment, resulting total and differential settlement of the tailings surface under both static and seismic conditions, and the effects of such settlements on the radon barrier layer of the cover of the disposal cell and erosion protection layer. Liquefaction and associated settlement are addressed in standard review plan Section 2.4. One of the purposes of this review is to determine if the licensee has an acceptable method for determining if tailings consolidation is sufficient to allow the placement of a radon barrier.

2.3.2 Review Procedure

The reviewer should examine the assessments of the magnitudes and distributions of settlement of the disposal cell and the analyses of the potential for cracking of the radon barrier from tensile strains in order to determine the adequacy of the design.

The reviewer should confirm that clay layers and slime in the tailings pile and foundations have been considered in the assessment of both immediate and long-term settlement.

In reviewing the assessment of settlements, the reviewer should give particular attention to the identification and thicknesses of compressible soil layers within the tailings and in the foundation. Settlement should be calculated at several locations within the disposal cell to enable a determination of the overall settlement pattern of the disposal cell cover. The locations for settlement calculations should be selected considering the presence of sand/slime tailings and foundation materials. The tailings are expected to be a hydraulically placed material comprised of interspersed sand and slime tailings. The following specific items should be reviewed to determine the acceptability of the assessment of the magnitudes and distribution of settlement:

(1) The analysis of immediate settlement of tailings surfaces, considering rebound from excavation and settlement from instantaneous compression of underlying materials and the tailings pile. The computation of incremental tailings loading and the width of the loaded area, as well as the determination of the undrained modulus and Poisson’s ratio should be examined. Calculations of the settlement of hydraulically placed tailings should be examined.

(2) The analysis of consolidation settlement from delayed compression (caused by pore-pressure dissipation) of underlying materials and the tailings pile.

The calculation of settlement should be reviewed to ensure that each compressible soil layer within or underneath the tailings pile is considered and is assigned proper thickness and that the appropriate level of stress change is applied at the mid-depth of the soil layer.

(3) The estimate of the time at which the primary consolidation settlement of the tailings will be essentially complete. Generally, the radon barrier and disposal cell cover may be placed only after the settlement of tailings is essentially complete.

(4) The analysis of secondary settlement from long-term creep.

(5) The distribution of settlement magnitudes for assessment of differential settlement.

(6) Evaluation of the potential for cracking of the radon barrier layer as a result of long-term settlement of the cover.

2.3.3 Acceptance Criteria

The analysis of tailings settlement will be acceptable if it meets the following criteria:

(1) Computation of immediate settlement follows the procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982). If a different procedure is used, the basis for the procedure is adequately explained.

The procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982) for calculation of immediate settlement is adequate if applied incrementally to account for different stages of tailings emplacement. If this method is used, the reviewer should verify that the computation of incremental tailings loading and the width of the loaded area, as well as the determination of the undrained modulus and Poisson's ratio, have been computed and documented.

Settlement of tailings arises from compression of soil layers within the disposal cell and in the underlying materials. Because compression of sands occurs rapidly, compression of sand layers in the disposal cell and foundations must be considered in the assessment of immediate settlement. However, the contribution of immediate settlement to consolidation settlement cannot be ignored. Clay layers and slime undergo instantaneous elastic compression controlled by their undrained stiffness as well as long-term inelastic compression controlled by the processes of consolidation and creep (NRC, 1983a).

(2) Each of the following is appropriately considered in calculating stress increments for assessment of consolidation settlement:

(a) Decrease in overburden pressure from excavation

(b) Increase in overburden pressure from tailings emplacement

(c) Excess pore-pressure generated within the disposal cell

(d) Changes in ground-water levels from dewatering of the tailings

(e) Any change in ground-water levels from the reclamation action

(3) Material properties and thicknesses of compressible soil layers used in stress change and volume change calculations for assessment of consolidation settlement are representative of *in situ* conditions at the site.

(4) Material properties and thicknesses of embankment zones used in stress change and volume change calculations are consistent with as-built conditions of the disposal cell.

(5) Values of pore pressure within and beneath the disposal cell used in settlement analyses are consistent with initial and post-construction hydrologic conditions at the site.

(6) Methods used for settlement analyses are appropriate for the disposal cell and soil conditions at the site. Contributions to settlement by drainage of mill tailings and by consolidation/compression of slimes and sands are considered. Both instantaneous and time-dependent components of total and differential settlements are appropriately considered in the analyses (NRC, 1983a,b,c).

The procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982) for calculation of secondary compression is adequate.

(7) The disposal cell is divided into appropriate zones, depending on the field conditions, for assessment of differential settlement, and appropriate settlement magnitudes are calculated and assigned to each zone.

(8) Results of settlement analyses are properly documented and are related to assessment of overall behavior of the reclaimed pile.

(9) An adequate analysis of the potential for development of cracks in the radon/infiltration barrier as a result of differential settlements is provided (Lee and Shen, 1969).

2.3.4 Evaluation Findings

If the staff review, as described in standard review plan Section 2.3, shows that the settlement has no impact on the integrity and functionality of the radon barrier and disposal cell cover, then the following conclusions can be presented in the technical evaluation report. If the settlement impacts the cell cover integrity, then the licensee will be required to revise the design to ensure the functionality of the cell cover before a technical evaluation report can be prepared.

The staff has completed its review of the settlement at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.3.2 and the acceptance criteria outlined in Section 2.3.3 of this standard review plan.

The licensee has acceptably described settlement by presenting computations following the procedure recommended in NAVFAC DM–7.1 (Department of the Navy, 1982) or by explaining the technical merit for an alternate procedure. Material properties, thickness, and load increments used to calculate settlement are representative of site conditions. The applicant has acceptably considered each of the following: (1) decrease in overburden pressure from excavation, (2) increase in overburden pressure from emplaced tailings, (3) excess pore-pressure generated within the tailings disposal cell, (4) changes in ground-water levels from dewatering of the tailings, and (5) changes in ground-water levels from reclamation actions. Pore pressures within and beneath the disposal cell/embankment are consistent with initial and as-built hydrologic site conditions. Methods used to determine settlement are appropriate for the tailings embankment and soil conditions at the site. The results of the settlement analyses are properly documented. The tailings embankment has been subdivided acceptably into assessment zones with appropriately assigned settlement magnitudes. The settlement data provide information to assess the possibility of surface ponding or sudden change of gradient caused by settlement. An acceptable analysis for the development of cracks in the radon/infiltration barrier is provided.

On the basis of information presented in the application and the detailed review conducted of the characteristics of the settlement at the ______________ mill facility, the NRC staff concludes that the settlement and associated conceptual and numerical models present information needed to demonstrate compliance with 10 CFR Part 40, Appendix Ae. Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.3.5 References

American Society for Testing and Materials Standards:

D 2435, “Test Method for One-Dimensional Consolidation Properties of Soil.”

D 4719, “Test Method for Pressuremeter Testing in Soils.”

Department of the Navy. 1982. *Soil Mechanics.* NAVFAC DM–7.1. May 1982.

Lee, K.L. and C.K. Shen. “Horizontal Movements Related to Subsidence.” *ASCE Journal of Soil Mechanics and Foundations Division*. Vol. 95, No. SM1. 1969.

NRC. 1983a. NUREG/CR–3204, “Consolidation of Tailings.” Washington, DC: NRC. 1983a.

———. NUREG/CR–3199, "Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials." Washington, DC: NRC. 1983b.

———. NUREG/CR–3397, “Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments.” Washington, DC: NRC. 1983c.

2.4 Liquefaction Potential

2.4.1 Areas of Review

The staff should review the analysis of the liquefaction potential of subsurface, pile, and embankment materials, and the associated test and data interpretations. Consequences of the liquefaction of subsurface soils and/or uranium mill tailings affecting the settlements within and stability of the disposal cell and the erosion protection layer should also be reviewed. Design features or mitigation actions that address liquefaction potential should be examined. The effect of settlements not induced by liquefaction is considered in standard review plan Section 2.3 and is also considered in standard review plan Section 2.4.3.

2.4.2 Review Procedures

The reviewer should examine the analysis of liquefaction potential by studying the results of geotechnical investigations and *in situ* tests such as standard penetration, cone penetration, piezocone, density, and strength tests as well as boring logs, laboratory classification test data, water table measurements, perched water zones, and soil profiles, to determine if any of the site soils or the tailings pile material could be susceptible to liquefaction.

If it is determined that there may be soils susceptible to liquefaction beneath the site or in the tailings pile, the reviewer should examine the adequacy of site exploration programs, the laboratory test program, and the analyses. Where global liquefaction potential exists, the reviewer should determine that it has been mitigated or eliminated. Minor or local liquefaction potential should be accounted for in settlement analyses.

The reviewer should compare the liquefaction potential analysis in the reclamation plan to an independent study performed by the staff, if necessary.

2.4.3 Acceptance Criteria

The analysis of the liquefaction potential will be acceptable if the following criteria are met:

(1) Applicable laboratory and/or field tests are properly conducted (NRC, 1978, 1979; U.S. Army Corps of Engineers, 1970, 1972).

(2) Data for all relevant parameters for assessing liquefaction potential are adequately collected and the variability has been quantified.

(3) Methods used for interpretation of test data and assessment of liquefaction potential are consistent with current practice in the geotechnical engineering profession (Seed and Idriss, 1971, 1982; National Center for Earthquake Engineering Research, 1997). An assessment of the potential adverse effects that complete or partial liquefaction could have on the stability of the embankment may be based on cyclic triaxial test data obtained from undisturbed soil samples taken from the critical zones in the site area (Seed and Harder, 1990; Shannon & Wilson, Inc. and Agbabian-Jacobsen

Associates, 1972).

(4) If procedures based on laboratory tests combined with ground response analyses are used, laboratory test results are corrected to account for the difference between laboratory and field conditions (NRC, 1978; Naval Facility Engineering Command, 1983).

(5) The time history of earthquake ground motions used in the analysis is consistent with the design seismic event.

(6) If the potential for complete or partial liquefaction exists, the effects such liquefaction could have on the stability of slopes and settlement of tailings are adequately quantified.

(7) If a potential for global liquefaction is identified, mitigation measures consistent with current engineering practice or redesign of tailings ponds/embankments are proposed and the proposed measures provide reasonable assurance that the liquefaction potential has been eliminated or mitigated.

(8) If minor liquefaction potential is identified and is evaluated to have only a localized effect that may not directly alter the stability of embankments, the effect of liquefaction is adequately accounted for in analyses of both differential and total settlement and is shown not to compromise the intended performance of the radon barrier. Additionally, the disposal cell is shown to be capable of withstanding the liquefaction potential associated with the expected maximum ground acceleration from earthquakes. The licensee may use post-earthquake stability methods (e.g., Ishihara and Yoshimine, 1990) based on residual strengths and deformation analysis to examine the effects of liquefaction potential. Furthermore, the effect of potential localized lateral displacement from liquefaction, if any, is adequately analyzed with respect to slope stability and disposal cell integrity.

2.4.4 Evaluation Findings

If the staff review, as described in standard review plan Section 2.4, results in the acceptance of the licensee liquefaction potential analysis and conclusions on the impact on the performance of the disposal cell, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the liquefaction potential at the ______________ uranium mill facility. This review included an evaluation using the review procedures in standard review plan Section 2.4.2 and acceptance criteria outlined in Section 2.4.3 of this standard review plan.

The licensee has acceptably evaluated liquefaction potential based on results from properly conducted laboratory and/or field tests. The methods used for interpretation of test data are consistent with current practice. Where global liquefaction is identified, mitigation measures or redesign of tailings ponds/embankments are proposed and the new design provides reasonable assurance that the liquefaction potential has been eliminated or mitigated. In the case of minor/local liquefaction potential, its effect is accounted for in the analysis of both differential and total settlement and is shown not to compromise the intended performance of the radon barrier and erosion protection.

On the basis of the information presented in the application and the detailed review conducted of the liquefication potential at the _______________ uranium mill facility, the NRC staff concludes that the results of evaluation of liquefaction potential and associated conceptual and numerical models present input to a demonstration of compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides long-term stability requirements for the slopes of the tailings embankment and cover; and Criterion 6(1), which requires that impoundment designs povide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.4.5 References

American Society for Testing and Materials Standards:

D 3999, “Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus.”

D 4015, “Test Method for Modulus and Damping of Soils by the Resonant-Column Method.”

Ishihara, K. and M. Yoshimine. “Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquake.” *Soil Foundations*. Vol. 32, No. 1. Japanese Society of Soil Mechanics and Foundation Engineering. 1990.

National Center for Earthquake Engineering Research. “Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils.” T.L. Youd and I.M. Idriss, eds. Technical Report No. NCEER 97-002. Buffalo, New York: State University of New York. 1997.

Naval Facility Engineering Command. “Soil Dynamics, Deep Stabilization, and Special Geotechnical Construction. NAVFAC DM–7.3. Alexandria, Virginia: Department of the Navy. 1983.

NRC. Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants.” Rev. 1. Washington, DC: NRC, Office of Standards Development. March 1979.

———. Regulatory Guide 1.138, “Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants.” Washington, DC: NRC, Office of Standards Development. April 1978.

Seed, H.B. and I.M. Idriss. “Ground Motions and Soil Liquefaction During Earthquakes.” Earthquake Engineering Research Institute. *Engineering Monograph*: 5. 1982.

Seed, H.B. and I.M. Idriss. “A Simplified Procedure for Evaluating Soil Liquefaction Potential.” *Journal of Soil Mechanics and Foundation Division.* Vol. 97, No. SM 9. pp. 1,249–1,274. 1971.

Seed, R.B. and L.F. Harder. “SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength.” Proceedings of the H. Bolton Seed Memorial Symposium. Berkeley, California: University of California, May 10–11. pp. 351–376. 1990.

Shannon & Wilson, Inc. and Agbabian-Jacobsen Associates. “Soil Behavior Under Earthquake Loading Conditions: State-of-the-Art Evaluation of Characteristics for Seismic Responses Analyses.” Washington, DC: U.S. Atomic Energy Commission. 1972.

U.S. Army Corps of Engineers. “Soil Sampling.” Manual EM 1110-2-1907. March 1972.

———. “Laboratory Soil Testing, Engineering.” Manual EM1110-2-1906. November 1970.

2.5 Disposal Cell Cover Engineering Design

2.5.1 Areas of Review

The staff should review information presented on disposal cell cover engineering design. including field exploration data, laboratory test results, design details, and construction and installation considerations pertinent to the geotechnical aspects of design and any associated geomembranes (i.e., disposal cell configuration and thickness, compaction requirements, gradations, permeability, and dispersivity).

2.5.2 Review Procedures

The reviewer should examine the disposal cell design and engineering parameters to assess the geotechnical aspects of the disposal cell cover. Specific aspects of the review should consider the following items:

(1) Determination that an adequate quantity of the specified borrow material has been identified at the borrow source.

(2) Confirmation that placement density, specific gravity, moisture content, dispersivity, and shrinkage properties used in the disposal cell design have been determined by suitable laboratory testing so that long-term stability standards will be met. (Note that

permeability issues are discussed separately in standard review plan Section 2.7.)

(3) Confirmation that appropriate measures for controlling the effects of erosion, surface water flows, and vegetative deep root penetrations have been taken.

(4) Verification that the particle size gradation of the disposal cell cover material, bedding layers, other layers in the cover, and the rock layer are compatible to ensure stability against particle migration during the period of regulatory interest.

(5) Determination that the disposal cell has been designed to accommodate the effects of anticipated freeze-thaw cycles.

(6) Assessment, if bentonite amendment to the radon barrier material of the disposal cell cover is proposed, of whether supporting discussions define appropriate laboratory testing and field procedures associated with evaluating amended materials.

(7) Determination if the cracking potential of the disposal cell has been adequately addressed. Cracking from both settlement and shrinkage should be evaluated using standard review plan Section 2.3.

(8) Assessment of the acceptability of plans for installation and use of any geomembranes.

(9) Confirmation that the information used in the disposal cell cover design appropriately reflects the staff findings on the information reviewed using standard review plan Chapters 1.0, 2.0, 3.0, and 4.0.

Note that hydraulic conductivity aspects of the disposal cell cover design are assessed using standard review plan Section 2.7 and that review of the disposal cell design features is addressed in standard review plan Sections 2.2, 2.3, and 2.4. Review of the radon attenuation aspects of the disposal cell design is addressed in standard review plan Chapter 5.0.

2.5.3 Acceptance Criteria

The assessment of the disposal cell cover design and engineering parameters will be acceptable if it meets the following criteria:

(1) Detailed descriptions of the disposal cell material types [e.g., Unified Soil Classification System (Holtz and Kovacs, 1981)] and/or soil mixtures (e.g., bentonite additive) and the basis for their selection are presented.

An analysis is included demonstrating that an adequate quantity of the specified borrow material has been identified at the borrow source. The information on borrow material includes boring and test pit logs and compaction test data.

The soils that are considered suitable include the Unified Classification System Classes CL, CH, SC, and CL-ML, with desirable characteristics and limitations as listed in Table 3-1 of the “Construction Methods and Guidance for Sealing Penetrations in Soil Covers” (Bennett and Homz, 1991; Bennett and Kimbrell, 1991). The preferred material for the low-permeability layers is inorganic clay soil. This soil should be compacted to a low saturated hydraulic conductivity of at least 1 x 10^{-7} cm/sec. For drainage layers, cobble types GW, GP, SP, and SW are recommended, with GW and GP being the preferred types (Bennett, 1991).

Measures for resisting cracking, heaving, and settlement, and providing protection from burrowing animals, root penetration, and erosion over a long period of time are described.

(2) A sufficiently detailed description of the applicable field and laboratory investigations and testing that were completed, and the material properties (e.g., permeability, moisture-density relationships, gradation, shrinkage and dispersive characteristics, resistance to freeze-thaw degradation, cracking potential, and chemical compatibility, including any amendment materials) are identified (U.S. Army Corps of Engineers, 1970, 1972; Fermulk and Haug, 1990; NRC, 1978, 1979; Lee and Shen, 1969; Spangler and Handy, 1982).

(3) Details are presented (including sketches) of the disposal cell cover termination at boundaries, with any considerations for safely accommodating subsurface water flows.

(4) A schematic diagram displaying various disposal cell layers and thicknesses is provided.

The particle size gradation of the disposal cell bedding layer and the rock layer are established to ensure stability against particle migration during the period of regulatory interest (NRC, 1982).

(5) The effect of possible freeze-and-thaw cycles on soil strength and radon barrier effectiveness is adequately considered (e.g., Aitken and Berg, 1968).

If the region experiences prolonged freezing, the disposal cell cover may be affected by the freeze-thaw cycle. During freezing, ice crystals and lenses can form in the soil, causing heaving. On the other hand, during melting and thawing, the soil may lose its bearing capacity because of development of supersaturated conditions (Spangler and Handy, 1982). Major factors affecting growth of ice in soil are the temperature below the freezing point, the capillary characteristics of the soil, and the presence of water. The reviewer should check whether the soil is susceptible to frost heave, considering that uniformly graded soils containing more than 10 percent of particles smaller than 0.02 mm and well-graded soils with more than 3 percent of particles smaller than 0.02 mm are susceptible (Holtz and Kovacs, 1981; Spangler and Handy, 1982). After many freeze-thaw cycles, the soil may become a loose collection of aggregates with significantly reduced overall strength.

(6) A description is given (with sketches) of any penetrations (e.g., monitoring wells) through the disposal cell system, including details of penetration sealing and disposal cell cover integrity. Bennett and Kimbrell (1991) suggest methods for seal design that are acceptable.

(7) An adequate analysis is presented of the potential for development of cracks in the disposal cell cover as a result of differential settlement and shrinkage. Note that cracking issues associated with settlement are discussed in standard review plan Section 2.3.3.

(8) An adequate description of the geomembranes and their major properties (e.g., physical, mechanical, and chemical) is provided if low permeability geomembranes are proposed as a part of the disposal cell cover. Methods for installation of the membranes in accordance with the manufacturer's recommendations are discussed. The shear strength of the interface between compacted clay and geomembranes used in the stability analyses under both static and dynamic loads is noted. The expected service life of the geomembrane is analyzed.

(9) Information on site characterization, slope stability, settlement, and liquefaction used in the disposal cell cover design appropriately reflects the Licensee's evaluation, and therefore, constitutes inputs that would contribute to the demonstration of disposal cell design compliance with the regulations.

2.5.4 Evaluation Findings

If the staff review as described in standard review plan Section 2.5 results in the acceptance of the disposal cell cover design, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the disposal cell cover design at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.5.2 and acceptance criteria outlined in Section 2.5.3 of this standard review plan.

The licensee has acceptably defined the disposal cell cover design by presenting detailed descriptions of the disposal cell material types and/or soil mixtures, including the basis for their selection. The applicant has identified an adequate quantity of the specified borrow material at the borrow source. An acceptable schematic diagram displaying various disposal cell layers and thicknesses is provided. A description of the applicable field and laboratory investigations and testing is provided, including identification of material properties. The properties of the cover materials have been measured properly using standards such as American Society for Testing and Materials, NRC, or U.S. Army Corps of Engineers. Details (including sketches) have been provided of (1) disposal cell termination boundaries; (2) penetrations, including sealing and disposal cell integrity; and (3) geomembranes and their physical, mechanical, and chemical properties. Methods of installation for the membranes have been discussed and the expected service life has been justified. The analysis of the potential for development of cracks in the disposal cell cover is acceptable.

On the basis of the information presented in the application and the detailed review conducted of the disposal cell cover design at the _________________ uranium mill facility, the NRC staff concludes that the disposal cell engineering parameters and associated conceptual and numerical models are acceptable and provide input to demonstration of compliance with the following criteria in 10 CFR, Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings; and Criterion 6(1), which requires that impoundment design provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

2.5.5 References

American Society for Testing and Materials Standards:

D 75, "Practice for Sampling Aggregates."

D 4992, "Practice for the Evaluation of Rock To Be Used for Erosion Control."

Aitken, G.W. and R.L. Berg. "Digital Solution of Modified Berggren Equation to Calculate Depths of Freeze or Thaw in Multi-layered Systems." Special Report 122. Hanover, New Hampshire: Cold Regions Research & Engineering Laboratory. 1968.

Bennett, R.D. NUREG/CR–5432, "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Identification and Ranking of Soils for Disposal Facility Covers." Vol. 1. Washington, DC: NRC. 1991.

Bennett, R.D. and R.C. Homz. NUREG/CR–5432, "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Laboratory and Field Tests for Soil Covers." Vol. 2. Washington, DC: NRC. 1991.

Bennett, R.D. and A.F. Kimbrell. NUREG/CR–5432, "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Construction Methods for Sealing Penetrations in Soil Covers." Vol. 3. Washington, DC: NRC. 1991.

Fermulk, N. and M. Haug. "Evaluation of *In Situ* Permeability Testing Methods." *ASCE Journal of Geotechnical Engineering.* Vol. 116, No. 2. pp. 297–311. 1990.

Holtz, R.D. and W.D. Kovacs. *An Introduction to Geotechnical Engineering.* Englewood Cliffs, New Jersey: Prentice-Hall. 1981.

Lee, K.L. and C.K. Shen. 1969. "Horizontal Movements Related to Subsidence." *Journal of Soil Mechanics and Foundation Division.* Vol. 95, No. SM–1. New York, New York: American Society of Civil Engineers. 1969.

NRC. NUREG/CR–2684, "Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments." Washington, DC: NRC. 1982.

———. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Rev. 1. Washington, DC: NRC, Office of Standards Development. March 1979.

———. Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." April 1978. Washington, DC: NRC, Office of Standards

Development. April 1978.

Spangler, M.G. and R.L. Handy. *Soil Engineering*. New York, New York: Harper and Row. 1982.

U.S. Army Corps of Engineers. "Soil Sampling." Engineering Manual EM1110-2-1907. March 1972.

———. "Laboratory Soil Testing." Engineering Manual EM1110–2–1906. November 1970.

2.6 Construction Considerations

2.6.1 Areas of Review

The staff should review information on the geotechnical aspects of reclamation construction. These aspects should include details such as the sequence and schedule for construction activities, material specifications and placement procedures, and quality control aspects of the construction procedures. The geotechnical aspects of the planned construction operations should be reviewed to identify any deviations from standard engineering practice for earthworks, including measures to protect against erosion and provisions for a vegetative cover, if appropriate.

2.6.2 Review Procedures

The reviewer should determine if all the tailings and contaminated materials at the site can be placed within the configuration of the proposed stabilized pile. The construction sequence should be reviewed to verify the feasibility of achieving the intended final configuration of the tailings, particularly when tailings are to be relocated to new areas of the remediated pile, and to determine whether the schedule for completion is reasonable. The reviewer should also confirm that the construction schedule will allow the radon barrier to be completed as expeditiously as practical after ceasing operations.

The reviewer should examine material placement, placement moisture content (drying, if needed), placement density, and desired permeability to ensure that design specifications will be met. If mixing of the fine tailings (slimes) with sand tailings is proposed, the specifications to control the mixture and the determination of the engineering properties of this mixture should be examined for adequacy.

The reviewer should examine the proposed construction quality control program to verify that adequate provisions have been included to ensure that the construction will be in accordance with the NRC-approved reclamation plan. In particular, details of the proposed testing and inspection program, including the type and frequency of tests proposed, should be reviewed and compared with NRC guidance on testing and inspection.

Methods and schedules for emplacing the vegetative cover should be reviewed if necessary, to determine that they are reasonable, and that seeds for the planned vegetation are compatible with the local climate.

2.6.3 Acceptance Criteria

The analysis of construction considerations will be acceptable if the following criteria are met:

(1) Engineering drawings are at appropriate scales to completely and clearly show the design features (e.g., embankments, riprap, and channels).

(2) Sources and quantities of borrow material are identified, are shown to have been adequately characterized and quantified through field and laboratory tests, and are demonstrated to be adequate for meeting the geotechnical design requirements for the disposal cell (NRC, 1978, 1979). The background levels of contamination in the borrow materials, if any, are properly established.

(3) Methods, procedures, and requirements for excavating, hauling, stockpiling, and placing of contaminated and non-contaminated materials and other disposal cell materials are provided and are shown to be consistent with commonly accepted engineering practice for earthen works (Department of the Navy, 1982a,b; Denson, et al., 1987).

Material placement and compaction procedures are adequate to achieve the desired moisture content (drying, if needed) placement density and permeability. Recommendations made in NUREG/CR–5041 (Denson, et al., 1987) for gradation, placement, and compaction necessary to achieve design drainage rates and volumes, prevent internal erosion or piping, and allow for collection and removal of liquids, are acceptable. Compaction specifications include restrictions on work related to adverse weather conditions (e.g., rainfall, freezing conditions).

Specifications for controlling the mixture of fine tailings (slime) with sand tailings are consistent with commonly accepted engineering practice and testing programs for determination of engineering properties of this mixture.

(4) A plan for embankment construction is presented, that demonstrates embankments can be constructed in accordance with the design.

(5) Plans, specifications, and requirements for disposal cell compaction are supported by field and laboratory tests and analyses to assure stability and reliable performance.

(6) Testing and surveying programs to determine the extent of cleanup required are adequate. The contamination cleanup plan includes the method for determining the extent of the contaminated area and a confirmation program to demonstrate that the contaminated material has been removed. Details of the site cleanup (radiological aspects) are addressed in standard review plan Chapter 5.0.

(7) A plan for settlement measurement is provided that is satisfactory for producing representative settlement data throughout the area of the disposal cell. Settlement measurement stations are of sufficient coverage and are strategically placed to yield adequate information for determination of total, differential, and residual settlements. Monitoring monuments are designed to be durable. The reviewer should also determine

the reasonableness of the proposed monitoring frequency in accordance with NUREG/CR–3356 (NRC, 1983). In the past, the staff has determined that the final radon barrier may be emplaced once 90 percent of expected settlement has occurred.

(8) All tailings and contaminated materials at the site can be placed within the planned configuration of the stabilized pile.

(9) Procedures, specifications, and requirements for riprap, rock mulch, and filter production and placement are provided and are shown to be consistent with commonly accepted engineering practice and the design specifications (NRC, 1977, 1982).

(10) The construction sequence is described and demonstrated to be adequate to achieve the intended configuration for the tailings, particularly when tailings are to be relocated to new areas of the reclaimed pile. The proposed time to completion has been shown to be reasonably achievable, and the construction schedule provides for completing the radon barrier as expeditiously as practical after ceasing operations in accordance with an approved reclamation plan.

(11) The vegetation program or rock cover design is described and demonstrated to be adequate (Wu, 1984; NRC, 1982).

(12) Appropriate quality control provisions are provided to ensure that the construction will be in accordance with the reclamation plan. The descriptions of the methods, procedures, and frequencies by which the construction materials and activities are to be tested and inspected are reasonable and appropriate records will be maintained (NRC, 1983).

(13) Tailings are placed below grade, or the licensee has demonstrated that the above-grade disposal design provides reasonably equivalent isolation of the tailings from natural erosional forces. Tailings pile topographic features take into account wind protection and vegetation cover.

2.6.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the licensee proposed construction considerations, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of construction considerations at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.6.2 and the acceptance criteria outlined in Section 2.6.3 of this standard review plan.

The licensee has acceptably described the construction considerations by (1) providing complete engineering drawings showing all design features; (2) describing sources and quantities of borrow material, including acceptable field and laboratory testing; and (3) identifying methods, procedures, and requirements for excavations, haulage, stockpiling, and placement of materials and demonstrating that all are consistent with accepted engineering practices for earthen works. An acceptable plan for embankment construction is provided. Disposal cell compaction plans are supported by field and laboratory tests that assure stability and performance. The licensee has an acceptable program to determine the extent of cleanup using appropriate testing and surveying programs. An acceptable plan for settlement measurement is provided, including (1) proper coverage and placement of settlement measurement stations, (2) durable monitoring monuments, and (3) reasonable monitoring frequencies. All tailings and contaminated materials have been demonstrated to fit within the planned configuration of the stabilized pile. Procedures, specifications, and requirements for riprap, rock mulch, and filters are provided and are shown to be consistent with commonly accepted engineering practices and design specifications. An acceptable construction sequence, including a reasonable time to completion, has been described. An acceptable vegetation program or rock cover design is proposed. Appropriate quality control provisions are in place to ensure that construction will be in accordance with the reclamation plan and that appropriate records will be maintained.

On the basis of the information presented in the application and the detailed review conducted of the construction considerations at the _______________ uranium mill facility, the NRC staff concludes that the construction considerations and associated conceptual and numerical models provide input to a demonstration of compliance with the following criteria in 10 CFR, Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient; Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years; and Criterion 6A(1), which requires that the radon barrier be completed as expeditiously as practical after ceasing operations in accordance with a Commission-approved reclamation plan.

2.6.5 References

American Society for Testing and Materials Standards:

D 698, “Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.”

D 1556, “Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method.”

D 1557, “Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.”

D 2167, “Test Method for Density and Unit Weight of Soil In Place by the Rubber Balloon Method.”

D 2922, “Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shouldow Depth).”

D 2937, “Test Method for Density of Soil in Place by the Drive Cylinder Method.”

D 3017, “Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shouldow Depth).”

D 3740, “Practice for the Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.”

D 4253, “Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.”

D 4254, “Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.”

D 4643, “Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method”

D 4718, “Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles.”

D 4914, “Test Methods for Density of Soil and Rock In Place by the Sand Replacement Method in a Test Pit.”

D 5030, “Test Method for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit.”

Denson, R.H., et al. NUREG/CR–5041, “Recommendations to the NRC for Review Criteria for Alternative Methods of Low-Level Radioactive Waste Disposal.” Washington, DC: NRC. 1987.

Department of the Navy. “Foundations and Earth Structures.” NAVFAC DM–7.2. May 1982a.

———. “Soil Dynamics, Deep Stabilization, and Special Geotechnical Construction.” NAVFAC DM–7.3. May 1982b.

NRC. NUREG/CR–3356, “Geotechnical Quality Control: Low-Level Radioactive Waste and Uranium Mill Tailings Disposal Facilities.” Washington, DC: NRC. 1983.

———. NUREG/CR–2684, “Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments.” Washington, DC: NRC. 1982.

———. Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants.” Rev. 1. Washington, DC: NRC, Office of Standards Development. March 1979.

———. Regulatory Guide 1.138, “Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants.” Washington, DC: NRC, Office of Standards Development. April 1978.

———. Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.” Rev. 2. Washington, DC: NRC, Office of Standards Development. 1977.

Wu, T.H. "Effect of Vegetation on Slope Stability: Soil Reinforcement and Moisture Effects on Slope Stability." Transportation Research Record 965. National Research Council, Transportation Research Board. 1984.

2.7 Disposal Cell Hydraulic Conductivity

2.7.1 Areas of Review

The staff should review test results, calculations, the technical bases for disposal cell design hydraulic conductivity values, the field testing program, and the quality control program.

2.7.2 Review Procedures

The reviewer should examine the geotechnical design aspects of the disposal cell to ensure that the disposal cell cover component has a minimal hydraulic conductivity, to limit radon emissions from, and water infiltration into, stabilized mill tailings. The geotechnical reviewer should coordinate with the water resources protection reviewer (see standard review plan Chapter 4.0) to ensure that regulatory requirements for ground-water protection can be met by the proposed radon barrier.

The reviewer should verify that an adequate technical basis has been presented for the design hydraulic conductivity (K) value for the disposal cell cover. For any situation in which a $K<10^{-7}$ cm/sec is proposed by the licensee, the staff should verify that either a test fill program will be undertaken to verify the constructability to achieve the desired K value, or the reclamation plan narrative and accompanying analyses have adequately demonstrated the acceptability of the design K value, considering technical papers on this subject (e.g., Rogowski, 1990; Panno, et al., 1991; Benson and Daniel, 1990). If the reclamation plan acceptably demonstrates that field testing is not required, the reviewer should document the technical basis in the technical evaluation report. If field testing is required, the staff should ensure that the test fill specifications require that the hydraulic conductivity value be verified by in-place testing with double-ring infiltrometers or other approved methods.

The test reviewer should examine the test fill construction plan and verification program for adequacy, including such aspects as (1) use of proper procedures and equipment for placement and compaction operations; (2) verification of the material and thickness for the barrier test zone; (3) comparison of gradation, bentonite amendment, and moisture/density testing with specifications; (4) review of the quality control plan; and (5) review of the proposed construction schedule.

2.7.3 Acceptance Criteria

The analysis of disposal cell hydraulic conductivity will be acceptable if it meets the following criteria:

(1) A sufficient technical basis is provided for the design hydraulic conductivity (K) value for the disposal cell.

The hydraulic conductivity is minimized by compacting fine-grained soil for a sufficient depth above the stabilized tailings. Natural borrow soils having insufficient silt and clay content to effectively reduce the hydraulic conductivity of the barrier can be amended with bentonite for improved effectiveness. (Note that construction issues are discussed separately using standard review plan Section 2.6.)

(2) A field testing program adequate to verify the constructability of the disposal cell with a design hydraulic conductivity $K<10^{-7}$ cm/sec is provided unless the reclamation plan demonstrates that field testing is not required (Benson and Daniel, 1990; NRC, 1979).

To meet the U.S. Environmental Protection Agency (EPA) ground-water standards, designers of disposal cells for mill tailings sites are proposing increasingly smaller design hydraulic conductivity (K) values. It is not unusual for laboratory permeability test values to yield results of 10^{-8} to 10^{-10} cm/sec. Such tests are performed on compacted soil samples considered by the design engineer to represent the soil to be used for the disposal cell. However, several technical papers (Rogowski, 1990; Panno et al., 1991; Benson and Daniel, 1990) have raised serious questions concerning the exclusive use of laboratory testing for demonstrating hydraulic conductivity values in those cases in which a radon barrier K-value less than 10^{-7} cm/sec is specified. On the basis of these technical papers, field testing is necessary to confirm the radon barrier hydraulic conductivity, since construction operations and soil material variability can create preferred pathways, joints, seams, holes, and flaws that effectively increase the value of this parameter. Test results should take into consideration the variability and uncertainty in site conditions and material properties. The test results should be properly documented and available for inspection.

(3) An appropriate quality control program is followed for the field testing to determine hydraulic conductivity (NRC, 1983).

For all cases in which $K<10^{-7}$ cm/sec and the test fill program requirement has been defined, specifications and related documents (Remedial Action Inspection Plan, etc.) will require an adequate quality control program. An acceptable quality control program should contain mechanisms to ensure that as-built construction duplicates the test fill construction techniques on the cell barrier (NRC, 1983). The objective of the quality control program will be to provide assurance that uniform and high-quality construction of the cell barrier has been achieved. Records for implementation of the quality control program during the construction of the cell barrier should be properly maintained and available for inspection.

(4) A reasonable construction schedule is proposed. The proposed construction schedule should promote completion of the radon barrier as expeditiously as practical after ceasing operations in accordance with a written, Commission-approved reclamation plan.

2.7.4 Evaluation Findings

If the staff review as described in standard review plan Section 2.7 results in the acceptance of the disposal cell hydraulic conductivity, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the disposal cell hydraulic conductivity at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.7.2 and the acceptance criteria outlined in Section 2.7.3 of this standard review plan.

The licensee has acceptably evaluated the disposal cell cover materials hydraulic conductivity by providing a sufficient technical basis for the design K-value for the disposal cell. A field testing program adequate to verify the constructability of the disposal cell with a hydraulic design conductivity of $K<10^{-7}$ cm/sec is presented. The applicant followed an acceptable quality control program for the field testing to determine the hydraulic conductivity.

On the basis of the information presented in the application and the detailed review conducted of the disposal cell hydraulic conductivity at the _______________ uranium mill facility, the NRC staff concludes that the disposal cell hydraulic conductivity and associated conceptual and numerical models provide an acceptable input to the demonstration of compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

2.7.5 References

American Society for Testing and Materials Standards:

D 2434. “Test Method for Permeability of Granular Soils (Constant Head).”

D 3385. “Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers.”

D 5093. “Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer With a Sealed Inner Ring.”

Benson, C.H. and D.E. Daniel. “Influence of Clods on Hydraulic Conductivity of Compacted Clay.” *ASCE Journal of Geotechnical Engineering.* Vol. 116, No. 8. pp. 1,231–1,248. 1990.

NRC. NUREG/CR–3356, “Geotechnical Quality Control: Low-Level Radioactive Waste and Uranium Mill Tailings Disposal Facilities.” Washington, DC: NRC. 1983.

———. Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants.” Rev. 1. Washington, DC: NRC, Office of Standards Development. March 1979.

Panno, S.V., et al. “Field-Scale Investigation of Infiltration Into a Compacted Soil Liner. *Ground Water.* Vol. 29, No. 6. pp. 914–921. 1991.

Geotechnical Stability

Rogowski, A.S. “Relationship of Laboratory- and Field-Determined Hydraulic Conductivity in Compacted Clay Layer.” EPA/600/S2–90/025. Cincinnati, Ohio: Risk Reduction Engineering Laboratory. 1990.

3.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

3.1 Hydrologic Description of Site

Criterion 1 of 10 CFR Part 40, Appendix A, addresses the general goals of siting and designing facilities to provide for permanent isolation of tailings, and minimizing the potential for dispersion by natural forces, without the need for active maintenance. Information presented in Section 3.1 will be used in later sections of this standard review plan to assess the ability of the site and the site design to meet this and other requirements of 10 CFR Part 40.

It is important to note that the siting criteria presented in 10 CFR Part 40, Appendix A are intended to apply to uranium mills that have not yet been constructed. For many, if not most, uranium mills, reclamation plans are developed for sites that have existed for several decades. In fact, many mills were producing uranium before the siting criteria were developed. Therefore, the staff concludes that Criterion 1 is more relevant to new facilities (or modifications to old facilities) than to facilities that existed before regulations were developed.

3.1.1 Areas of Review

The staff should review hydrologic site characterization information, including (1) identification of the relationships of the site to surface-water features in the site area and (2) identification of mechanisms, such as floods and dam failures, that may require special design features to be implemented. This review requires identification of the hydrologic characteristics of streams, lakes (e.g., location, size, shape, drainage area), and existing or proposed water control structures that may adversely affect the long-term stability of the site design features.

3.1.2 Review Procedures

The staff should evaluate the completeness of the information and data, by sequential comparison with information available from references. On the basis of the description of the hydrosphere (e.g., geographic location and regional hydrologic features), potential site flood mechanisms are identified. The information normally presented is not amenable to independent verification, except through cross-checks with available publications related to hydrologic characteristics of the site region and through observation during site visits.

The staff should also analyze geomorphic considerations, as described in Section 1 of this standard review plan. On the basis of these analyses, the staff should estimate the potential for geomorphic instability to occur and to have a significant effect on the ability of the site and its protective features to prevent flood intrusion and erosion over a long period of time. If geomorphic problems are identified, the staff should give particular attention to several areas of the design, depending on site conditions and potential for geomorphic changes to occur. These areas include the (1) apron and toe of the disposal cell, (2) intersection of natural gullies with erosion protection features, and (3) diversion channel outlets. A detailed discussion of the erosion protection design for these and other features is given in Section 3.4.2 of this standard review plan.

3.1.3 Acceptance Criteria

The hydrologic description of the site will be considered acceptable if:

(1) The description of structures, facilities, and erosion protection designs is sufficiently complete to allow independent evaluation of the impact of flooding and intense rainfall.

(2) Site topographic maps are of good quality and of sufficient scale to allow independent analysis of pre- and post-construction drainage patterns.

(3) The reclamation plan contains sufficient information for the staff to independently evaluate the hydraulic designs presented. In general, detailed information is needed for each method that is used to determine the hydraulic designs and erosion protection provided to meet NRC regulations. NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and, thus, conform to NRC requirements. NUREG–1623 (NRC, 2002) also provides discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement, without the use of active maintenance. Specific design methods are provided and form the primary basis for staff review of erosion protection designs.

3.1.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the information acceptably characterizes the site and the site design features, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the flooding potential at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that (1) the flood analyses and investigations adequately characterize the flood potential at the site, (2) the analyses of hydraulic designs are appropriately documented, and (3) the general reclamation plan with respect to surface-water hydrology and erosion considerations, represents a feasible plan, for complying with the requirements of 10 CFR Part 40, Appendix A. The characterization of flood potential and the documentation of the site design conform to the requirements of Criterion 1 of 10 CFR Part 40, Appendix A, which requires a design that provides for permanent isolation of tailings and minimizes disturbance and dispersion by natural forces.

3.1.5 References

NRC. NUREG–1623, "Design of Erosion Protection for Long-Term Stabilization." Washington, DC: NRC. 2002.

3.2 Flooding Determinations

3.2.1 Areas of Review

The staff should assess the flooding potential for the site, and should determine precipitation potential, precipitation losses, runoff response characteristics, and peak flow estimates for the probable maximum flood or project design flood (if a flood less than the probable maximum flood is used). The staff should review the following design analyses: (1) the analyses and justification for the use of a flood less than the probable maximum flood, if applicable; (2) the probable maximum precipitation potential and resulting runoff for site drainage and for drainage areas adjacent to the site; and (3) the modeling of physical rainfall and runoff processes to estimate flood conditions at the site.

The assessment of flooding also should include a review of possible geomorphic changes that could affect the erosion protection design for the site. As applicable, the staff should review the following: (1) identification of types of geomorphic instability; (2) changes to, and impacts associated with, flooding and flood velocities from geomorphic changes; and (3) mitigative measures to reduce or control geomorphic instability. This information must be reviewed to determine the acceptability of hydraulic engineering designs to mitigate the geomorphic conditions and to avoid the need for ongoing active maintenance.

The assessment of flooding should also include a review of potential dam failures, if upstream reservoirs exist. Peak water levels, flood routing procedures, and velocities should be reviewed in the determination of potential hazards because of failure of upstream water control structures from either seismic or hydrologic causes. If an existing analysis concludes that seismic or hydrologic events will not cause failures of upstream dams and produce the governing flood at the site, the analysis should be reviewed to verify that information that supports such a conclusion (e.g., record of contact with dam designers) is included. If an analysis is provided that concludes that a dam failure flood from a probable maximum flood or a seismically induced flood is the design-basis flood, the computations should be reviewed to verify that appropriate and/or conservative model input parameters have been used.

3.2.2 Review Procedures

The evaluation of flooding is, for review purposes, separated into two parts: (1) flooding on large adjacent streams, as applicable, and (2) localized flooding on drainage channels and protective features. The acceptability of using the probable maximum flood as the design flood event is presented in Section 2.2.1 of NUREG–1623 (NRC, 2002). The review procedure for evaluating a probable maximum precipitation/probable maximum flood event is outlined in Appendix D of NUREG–1623 (NRC, 2002). For large drainage areas, probable maximum flood estimates approved by the U.S. Army Corps of Engineers and found in published or unpublished reports of that agency, or generalized estimates, may be used instead of independent staff-developed estimates. The staff should also assess flood history in the site area by examining historic regional flood data. For many areas, historic flood peaks could be a small percentage of the probable maximum flood. If the historic maximum floods exceed or closely approximate the proposed probable maximum flood estimates, the staff should perform a detailed evaluation to determine the basis for the estimates. The staff should compare basin lag times, rainfall distributions, soil types, and infiltration loss rates to determine if there is a logical basis for the probable maximum flood values being less than historic floods. Without such estimates, the staff should generally use U.S. Army Corps of Engineers models to independently estimate probable maximum flood discharge and water levels at the site. If detailed computer models are used, the staff should review the adequacy of the various input parameters to the model, including, but not limited to, the following: drainage area, lag times and times of concentration, design rainfall, incremental rainfall amounts, temporal distribution of incremental rainfall, and runoff/infiltration relationships.

The staff should review the dam failure analyses presented in the reclamation plan or should independently estimate the peak flows at the site. Often, it may be much easier to perform simplified flood analyses assuming a dam failure, rather than detailed analyses of the seismic resistance of a dam. In such cases, the staff should review those simplified flood analyses using the procedures outlined in standard review plan Section 3.3.4.

The staff should evaluate the information presented in the reclamation plan using procedures found in Appendix C of NUREG–1623 (NRC, 2002) in those cases in which it is documented that it is impractical to design erosion protection features for an occurrence of the probable maximum flood. These procedures contain detailed information regarding justification of a stability period of less than 1,000 years. To assure that minimum NRC requirements are met, the staff should independently check and evaluate the ability of the design to resist such flood events.

In the detailed review of flooding, the staff should carefully consider the following factors that are important in determining a local probable maximum precipitation/probable maximum flood event:

- Determination of Design Rainfall Event. The staff should consult appropriate hydrometeorological reports and determine that correct values of the 1- and 6-hour probable maximum precipitation events, as applicable, have been given.

- Infiltration Losses. The staff should check calculations to verify that appropriate values of infiltration have been selected.

- Times of Concentration. The staff should verify that appropriate methods (depending on the slope, configuration, etc.) have been selected. The staff should independently verify that the methods selected compare reasonably well with various velocity-based methods.

- Rainfall Distributions. The staff should verify that the rainfall distributions (particularly the 2½-, 5-, and 15-minute distributions) compare well with the distributions suggested in Appendix D to NUREG–1623 (NRC, 2002).

For dam failures, the staff should review estimates of flood potential and water levels. Depending on the potential for flooding, the staff should verify that the dam failure analyses are either realistic or conservative by determining locations and sizes of upstream dams, assuming an instantaneous failure (complete removal) of the dam embankment, and computing the peak outflow rate.

If this simplified analysis indicates a potential flooding problem, the analysis may be repeated using more refined techniques, and the staff may request additional information and data. Detailed failure models, such as those of the Army Corps of Engineers and National Weather Service, will be used to identify the outflows, failure modes, and resultant water levels at the site.

Assessments of flooding will be used to determine the acceptability of hydraulic engineering design to avoid the need for ongoing active maintenance at the site.

If a flood less than a probable maximum flood can cause dam failure and is proposed as the design-basis flood, the staff should employ the review procedures outlined above to determine the impracticality of designing for a probable maximum flood and to determine the acceptability of the flood used.

3.2.3 Acceptance Criteria

The flooding determinations for the site will be considered acceptable if:

The designs conform to the suggested criteria in Appendix D to NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to meet NRC requirements. It also presents discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Acceptable design methods are presented and form the primary basis for staff review of erosion protection designs. These methods were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical studies.

Information pertinent to computation of the design flood is submitted in sufficient detail to enable the staff to perform an independent flood estimate, Specifically:

- Model input parameters are adequate.

- Staff and the reclamation plan estimates of flood levels and peak discharges are in agreement.

- Computational methods for design flood estimates are adequate.

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"Worst conditions" postulated in the analysis of upstream dam failures are (1) an approximate 25-year flood on a normal operating reservoir pool level coincident with the dam-site equivalent of the earthquake for which the remedial action project is designed, (2) a flood of about one-half the severity of a probable maximum flood on a normal reservoir pool level coincident with the dam-site equivalent of one-half of the earthquake for which the remedial action project is designed; and (3) a probable maximum flood (or design flood) on a normal reservoir pool. Conditions 1 and 2 are applied when the dam is not designed with adequate seismic resistance; Condition 3 is applied when the dam is not designed to safely store or pass the design flood.

If the proposed design is based on less than a probable maximum flood event, the licensee offers reasonable assurance of conforming to the stability requirement of at least 200 years.

Dam failure analyses are either realistic or conservative, and include locations and sizes of upstream dams, instantaneous failure (complete removal) of the dam embankment, and compute the peak outflow rate.

3.2.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the flooding potential at the ______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.2.2 and the acceptance criteria outlined in Section 3.2.3 of this standard review plan.

On the basis of information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that the flood analyses and investigations adequately characterize the flood potential at the site and that the surface water hydrology and flooding considerations represent a feasible plan for meeting the requirements of 10 CFR Part 40, Appendix A.

The mill tailings at the ________________ uranium mill facility will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that this erosion protection is adequate, based on (1) selection of proper rainfall and flooding events; (2) selection of appropriate parameters for determining flood discharges; and (3) computation of flood discharges, using appropriate and/or conservative methods.

The licensee presented analyses to show that the site is located in an area rarely flooded by off-site floods and that it is protected from direct on-site precipitation and flooding. The erosion protection is large enough to resist flooding from the shallow depths and minimal forces of floods occurring from a probable maximum flood in the upstream drainage area. The staff therefore concludes that the erosion potential at the proposed site has been acceptably minimized, since any flooding at the site is mitigated by the erosion protection, and the forces associated with off-site floods are minimal. The staff also concludes that, because the rainfall and flooding events have very low probabilities of occurrence over a 1,000-year period, no damage to erosion protection is expected from these, or more frequent, events. Therefore, maintenance or repair of damage will not be necessary.

On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _______________ uranium mill facility, the NRC staff concludes that the flood analyses contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(a), requiring that upstream rainfall catchment areas are minimized to decrease erosion potential and to resist floods that could erode or wash out sections of the tailings disposal area; Criterion 6(1), requiring that the design be effective for a period of 200–1,000 years; and Criterion 12, requiring that active maintenance is not necessary to preserve isolation.

3.2.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.3 Water Surface Profiles, Channel Velocities, and Shear Stresses

3.3.1 Areas of Review

Depending on the type of computational models used, the staff should review the model, including the determination of flooding depths, channel velocities, and/or shear stresses used to determine riprap sizes needed for erosion protection. The staff should review the various detailed computations for each model and should review the acceptability of the input parameters to the model. The staff should estimate the flood levels, velocities, shear stresses, and magnitudes, as described below. The review should be oriented toward verifying that the site will not require ongoing active maintenance.

3.3.2 Review Procedures

Using the guidance presented in Appendix D to NUREG–1623 (NRC, 2002) the staff should verify that localized flood depths, velocities, and shear stresses used in models for rock size determination or soil cover slope analysis are acceptable. For off-site flooding effects, the staff should verify that computational models have been correctly and appropriately used and that the data from the model have been correctly interpreted. The staff should verify that acceptable models and input parameters have been used in all the various portions of the flood analyses and that the resulting flood forces have been adequately accommodated.

Staff estimates may be made independently from basic data, by detailed review and checking of the reclamation plan analyses, or by comparison with other estimates that have been previously reviewed in detail. The evaluation of the adequacy of the estimates is a matter of engineering judgment, and is based on the confidence in the estimate, the degree of conservatism in each parameter used in the estimate, and the relative sensitivity of each parameter as it affects the flood level, flood velocity, or design of the erosion protection.

The staff review should evaluate whether ongoing active maintenance will be required at the site.

3.3.3 Acceptance Criteria

The water surface profiles, channel velocities, and shear stresses calculated for the site will be considered acceptable if:

The proposed designs conform to the suggested criteria in Appendix D to NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to comply with NRC requirements. This document also contains discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific design methods are presented, and reasonable similarity to these methods forms the primary basis for staff acceptance of erosion protection designs. Specifically:

- Localized flood depths, velocities, and shear stresses used in models for rock size determination or soil cover slope analysis conform to the guidance presented in Appendix D to NUREG–1623 (NRC, 2002).

- For off-site flooding effects, computational models have been correctly and appropriately used and the data from the models have been correctly interpreted.

- Acceptable models and input parameters have been used in all the various portions of the flood analyses and the resulting flood forces have been adequately accommodated.

3.3.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the flooding models at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.3.2 and the acceptance criteria outlined in Section 3.3.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the flooding models for the ____________ uranium mill facility, the NRC staff concludes that flood velocities and forces associated with flooding at the site have been acceptably computed.

The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that adequate protection is provided by (1) selection of proper models to assess rainfall and flooding events, (2) selection of appropriate parameters for models for determining flood forces, and (3) computation of flood forces using appropriate and/or conservative methods.

The staff considers that the riprap layers proposed will not require active maintenance over the 1,000-year design life, because the licensee adopted models that conservatively compute flood forces used to design the erosion protection. Thus, the use of conservative design parameters will result in no damage to the erosion protection designed using those methods. The staff further concludes that the hydraulic design features are sufficient to protect the tailings from flood forces that are very large and have very low probabilities of occurrence over a 1,000-year period. Therefore, maintenance of the rock layers will not be necessary.

The staff concludes that the analyses and models used at the _______________ uranium mill facility contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 6(1), requiring the design to be effective for a period of 200 to 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary o preserve isolation of the tailings.

3.3.5 Reference

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.4 Design of Erosion Protection

3.4.1 Areas of Review

Design details and analyses pertinent to the following aspects of erosion protection will be reviewed, as applicable:

(1) Erosion protection for slopes and channel banks to protect against flooding from nearby large streams.

(2) Erosion protection for the top and side slopes of the pile.

(3) Erosion protection for the apron/toe area of the side slope.

(4) Erosion protection for drainage and diversion channels, including channel outlets.

(5) Durability of the erosion protection.

(6) Construction considerations, including specifications, quality assurance programs, quality control programs, and inspection programs.

In Section 3.4.2.4 (below), sedimentation in diversion channels is also addressed. Criterion 4(f) of 10 CFR Part 40, Appendix A, suggests that deposition of sediment in impoundment areas should be considered for enhancing the cover thickness. The staff considers it important to differentiate between beneficial and detrimental sediment accumulations. For example, if sediment could be conveniently routed to the middle of an impoundment, without long-term erosion or ponding of runoff that could affect ground-water conditions, such deposition may enhance long-term cover thickness. However, this is difficult to actually achieve. The major problem with sediment is that it tends to accumulate in diversion channels that are constructed on relatively flat slopes. High-velocity runoff from steep slopes carries sediment into low-velocity diversion channels, and that sediment can eventually accumulate and completely block the channel. Thus, it can be seen that some sediment buildup is good and some is bad. The review should evaluate the need for ongoing active maintenance of the site.

3.4.2 Review Procedures

The staff should check the analyses in the reclamation plan or perform independent review analyses of floods, flood velocities, and rock durability according to the guidelines in Appendix D to NUREG–1623 (NRC, 2002). The following areas should be evaluated.

(1) Banks of Natural Channels

The staff should review designs for riprap to be placed on the side slopes of a reclaimed pile or on natural channel banks to protect against erosive velocities from floods on large rivers. Guidance is presented in Appendix D to NUREG–1623 (NRC, 2002) for assessing floods, determining input parameters to models, and determining riprap requirements.

(2) Top Slope and Side Slopes

The staff should review input parameters to calculations and models according to the recommendations given in Appendix D to NUREG–1623 (NRC, 2002) and referenced technical procedures. The staff should assess the design flow rate, the depth of flow, angle of repose, specific gravity, and other parameters. For both the top and side slopes, the rock sizes should be checked using the recently developed, simplified procedures discussed in NUREG–1623 (NRC, 2002).

(3) Apron/Toe

The design of the apron and toe is reviewed by verifying that several design features in this area have been properly designed, in accordance with the recommendations in NUREG–1623 (NRC, 2002).

For the lower end of the side slope where it meets the toe, the staff should verify that proper consideration has been given to the potential occurrence of increased shear forces resulting from turbulence and energy dissipation produced by hydraulic jumps, when the flow transitions from supercritical to subcritical. The staff should verify that appropriate design criteria have been used to increase the rock size to account for the increased velocities or shear forces.

For the main area of the toe, the staff should assure that appropriate methods have been used to design the riprap, depending on the magnitude of the slope of the toe.

For the downstream end of the toe, the staff should verify that acceptable assumptions have been made regarding the assumed collapse of the rock into scoured areas to prevent gully intrusion. Flow concentrations, collapsed slopes, and computational models should be evaluated.

For the natural ground area at the downstream end of the toe, the staff should verify that appropriate methods have been used to compute scour depths and that natural erosion will not adversely affect long-term stability.

(4) Diversion Channels

Using the criteria and guidance presented in Appendix D to NUREG–1623 (NRC, 2002), the staff should evaluate the design of diversion channels in several critical areas.

For the main channel area, the staff should verify that appropriate models and input parameters have been used to design the erosion protection. The staff should assure that flow rates, flow depths, and shear stresses have been correctly computed.

For the channel side slopes, the staff should verify that the side slopes are capable of resisting flow velocities and shear stresses from flows that occur directly down the side slope. This occurs often when diversion channels are constructed perpendicular to natural gullies (which discharge into the diversion channel). The shear forces in these locations often greatly exceed the forces produced by flows in the channel, particularly when the slope of the natural ground in the area is greater than the slope of the diversion channel.

For the outlet of the diversion channel, the staff should evaluate the design of erosion protection to assure that erosion in the discharge area (normally a natural gully, swale, or channel) has been adequately addressed. Designs similar to apron/toe designs should be evaluated to determine their resistance to erosion. Appendix D to NUREG–1623 (NRC, 2002) discusses acceptable methods for designing channel outlets.

For the entire length of the diversion channel, the staff should evaluate the effects of sediment accumulations on flow velocities, channel capacity, and need for increased rock size. Particular attention should be given to designs in which steep natural streams discharge into relatively flat diversion channels, greatly increasing the potential for blockage of the channel. Appendix E to NUREG–1623 (NRC, 2002) discusses acceptable methods for assessing sedimentation in diversion channels.

(5) Rock Durability

The staff should review the results of durability testing of proposed rock sources to assure that durable rock will be used. Appendix D to NUREG–1623 (NRC, 2002) presents a detailed method for evaluating rock quality for various locations and applications. If durable rock is not available to the site, to the extent practical, the reviewer should review the alternative proposed by the applicant and the associated analysis to assure that the alternative provides reasonable assurance that the radon barrier will be effective for 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years.

(6) Construction Considerations

The staff should review the plans, specifications, inspection programs, and quality assurance/quality control programs to assure that adequate measures are being taken to construct the design features according to accepted engineering practices. The staff should compare the information presented with typical programs used in the construction industry. Appendix F to NUREG–1623 (NRC, 2002) contains examples of acceptable specifications and testing programs that were approved by the staff and actually applied at several sites.

(7) The review shall specifically evaluate whether the erosion protection design is sufficient to avoid the need for ongoing active maintenance at the site.

3.4.3 Acceptance Criteria

The design of erosion protection for the site will be considered acceptable if:

The proposed designs conform to the suggested criteria in NUREG–1623 (NRC, 2002) . NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to comply with NRC requirements. This document also contains discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific design methods are presented, and reasonable similarity to these methods forms the primary basis for staff acceptance of erosion protection designs. NUREG–1623 (NRC, 2002) updates and expands the final staff technical position (NRC, 1990).

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment.

(2) The licensee must demonstrate a site-specific need for the use of active maintenance and an economic benefit.

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The staff should determine if the licensee's estimate of funding required for active maintenance is adequate. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.4.4 Evaluation Findings

If the staff evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the erosion protection designs are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the design of erosion protection at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.4.2 and the acceptance criteria outlined in Section 3.4.3 of this standard review plan.

On the basis of the information presented in the application and the detailed review conducted of the erosion protection features, the staff concludes that the designs are acceptable.

The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff. The staff considers that erosion protection that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in standard review plan Sections 3.2 and 3.3, the staff concludes that adequate erosion protection designs are provided by (1) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge, and (2) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time. Further, the staff considers that the riprap layers proposed will be durable over the 1,000-year design life, for the following reasons: (1) the rock proposed for the riprap layers was evaluated using rock quality procedures suggested by the staff and is not expected to deteriorate significantly over the 1,000-year design life; (2) the rock fragments are dense, resistant to abrasion, and free from cracks, seams, and other defects; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

The riprap for the relatively flat top and side slopes is designed to be sufficiently large to minimize erosion potential. The rock will be capable of resisting flooding and erosion, depending on the slope selected. Thus, the staff concludes that the relatively steep slopes, with their corresponding rock designs, are acceptable.

On the basis of its review of the designs for the _______________ uranium mill facility, the staff concludes that the hydraulic designs contribute to meeting the requirements of 10 CFR Part 40,

Appendix A: (1) Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; (2) Criterion 4(c), requiring embankments and cover slopes to be relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety that ensure long-term stability; (3) Criterion 4(d), requiring that the rock cover reduces wind and water erosion to negligible levels, including consideration of such factors as the shape, size, composition, and gradation of the rock particles; (4) Criterion 4(f), requiring the design to promote deposition, where feasible; (5) Criterion 6(1), requiring the design to be effective for 200 to 1,000 years; and (5) Criterion 12, requiring that active on-going maintenance is not necessary to preserve isolation.

3.4.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

———. “Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites.” Washington, DC: NRC. 1990.

3.5 Design of Erosion Protection Covers

3.5.1 Areas of Review

If a soil or vegetative cover is proposed, the following design details, calculations, and analyses will be reviewed:

(1) Determination of allowable shear stresses and permissible velocities for the cover.

(2) Determination of allowable shear stresses and permissible velocities for the cover in a degraded state, including the effects of fires, droughts, vegetation succession, and other impacts to the ability of the cover to function without maintenance.

(3) Information on types of vegetation proposed and their abilities to survive natural phenomena.

(4) Information, analyses, and calculations of input parameters to models used.

The review will consider whether the design of covers is sufficient to avoid the need for ongoing active maintenance at the site.

3.5.2 Review Procedures

If a soil cover is proposed, the staff should evaluate the design using the general criteria outlined in Appendix A to NUREG–1623 (NRC, 2002). Particular attention should be given to the input parameters to various models.

(1) The staff should verify that the design flow rate includes an appropriate flow concentration factor that reflects consideration of settlement, soil removal by sheet flow and wind, degradation of the vegetation cover, intrusion of trees, blockage of flows by fallen trees, etc.

(2) The staff should verify that estimates of Manning's "n" value correspond to the vegetation cover proposed and are proper for estimating allowable shear stresses and permissible velocities.

(3) The staff should verify that appropriate values of allowable shear stresses and permissible velocities have been used and conservatively reflect potential changes that could occur to the cover over a long period of time as a result of fires, droughts, diseases, vegetation succession, or general cover degradation.

(4) The staff should check analyses and/or independently calculate allowable slopes using several different methods and ranges of input parameters. Using a range of flow concentration factors, shear stresses, permissible velocities, "n" values, and models, the staff should check the sensitivity of the analyses and should verify that reasonable and appropriate values of input parameters have been selected.

If a sacrificial soil cover is proposed to meet the minimum 200-year stability requirement, the staff should check the calculations using Appendix B to NUREG–1623 (NRC, 2002) and the justification for reduction of the stability period using Appendix C to NUREG–1623 (NRC, 2002).

(5) The reviewer shall determine whether the design is adequate to avoid the need for ongoing active maintenance at the site.

3.5.3 Acceptance Criteria

The design erosion protection covers for the site will be considered acceptable if:

The designs conform to the suggested criteria in NUREG–1623 (NRC, 2002). NUREG–1623 (NRC, 2002) discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and, thus, meet NRC requirements. This document also provides discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Specific acceptance criteria for many of the review areas are presented and form the primary basis for staff review of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references.

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment.

(2) The licensee must demonstrate a site-specific need for the use of active maintenance.

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.5.4 Evaluation Findings

If the staff's evaluation of erosion protection covers confirms that the cover designs are acceptable, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the design of erosion protection covers at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.5.2 and the acceptance criteria outlined in Section 3.5.3 of this standard review plan.

On the basis of its review, the staff concludes that the designs are acceptable and meet the requirements of 10 CFR Part 40, Appendix A.

The mill tailings will be protected from flooding and erosion by an engineered soil cover. The staff considers that a satisfactory cover will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in standard review plan Sections 3.2 and 3.3, the staff concludes that adequate cover designs are provided by:

(1) Use of appropriate methods for determining cover slopes needed to resist the forces produced by the design discharge.

(2) Selection of a cover that will be capable of providing the necessary erosion protection for a long period of time.

On the basis of the information presented in the application and the detailed review conducted of the erosion protection covers for the ______________ uranium mill facility, the NRC staff concludes that the cover designs contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(b), requiring siting and design such that topographic features provide good wind protection; Criterion 4(c), requiring that embankments and cover slopes are relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety; Criterion 6(1), requiring the design to be effective for 200 to 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary to preserve isolation.

3.5.5 References

NRC. NUREG–1623, “Design of Erosion Protection for Long-Term Stabilization.” Washington, DC: NRC. 2002.

3.6 General References

American Nuclear Society. “American National Standard for Determining Design Basis Flooding at Power Reactor Sites.” ANSI/ANS–2.8. 1981.

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———. "Additional Guidance for Riprap Channel Protection." ETL1110–2–120. May 1971.

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4.0 PROTECTING WATER RESOURCES

The protection of water resources is a process that encompasses two distinct strategies. The first strategy is to prevent the spread of contaminants from disposal and processing sites into ground water or surface water. This strategy requires the staff to ensure that operations and decommissioning are conducted in such a manner as to minimize threats to ground water.

The second strategy is to mitigate the threat to public health and the environment from contaminants that have already been mobilized—particularly through ground water pathways—before initiation of decommissioning activities. This strategy applies only to those sites where ground-water contamination already exists and requires staff to review existing or proposed ground-water restoration activities to ensure that they will result in compliance with regulatory requirements. The NRC exercises exclusive, pre-emptive jurisdiction over all radiological and non-radiological ground-water contaminants from uranium mill tailings facilities, in accordance with Commission direction in Staff Requirements Memorandum SECY 099-277 (NRC, 2000).

Use of this chapter should be tailored to the specific situation and phase of operation at each site. The reviewer will select and emphasize the various aspects of the areas covered by this standard review plan chapter. The judgment on the areas to be given attention during the review is to be based on the specific licensee submittal being reviewed, an inspection of the material presented, and prior knowledge of the site and its operating history.

This chapter presents a standard approach for reviewing, evaluating, and documenting the evaluation findings for issues pertaining to water resource protection during the various phases of the license termination process at licensed uranium mill sites. Review of information concerning the protection of water resources shall be coordinated with the evaluation of the site stratigraphy, structural and tectonic information, and surface water and erosion protection information as described in standard review plan Chapters 1.0 and 3.0, respectively. Review procedures in this chapter pertain to the following four types of documents that are submitted for review by the staff:

(1) Licensees submit reclamation plans to obtain approval of surface reclamation and decontamination work, including stabilization of mill tailings, and elimination (or isolation) of present or potential contaminant sources.

(2) Licensees submit corrective action plans during operations or during the license termination process to obtain approval of ground-water restoration strategies at sites where ground-water contamination has been detected.

(3) Licensees submit ground-water restoration completion reports to confirm that the ground-water quality will remain stable after ground-water restoration strategies have been implemented and that ground-water protection standards have been correctly established.

(4) Long-term custodians submit long-term surveillance plans to describe the ground-water monitoring activities that will be implemented by the custodian.

The ultimate objective of the review is to determine if the proposed reclamation plans and corrective action plans will result in long-term compliance with 10 CFR Part 40, Appendix A. As stated in 10 CFR Part 40, Criterion 5, “Criteria 5A-5D and new Criterion 13 incorporate the basic ground-water protection standards imposed by the Environmental Protection Agency in 40 CFR Part 192, Subparts D and E (48 FR 45926; October 7, 1983), which apply during operations and prior to the end of closure. Ground-water monitoring to comply with these standards is required by Criterion 7A.” To meet this regulatory objective, the following issues must be evaluated:

(1) Site characterization.

(2) Ground-water protection standards.

(3) Hazard and as low as is reasonably achievable assessment for alternate concentration limits, as defined by 10 CFR Part 40, Appendix A, Criteria 5B(5) and 5B(6).

(4) Ground-water corrective action and monitoring plans.

Accordingly, this chapter contains a section for each of these areas. Discussions in this chapter incorporate acceptable practices from all previous staff technical positions and guidance documents pertaining to uranium mill tailings reclamation. This standard review plan supercedes those documents. The NRC exercises exclusive jurisdiction over all radiological and non-radiological ground-water contaminants from uranium mill tailings facilities.

4.1 Site Characterization

4.1.1 Areas of Review

The staff should review the characterization information, given the circumstances and life cycle of a particular site, and the nature of the document under review (reclamation plan, corrective-action plan). The staff should also evaluate regional and site-specific hydrologic information related to both the former processing site and the proposed disposal site if they are different. The hydrologic information should include both surface-water and ground-water systems, along with any interrelations among those systems. Complete site characterization should include or reference the following:

(1) Site background data that include descriptions of:

    (a) The site history of mining and/or milling operations>

    (b) Surrounding land and water uses>

    (c) Site meteorological data.

(2) Ground-water and surface-water hydrology data, including:

  (a) Descriptions of hydrogeology and ground-water conditions.

  (b) Estimation of hydraulic and transport properties for each hydrogeologic unit.

  (c) Descriptions of surface-water hydrology and estimations of ground-water and surface-water interactions.

  (d) Assessment of potential for flooding and erosion.

(3) Information concerning geochemical conditions and water quality, including:

  (a) Identification of constituents of concern.

  (b) Determination of background ground-water quality.

  (c) Confirmation of proper statistical analysis.

  (d) Delineation of the nature and extent of contamination.

  (e) Identification of contaminant source terms.

  (f) Characterization of subsurface geochemical properties.

  (g) Identification of attenuation mechanisms and estimation of attenuation rates.

(4) Human health and environmental risk evaluations, including:

  (a) Radiological risks.

  (b) Non-radiological risks.

  (c) A summary of risk evaluations from the site environmental report.

4.1.2 Review Procedures

The level of effort necessary to adequately characterize a particular site depends on site-specific circumstances. For example, if a particular site has no ground-water contamination and tailings are disposed off site, there will be very little need for detailed site characterization in support of water resources protection. Conversely, at a site with an existing source of ground-water contamination, the site characterization must be sufficient to support selection of cleanup strategies and to determine the level of risk to human health and the environment.

There is not a single acceptable approach to conducting a site characterization, because the appropriate level of site characterization is specific to the methods of tailings disposal and ground-water corrective action selected for a particular site. As such, the reviewer should:

(1) Thoroughly evaluate the characterization information using the acceptance criteria in standard review plan Section 4.1.3, but reserve final judgment until all sections of the application have been reviewed.

(2) Assess whether the level of detail and technical merit of the characterization are sufficient to support the proposals, assumptions, and assertions in the application that are used to demonstrate regulatory compliance.

4.1.3 Acceptance Criteria

Knowledge of the site is needed to evaluate the existing and potential contamination. This characterization information shall include a description of activities and physical properties that may affect water resources at the mill site. The site characterization will be acceptable if it meets the following criteria:

(1) It contains a description of the site that is sufficient to assess the environmental impact the former mill site may have on the surrounding area; the populations that may be affected by such impacts; and meteorological conditions that may act to transport contaminants off site. An acceptable site description will contain the following specific information:

- (a) A site history that includes:

  - (i) A list of the known leaching solutions and other chemicals used in the milling process and their relative quantities in mill wastes. The list should also identify any constituent listed in 10 CFR Part 40, Appendix A, Criterion 13, that may have been disposed of in the tailings pile.

  - (ii) A description of the wastes generated at the site during milling operations, waste discharge locations, types of retaining structures used (e.g., tailings piles, ponds, landfills), quantities of waste generated, and a chronology of waste management practices.

  - (iii) A summary of the known impacts of the site activities on the hydrologic system and background water quality.

  - (iv) If applicable, descriptions of any human activities or natural processes unrelated to the milling operation that may have altered the hydrogeologic system. Such human activities include ground-water use, crop irrigation, mine dewatering, ore storage, municipal waste land filling, oil and gas development, or exploratory drilling. Natural processes include geothermal springs, natural concentration of soluble salts by evaporation, erosion processes, and ground-water/surface-water interactions.

(b) Information pertaining to surrounding land and water uses that includes:

(i) A general overview of water uses, locations, quantities of water available, and the potential uses to which the quality of water is suited>

(ii) Definitions of the class-of-use category for each water source (e.g., drinking water, agricultural, livestock, limited use).

(iii) Identification of potential receptors of present or future ground-water or surface-water contamination.

(iv) Descriptions of non-mill-related human activities or natural processes that may affect water quality or water uses (e.g., oil and gas development, municipal waste landfills, crop irrigation, drought, and erosion).

Human water consumption is not the only water use that must be considered in the review. Any use that may bring someone into contact with the contaminated water must be considered when evaluating health hazards. For example, non-potable, radon-contaminated water piped to a public lavatory could pose a substantial health hazard.

(c) Sufficient meteorologic data for the region, including rainfall, temperature, humidity and evaporation data in sufficient detail to assess projected water infiltration through the disposal cell.

Monthly averages are an acceptable means of presenting general meteorological conditions; however, the reviewer shall ensure that extreme weather conditions are adequately described.

(2) The ground-water and surface-water hydrology is described adequately to support modeling predictions of likely contaminant migration paths; selection of monitor well locations; and, when ground-water contamination exists, selection of a restoration strategy. The following specific information is provided to support these objectives:

(a) A description of hydrogeologic units that may affect transport of contaminants away from the site via ground-water pathways, including:

(i) Hydrostratigraphic cross sections and maps are included to delineate the geometry, lateral extent, thickness, and rock or sediment type of all potentially affected aquifers and confining zones beneath the processing and disposal sites of such quality and quantity to support a technically defensible interpretation.

(ii) The hydrogeologic units that constitute the uppermost aquifer (where regulatory compliance will be evaluated) are identified. The uppermost aquifer is the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility property boundary.

(iii) If local perched aquifers are found at the site, their presence is noted. These formations may cause contaminated water to be diverted around monitoring systems, or may be improperly interpreted as the uppermost aquifer. Any saturated zone created by uranium or thorium recovery operations would not be considered an aquifer unless the zone is or potentially is (1) hydraulically interconnected to a natural aquifer, (2) capable of discharge to surface water, or (3) reasonably accessible because of migration beyond the vertical projection of the boundary of the land transferred for long-term government ownership and care in accordance with 10 CFR Part 40, Appendix A, Criterion 11.

(iv) Unsaturated zones, through which contaminants may be conveyed to the water-bearing units, are described. This information is adequate to support the assumptions used in estimating the source term for contaminant transport pathways. This information includes identification of potential preferential flow pathways that are either natural (e.g., buried stream channels), or man-made (e.g., abandoned wells or mine shafts).

(v) Information is presented on geologic characteristics that may affect ground-water flow beneath the former mill site. Examples of pertinent geologic characteristics include identification of significant faulting in the area, fracture and joint orientation and spacing for the underlying bedrock, and geomorphology of soil and sedimentary deposits (e.g., fluvial, glacial, or volcanic deposits).

(vi) Hydraulic-head contour maps, of both local and regional scale, for the uppermost aquifer and any units connected hydraulically beneath the site are sufficient to determine hydraulic gradients, ground-water flow direction, and proximity to offsite ground-water users. These maps are based on static water level observations at onsite and regional wells. Several measurements are taken at each observation well (American Society for Testing and Materials Standards D 4750, D 5092, D 5521, D 5787, and D 5978). These measurements are sufficiently spaced in time to capture water-level fluctuations caused by seasonal changes or local pumping of ground water. Enough observation wells are sampled to produce an adequate water elevation contour map. The appropriate number of wells is dependent on the size of the site and the choice of contour interval. However, as a rough estimate, there is at least one observation well for each contour line on the map. A more detailed contour map (small contour interval) is produced for the site and surrounding properties. The level of detail used for the regional contour map may be limited by the number of observation wells available offsite. The reviewer shall bear in mind that calculations of hydraulic gradients from hydraulic head contour maps are only rigorously valid for horizontal flow in aquifers.

(b) Estimations of hydraulic and transport properties of the underlying aquifer

Hydrogeologic parameters used to support the choice of a ground-water restoration strategy or to demonstrate compliance include hydraulic conductivity, saturated thickness of hydro geologic units, hydraulic gradient, effective porosity, storage coefficient, and dispersivity. The reviewer shall consider the influence of each of these parameters on evaluating compliance with standards established pursuant to 10 CFR Part 40, Appendix A, and determine whether estimates for each parameter are reasonably conservative, based on the data provided.

(i) Hydraulic conductivity and storage coefficients are determined by conducting aquifer pump tests on several wells at the site. Pump test methods that are consistent with American Society for Testing and Materials standards for the measurement of geotechnical properties and for aquifer hydraulic tests are considered acceptable by the NRC. These American Society for Testing and Materials Standards are D 4044, D 4050, D 4104, D 4105, D 4106, D 4630, D 5269, D 5270, D 5472, D 5473, D 5737, D 5785, D 5786, D 5850, D 5855, D 5881, and D 5912. Any other peer-reviewed method or commonly accepted practice for aquifer parameter estimation may be used. When curve fitting is used to analyze pump test data, deviations of observation data from ideal curves are explained in terms of likely causes (e.g., impermeable or recharge boundaries, leaky aquitards, or heterogeneities). When average hydraulic parameters are reported, the reviewer shall consider that many hydrogeologic parameters, including hydraulic conductivity, typically exhibit a log-normal distribution. Consequently, the geometric mean may be more representative of the overall conditions within a unit than the arithmetic mean.

(ii) Horizontal components of hydraulic gradient are estimated by measurement of the distance between contour intervals on hydraulic head contour maps. Vertical components of hydraulic gradient are estimated from head measurements in different aquifers or at different depths in the same aquifer.

(iii) Generally, analyses considering steady-state conditions are acceptable unless site conditions indicate otherwise. If transient conditions are modeled, storage coefficients estimated from standard tests indicated in (i) above are used.

(iv) If contaminant transport is modeled, then longitudinal and transverse dispersivity values are either obtained from a tracer test or conservative values based on published literature are used. Because dispersivities depend on the size of the modeled region, the reviewer shall carefully compare the values for dispersivity used in the licensee transport modeling with those values cited in survey studies such as Gelhar, et al. (1992), and verify that they represent conservative estimates for the site.

(c) Estimation of ground-water/surface-water interactions at sites with nearby streams, rivers, or lakes.

The locations of surface-water bodies that are connected to the site ground-water flow system are identified. Surface-water elevations shall be used to help describe the site ground-water flow system if a stream or other surface-water body discharges into or drains the site ground-water flow system. Another acceptable approach is to evaluate hydraulic head contour based on data from monitor wells in the vicinity of streams.

(3) Geochemical conditions and water quality are characterized sufficiently to:

(a) Identify the constituents of concern.

Any chemical or radiological constituent that is reasonably expected to be in or derived from the tailings is a potential constituent of concern. 10 CFR Part 40, Appendix A, Criterion 13 provides a non-inclusive list of constituents of concern which standards must be set and complied with. Criterion 13 also provides flexibility to add constituents on a case-by-case basis.

Table 4.1.3-1 presents a list of constituents commonly associated with uranium mill tailings.[1] This list is based on a chemical survey performed by NRC staff at 17 licensed mill tailings sites.

Most of the constituents in 10 CFR Part 40, Appendix A, Criterion 13 are organic compounds that are not normally associated with uranium milling processes. The expected presence of organic compounds is assessed from knowledge of the chemicals used during the milling process or other materials that may have been disposed of in the tailings. If there is no record of organic compounds used in the process, screening tests for volatile and semi-volatile organic compounds are performed to confirm the absence of organic compounds in the tailings and ground water.

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[1]Smith, R.D. “Memorandum (February 9) Sampling of Uranium Mill Tailings Impoundments for Hazardous Constituents.” 1987.

Table 4.1.3-1. Common Uranium Mill Chemical Constituents

Inorganic Constituents	Organic Constituents
Arsenic	Carbon Disulfide
Barium	Chloroform
Beryllium	Diethyl Phthalate
Cadmium	2—Butanone
Chromium	1,2—Dichloroethane
Cyanide	Naphthalene
Lead	
Mercury	
Molybdenum	
Net Gross Alpha*	
Nickel	
Radium-226 and -228	
Selenium	
Silver	
Thorium-230	
Uranium	
* Excluding Radon, Radium, and Uranium	

Staff may require the addition of constituents associated with the milling process that are not specifically listed in 10 CFR Part 40, Appendix A, Criterion 13, to ground-water monitoring programs. These constituents may be added on a case-by-case basis, if they are capable of posing a substantial present or potential hazard to human health or the environment. If the staff requires a constituent to be added to the list in Criterion 13, the NRC must establish an associated compliance limit for each added constituent at a level that will be protective of human health and the environment.

Some constituents which typically do not present a hazard to human heath and the environment may pose such a hazard to some specific human or environmental populations, under site-specific circumstances. As an example, three constituents associated with uranium mill tailings may be candidates for site-specific evaluations during licensing reviews and potential NRC regulation on a case-by-case basis, under specific circumstances. Illustrative constituents, circumstances, and potential harm are tabulated in Table 4.1.3-2.

The above examples are not all inclusive. The reviewer should examine these and other constituents that produce similar potential harm under specific circumstances. Non-radiological constituents that degrade the water quality and produce and impact on the designated water use beyond the proposed long-term

Table 4.1.3-2. Non-Radiological Ground-Water Constituents That May Produce Harm

Constituent	Exposure Circumstance	Potential Harm
Sodium	Drinking water pathway, human exposure	Some segments of the human population with elevated blood pressure may be sensitive to sodium intake above a recommended limit. The EPA added sodium to its Drinking Water Contaminant Candidate List for further evaluation.
Sulfate	Drinking water pathway, human exposure	Some segments of the human population are sensitive to elevated sulfate in drinking water, which can produce osmotic diarrhea. The EPA added sulfate to its Drinking Water Contaminant Candidate List for further evaluation.
Ammonia, Ammonium ion	Surface water pathway, aquatic organism exposure	Various aquatic species are sensitive to ammonia levels as low as 0.38 mg/L. These levels are far lower than exposure limits that would produce an adverse impact to human populations.

The above examples are not all-inclusive. The reviewer should examine these and other constituents that produce similar potential harm under specific circumstances. Non-radiological constituents that degrade the water quality and produce and impact on the designated water use beyond the proposed long-term care boundary must also be evaluated to determine whether they should be included in the license. The reviewer should consult with the appropriate non-Agreement State agency on the designated water use for the ground-water resource an any numerical limits the State has determined to be a hazard.

Close coordination with the State may be needed to determine the need for including such constituents in the license, along with evaluating the benefits and costs of potential mitigative measures.

In identifying additional constituents, the staff should ensure that any additions are made based on a sound technical and regulatory basis. Examples of sound technical bases are the following:

(1) NRC and the U.S. Environmental Protection Agency agree to use one federal contact with a licensee, which is NRC. This approach requires NRC to include some constituents in its licenses, that are not normally licensed by the NRC.

(2) Trends in ground-water contamination show that after several years of decreases in the level of contamination, the level of contamination is beginning to rise again.

(3)Surrogate parameters that cover a family of constituents show an increase in concentration in ground water. Therefore, the staff may require licensees to monitor for all constituents found in that family.

(4) Some constituents used in the milling process, but not listed in Criterion 13, may pose a hazard to some specific human and environmentally sensitive populations, under site-specific circumstances, including degradation of a designated water use beyond the proposed long-term care boundary.

Even if the criteria for identifying a constituent of concern are met, NRC may still decide to exclude certain constituents on a site-specific basis if it can be shown that the constituents are not capable of posing a substantial present or potential hazard to human health or the environment. In considering such exclusions, the reviewer must consider potential adverse effects on ground-water quality and hydraulically connected surface-water quality. NRC may decide to exclude a constituent if the dissolved concentration of the constituent in the tailing fluids is equal to or less than the concentration of that constituent in the background water quality. Alternately, NRC may decide to exclude a constituent if the dissolved concentration of the constituent in the tailing fluids is equal to or less than the maximum value for ground-water protection listed in 10 CFR Part 40, Appendix A, Table 5C.

New constituents of concern should be added in a timely manner. This is done either at the time the corrective action plan is accepted for review, or at some time during the lifetime of the corrective action plan. New constituents will not be required at the time of the license termination monitoring submittal, unless the one-time, pre-termination ground-water sampling identifies constituents at concentrations that pose a hazard to human health and the environment. The reviewer should consult Appendix E (Section E3.3.2(1)) for those sites nearing license termination, regarding the one-time, pre-termination ground-water sampling and analysis.

(b) Present a determination of background (baseline) water quality.

Background water quality is defined as the chemical quality of water that would be expected at a site if contamination had not occurred from the uranium milling operation.

Water quality data available from studies conducted in conjunction with initial licensing for operation of the facility are used to establish the background. If constituents of concern identified by NRC were not sampled in the original background monitoring program, the licensee should have conducted additional sampling to establish background levels. When adequate site-specific baseline data cannot be obtained for identified constituents of concern, samples of adjacent, and up-gradient, uncontaminated water are taken as proxies to onsite baseline samples.

To determine acceptability of the determination of background water quality, the following information is provided:

(i) Maps are of sufficient detail and legibility to show the background monitoring locations.

(ii) Descriptions of sampling methods, monitoring devices, and quality assurance practices are provided. Examples of acceptable methods are those that are consistent with American Society for Testing and Materials Standards D 4448, D 4696, and D 4840. Other methods, if used, are properly referenced and justified.

(iii) When they exist, zones of differing background water quality are delineated. The possible causes of these differing water quality zones are discussed (e.g., changes from geochemically oxidizing to reducing zones in the aquifer; changes in rock type across a fault boundary).

(iv) A table for each zone of distinct water quality, listing summary statistics (i.e., mean, standard deviation, and number of samples) for baseline water quality sampling for each constituent of concern, is provided.

(v) A pre-operational monitoring program has been in place for 1 year, consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 7. Samples are taken at least monthly under this program. However, it is unlikely that mills in existence prior to the ground-water compliance provisions of 10 CFR Part 40, Appendix A, will have one full year of monthly baseline data from a pre-operational monitoring program.

Alternatively, background water quality may already be defined by a condition in the license. If this is the case, background limits for a ground-water protection standard have already been identified, and the reviewer should rely on those along with any constituents and standards listed in Criterion 5(c) as the regulatory limits applicable to this site.

(c) Confirm the proper use of statistical techniques for assessing water quality.

Statistical hypothesis testing methods used for (i) establishing background water quality; (ii) establishing ground-water protection standards for compliance monitoring; (iii) determining the extent of ground-water contamination; and (iv) establishing the ground-water cleanup goals, are described in American Society for Testing and Materials Standard D 6312.

(d) Define the extent of contamination.

A hazardous constituent is defined in 10 CFR Part 40, Appendix A, Criterion 5B(2), as a constituent that meets all three of the following tests:

(i) The constituent is reasonably expected to be in or derived from the byproduct material in the disposal area.

(ii) The constituent has been detected in the ground water in the uppermost aquifer.

(iii) The constituent is listed in Part 40, Appendix A, Criterion 13.[2]

For each hazardous constituent, the licensee determines the extent of contamination in ground water at the site. Ground-water contamination at uranium mill sites is usually limited to the uppermost aquifer. Maps showing the locations of sampling wells should be included, along with a discussion of sampling practices. The most useful way to present this information is on a map showing concentration contours for each hazardous constituent and water surface elevation contours. In this manner, the reviewer readily examines the size, shape, source, and direction of movement.

[2]Including a constituent which may pose a hazard to some specific human or environmentally sensitive populations, under site-specific circumstances, and can, therefore, be added to the list in Criterion 13 on a case-by-case basis.

The extent of contamination is delineated in three dimensions. This typically involves drilling a number of characterization wells and determining whether the water quality in each of these wells meets background water quality or whether the ground water is contaminated. It may not be necessary to sample all hazardous constituents to delineate the extent of contamination. Two or three indicator parameters (e.g., total dissolved solids, and chloride) might be selected. These indicators should be conservative—meaning that they are neither reactive, nor are they easily sorbed to soil—so that they provide a good indication of the maximum extent of contamination.

The transition from contaminated to uncontaminated ground water is often gradual. Thus, difficulty arises in determining where the contaminated water ends and the background water begins. The background sample data provide the easiest means for comparison of characterization well measurements to background measurements for the indicator parameters. Statistical methods described in American Society for Testing and Materials Standard D 6312 are suitable for determining whether contaminant concentrations exceed background levels.

Complications in delineating the extent of contamination arise at sites that have zones of differing water quality, or where onsite background water quality is not properly determined before discovery of ground-water contamination. Where zones of differing water quality are present, the reviewer shall verify that characterization wells are compared with the background sample from the appropriate water quality zone. Where onsite background water quality has not been properly determined, then upgradient or offsite samples are obtained.

The reviewer shall verify that the licensee has presented the following information to support determining the extent of contamination.

(i) A map or maps showing the distribution of surface wastes and contaminated materials at and near the site.

(ii) A map or maps showing the approximate shape and extent of ground-water contamination (e.g., concentration contour maps for indicator parameters in ground water).

(iii) Identification of any offsite sources of water contamination or other factors that may have a bearing on observed water quality.

(e) Properly estimate the source term.

Existing sources of ground-water contamination are defined in terms of location and rate of entry into the subsurface. At some sites, the contaminant sources have been effectively eliminated through stabilization or removal of tailings piles. However, residual sources may still exist in contaminated subsurface soils at the site. For ground-water contamination that originates from an onsite tailings pile, the source term is determined based on the chemical properties of the leachate and the rate at which leachate is released from the disposal area. The level of review given to source term calculations is commensurate with the overall importance of source term estimations to the selection of the restoration strategy.

(i) Source terms are reasonably correlated to the history of ore processing. All facilities from which leakage can occur are identified. Leaking constituents are identified based on the nature of the processing fluids. The volume of leakage is estimated in a realistic yet conservative manner. This can be done using water balance calculations, infiltration modeling, or seepage monitoring approaches.

(ii) When geochemical models are used to predict the fate and transport of existing contamination where the original source has been eliminated, the distribution of each hazardous constituent in place is taken as the source term.

(f) Characterize the subsurface geochemical properties.

To effectively model the fate and transport of contaminants in ground water, it is important to characterize the geochemical properties of the natural waters and the aquifer mineralogy. Characterization of the underlying lithologies includes measurements of buffering capacity, total organic carbon, cation exchange capacity, and identification of the clay mineralogy. The general chemical characteristics of fluids within the lithologies are described by measurements of pH, temperature, dissolved oxygen, redox potential, buffering capacity, and the concentrations of major ions and trace metals.

(i) Aquifer geochemistry data are adequate to model the attenuation of contaminants. The values of the geochemical parameters used in transport models are justified. Acceptable parameter estimation methods are direct measurement, use of a conservative bounding estimate, reference to literature values for similar aquifer conditions, and laboratory studies of aquifer materials.

(g) Identify contaminant attenuation mechanisms.

The major attenuation mechanisms that work to mitigate the effects of ground-water contamination are dilution in surrounding ground water, sorption of contaminants to the soil matrix, and immobilization of contaminants from geochemical and biochemical reactions.

(i) Claims that contamination is reduced by dilution are supported by a sufficient technical basis. There are two mechanisms for dilution of a contaminant plume in ground water: dispersion and mixing. Dispersion is a process whereby contaminant plumes tend to spread out and become less concentrated as they move away from the source. Mixing is the result of uncontaminated water being added to the ground-water system through natural recharge, injection, or upward movement of water from underlying aquifers, which reduces the concentration of contaminants. Estimation of surface recharge or upward flow through leaky aquitards is either established from field measurements, or through use of conservative assumptions are used.

(ii) The values of sorption coefficients are based on the nature of the constituent and site-specific geochemical conditions. The degree of sorption of contaminants to the soil matrix depends on the affinity of each constituent for the soil in a particular aquifer. Constituents that carry a positive charge, as do most trace metals in solution, are good candidates for cation exchange adsorption to clay and oxide surfaces. However, because surface charges of clays and oxides decrease with decreasing pH, the reviewer shall carefully examine claims of attenuation from cation exchange under low pH conditions. Organic contaminants tend to be hydrophobic and are strongly attenuated in soils that have high organic carbon content. Most contaminant fate and transport models quantify the affinity of contaminants for soil by use of a distribution coefficient or K_D. Batch or column equilibria experiments, using representative leachate and soil samples, are performed to support estimations of K_D for each hazardous constituent.

(iii) Attenuation from geochemical or biochemical equilibrium reactions is estimated by use of acceptable modeling software packages such as MINTEQA2 (Allison, et al., 1991) and PHREEQE (Parkhurst, et al., 1980). However, these packages are limited in that they do not consider transport of contaminants. Thus, results are only valid for reactions within a confined space (e.g., within the disposal cell). More recently developed reactive transport models [e.g., PHREEQC Version 2 (Parkhurst and Appello, 1999)] are also acceptable for constructing a geochemical model for the site. The reviewer shall determine that all model input parameters have sufficient technical bases and represent reasonably conservative estimations. Additionally, conclusions drawn from such models are supported by field observation; that is, they are consistent with site characterization data.

(iv) At sites from which the contamination source has been effectively eliminated, monitoring data are used to assess attenuation of contaminants. If the contaminant source has been eliminated by surface reclamation, changes in the nature and extent of contamination over time are monitored. In such situations the center of mass of the contaminant plume moves along the direction of ground-water flow. The effects of dispersion are also observable over time as a decrease in peak concentrations near the center of the contaminant plume and a lateral spreading of the plume. If significant precipitation or adsorption is occurring, it is reflected in a decrease in the mass of contaminants in the aqueous phase.

4.1.4 Evaluation Findings

If the staff review, as described in standard review plan Section 4.1, results in the acceptance of the site characterization, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the site characterization at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.1.2 and the acceptance criteria outlined in Section 4.1.3 of this standard review plan.

The licensee has presented an acceptable history of the site, including (1) a description of leaching solutions and other chemicals used in the process and their relative quantities; (2) a description of (a) the wastes generated at the site during the milling process, and (b) the waste handling facilities; (3) a summary of the known impact of site activities on the hydrologic system and water quality; and (4) a description of activities unrelated to uranium milling that may have altered the hydrologic system.

The licensee has presented acceptable information pertaining to the surrounding land and water use including (1) an overview of water uses, quantity available, and potential uses to which the water is suited; (2) definitions of the class-of-use category of each water source; (3) identification of potential receptors of ground-water or surface-water contamination; (4) assessment of variations in dilution effects of stream flow on contaminants; and (5) assessments of the effects of meteorological conditions on erosion, infiltration, and water-table elevation.

The licensee has presented acceptable meteorologic data, including (1) wind speed and direction, (2) rainfall, (3) evaporation data (4) temperature, and (5) humidity, to allow an evaluation of potential impacts of the meteorologic conditions on disposal cell performance.

The ground-water and surface-water hydrology is adequately described, including (1) geometry, lateral extent, and thickness of potentially affected aquifers and confining units; (2) a determination of which aquifers constitute the uppermost aquifer where regulatory compliance will be evaluated; (3) descriptions of the unsaturated units that convey hazardous constituents to the water-bearing units; (4) maps of acceptable detail showing the relative dimensions and locations of hydrogeologic units that have been impacted by milling activities; (5) information on geologic characteristics that may affect ground-water flow beneath the site; and (6) hydraulic head contour maps of both local and regional scale for the uppermost aquifer beneath the site.

The estimation of hydraulic and transport properties is acceptable and includes (1) hydraulic conductivity and storage coefficients determined by conducting aquifer pump tests on several wells; (2) determination of hydraulic gradients using hydraulic head contour maps; (3) calculations of storage coefficients, as applicable; and (4) longitudinal and transverse dispersivities, as appropriate. The evaluation of ground-water/surface-water interactions with nearby streams, rivers, or lakes is acceptable.

Geochemical conditions and water quality are adequately analyzed, including identification of constituents of concern that are reasonably expected to be derived from the tailings. Each constituent of concern is found in 10 CFR Part 40, Appendix A, Table 5C or 10 CFR Part 40,

Appendix A, Criterion 13, or has been included as a specific condition in the license. The licensee has made an acceptable determination of baseline water quality, including (1) maps of appropriate scale and legibility; (2) descriptions of sampling methods, monitoring devices, and quality assurance practices; (3) where applicable, delineation of zones of differing water quality and their possible origin; and (4) a table of summary statistics for each zone of differing quality. The applicant has presented an acceptable delineation of the extent of contamination supported by appropriate samples, maps of surface wastes and contaminated materials, maps of the approximate shape and extent of ground-water contamination, and identification of any off-site sources of water contamination. The description of the source term is acceptable and includes not only mill tailings constituents but those contaminants that might mobilize by contact with tailings leachate.

The characterization of the subsurface geochemical properties is acceptable. Attenuation mechanisms have been described, including the technical bases for determining that contamination will be reduced by dilution, sorption on the soil matrix, or geochemical or biochemical reactions. The licensee has presented direct measurements in support of attenuation of contaminants where the source has been eliminated by surface reclamation.

On the basis of the information presented in the application and the detailed review conducted of the site characterization for the _______________ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 5B, which requires the NRC to establish a list of hazardous constituents, concentration limits, a point of compliance, and a compliance period; Criterion 5C, which provides a table of concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5E, which requires licensees conducting ground-water protection programs to consider the use of bottom liners, recycle of solutions and conservation of water, dewatering of tailings, and neutralization to immobilize hazardous constituents; Criterion 5F, which requires that, where ground-water impacts caused by seepage are occurring at an existing site, action be taken to alleviate the conditions that lead to seepage and restore ground-water quality. Technical specifications for the seepage control system must be established, and a quality assurance, testing and inspection program must be established to insure the specifications are met. Criterion 5G, which requires that licensees/operators perform site characterization in support of a tailings disposal system proposal; Criterion 5H, which requires steps be taken during stockpiling of ore to minimize penetration of radionuclides into underlying soils; Criterion 7 which requires a year of monitoring prior to mill operations; Criterion 7A, which requires three types of monitoring systems: detection, compliance, and corrective action; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

4.1.5 References

Allison, J.D., D.S. Brown, and K.J. Novo-Gradac. "MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual." EPA Publication EPA/600/3–91/021. Washington, DC: EPA. 1991.

American Society for Testing and Materials Standards:

D 4044, "Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers."

D 4050, "Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems."

D 4104, "Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)."

D 4105, "Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method."

D 4106, "Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method."

D 4448, "Standard Guide for Sampling Ground-water Monitoring Wells."

D 4630, "Standard Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by *In Situ* Measurements Using the Constant Head Injection Test."

D 4750, "Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)."

D 4840, "Standard Guide for Sampling Chain-of-Custody Procedures."

D 5092, "Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers."

D 5269, "Standard Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method."

D 5270-96, "Standard Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers."

D 5472, "Standard Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well."

D 5473, "Standard Test Method for (Analytical Procedure for) Analyzing the Effects of Partial Penetration of Control Well and Determining the Horizontal and Vertical Hydraulic Conductivity in a Nonleaky Confined Aquifer."

D 5521, "Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers."

D 5737, "Standard Guide for Methods for Measuring Well Discharge."

D 5785, "Standard Test Method for (Analytical Procedure for) Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)."

D 5786, "Standard Practice for (Field Procedure) for Constant Drawdown Tests in Flowing Wells for Determining Hydraulic Properties of Aquifer System."

D 5787, "Standard Practice for Monitoring Well Protection."

D 5850, "Standard Test Method for (Analytical Procedure for) Determining Transmissivity, Storage Coefficient, and Anisotropy Ratio from a Network of Partially Penetrating Wells."

D 5855, "Standard Test Method for (Analytical Procedure for) Determining Transmissivity and Storage Coefficient of a Confined Nonleaky or Leaky Aquifer by Constant Drawdown Method in a Flowing Well."

D 5881, "Standard Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug)."

D 5912, "Standard Test Method for (Analytical Procedure for) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug)."

D 5978, "Standard Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells."

D 6312, "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs."

Gelhar, L.W., C. Welty, and K.R. Rehfeldt. "A Critical Review of Data on Field-scale Dispersion in Aquifers." *Water Resources Research.* Vol. 28, No. 7. 1992.

NRC. "Concurrent Jurisdiction of Non-Radiological Hazards of Uranium Mill Tailings." Staff Requirements Memorandum to SECY–99–0277. Washington DC: NRC; Office of the Executive Director of Operations. August 11, 2000.

———. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC, Office of Nuclear Material Safety and Safeguards. 2001

Parkhurst, D.L. and A.A.J. Appello. "User's Guide to PHREEQC (Version 2)—A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Modeling." 99-4259. Washington, DC: U.S. Geological Survey. 1999.

Parkhurst, D.L., Thorstensen, and L.N. Plummer. "PHREEQEM-A Computer Program for Geochemical Calculations." U.S. Geological Survey Water Resources Investigation 80-96. 1980.

4.2 Ground-Water Protection Standards

4.2.1 Areas of Review

Ground-water protection standards are established for each hazardous constituent. A hazardous constituent is defined in 10 CFR Part 40, Appendix A, Criterion 5B(2), as a constituent that meets all three of the following tests:

(1) The constituent is reasonably expected to be in or derived from the byproduct material in the disposal area.

(2) The constituent has been detected in the ground water in the uppermost aquifer.

(3) The constituent is listed in 10 CFR Part 40, Appendix A, Criterion 13.

Even when constituents meet the three aforementioned tests, the Commission may exclude a detected constituent from the set of hazardous constituents, on a site-specific basis, if it finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. In deciding whether to exclude constituents, the considerations identified in 10 CFR Part 40, Appendix A, Criterion 5B(3), must be considered. In addition, as required by 10 CFR Part 40, Appendix A, Criterion 5B(4), any underground sources of drinking water and aquifers exempted by the EPA will be considered. Relevant EPA guidance is presented in 40 CFR 144.7, 144.3, and 146.4. The staff should review the technical basis the licensee has presented for the following elements of acceptable ground-water protection standards:

(1) The list of hazardous constituents.

(2) A description of the point of compliance.

(3) Ground-water protection standards for hazardous constituents that may be either:

(a) Commission-approved background concentrations.

(b) Maximum concentration limits.

(c) Alternate concentration limits.

The staff should also review additional ground-water protection standards that contain provisions for ground-water protection dealing with the design of surface impoundments and tailings disposal cells. Evaluation of disposal system performance is addressed in standard review plan Section 4.3.3.

4.2.2 Review Procedures

The reviewer should examine the ground-water protection standards to verify that they have been defined consistent with the acceptance criteria in standard review plan Section 4.3.2. Specifically, the reviewer should reference the existing license or:

(1) Verify that the licensee has identified all constituents of concern that are present in the tailings leachate.

(2) Verify that the point of compliance has been properly delineated.

(3) Evaluate whether the proposed concentration limits for each ground-water protection standard are within a range that is reasonably expected to represent background concentrations; or, if any alternate concentration limits are proposed, verify that the appropriate evaluations have been presented in accordance with Criterion 5(B)(6) of 10 CFR Part 40, Appendix A.

4.2.3 Acceptance Criteria

Ground-water protection standards establish a concentration limit for each hazardous constituent at the point of compliance. The development of ground-water protection standards will be acceptable if it meets the following criteria:

(1) Hazardous constituents are identified using the definition given in 10 CFR Part 40, Appendix A, Criterion 5(B).

(2) A point of compliance is established in accordance with 10 CFR Part 40, Appendix A, Criterion 5B(1).

The point of compliance is the location at which the ground water is monitored to determine compliance with the ground-water protection standards. The objective in selecting the point of compliance is to provide the earliest practicable warning that the impoundment is releasing hazardous constituents to the ground water. The point of compliance must be selected to provide prompt indication of ground-water contamination on the hydraulically downgradient edge of the disposal area. The point of compliance is defined as the intersection of a vertical plane with the uppermost aquifer at the hydraulically downgradient limit of the waste management area.

The “uppermost aquifer” is defined in 10 CFR Part 40, Appendix A, as “the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility’s property boundary.” Therefore, a proper selection of the point of compliance includes identification of point of compliance locations in the aquifer nearest to the ground surface, as well as other aquifers that are hydraulically interconnected with that aquifer, as warranted by site-specific conditions.

When tailings are disposed of on site, the NRC generally interprets the downgradient limit of the waste management area to be the edge of the reclaimed tailings side slopes. However, it is not recommended that licensees be required to compromise the cover integrity to install monitoring wells at the actual edge of the reclaimed tailings.

(3) A concentration limit is specified for each of the hazardous constituents. Those limits may be:

(a) Commission-Approved Background Concentrations.

10 CFR Part 40, Appendix A, requires that the Commission-approved background concentration be the concentration limit, except for constituents listed in Table 5C of 10 CFR Part 40, Appendix A, which, if present in excess of background, are subject to the respective maximum concentration limits listed in Table 5C.

Proper statistical methods, such as those discussed in American Society for Testing and Materials Standard D 6312, are used to determine the expected range of naturally occurring background (baseline) concentrations for each constituent of concern. Acceptable statistical techniques are also presented in Haan (1977) and Hirsch, et al. (1992).

(b) Maximum Concnetration Limits

The respective values given in the table in paragraph 5C of 10 CFR Part 40, Appendix A, must not exceed if the constituent is listed in the table and if the background level of the constituent is below the value listed. Note that the U.S. EPA has revised some of these limits under the Safe Drinking Water Act, therefore, for risk assessments used for an alternate concentration limit proposal, where a drinking water exposure pathway is estimated, the reviewer should refer to the most recent Safe Drinking Water Act maximum concentration limits.

(c) Alternate Concentration Limits

Alternate concentration limits are established on a site-specific basis, provided it can be demonstrated that (i) the constituents will not pose a substantial present or potential hazard to human health or the environment, as long as the alternate concentration limits are not exceeded and (ii) the alternate concentration limits are as low as is reasonably achievable, considering practicable corrective actions. Licensees are required to implement detection monitoring programs to detect and identify site-specific hazardous constituents, and compliance monitoring programs to verify compliance with the established site-specific standards for individual constituents. Standard review plan Sections 4.3.3 and 4.4.3 contain acceptance criteria for determining potential hazards, and for "as low as is reasonably achievable" demonstrations, respectively.

When an applicant proposes alternate concentration limits, the reviewer should recognize that additional site characterization may be necessary to demonstrate the potential risk to human health and the environment is acceptable. Typically, long-term ground-water monitoring will be required to assure that human health and the environment are protected.

4.2.4 Evaluation Findings

If the staff review, as described in standard review plan Section 4.2, results in the acceptance of the site ground-water protection standards, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the ground-water protection standards at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.2.2 and the acceptance criteria outlined in Section 4.2.3 of this standard review plan.

The licensee has acceptably identified the hazardous constituents and has established acceptable concentration limits and cleanup standards. Established background levels are acceptable. Acceptable statistical methods have been used to establish the concentration limits. If alternate concentration limits have been requested, the licensee has acceptably supported the request with appropriate data and calculations. The licensee has established an acceptable point of compliance at the edge of the tailings impoundment on the downgradient direction of hydraulic flow.

On the basis of the information presented in the application and the detailed review conducted of the ground-water protection standards for the _______________ uranium milling facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 5B, which requires the NRC to establish a list of hazardous constituents, concentration limits, a point of compliance, and a compliance period and, which allows use of alternate concentration limits under certain conditions; Criterion 5C, which provides a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 7A, which requires three types of monitoring systems: detection, compliance, and corrective action; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

4.2.5 References

American Society for Testing and Materials Standards

D 6312, “Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs.”

Haan, C.T. *Statistical Methods in Hydrology*. Iowa State University Press. 1977.

Hirsch, R.M., D.R. Helsel, T.A. Cohn, and E.J. Gilroy. *Statistical Analysis of Hydrologic Data, Handbook of Hydrology.* D.R. Maidment, ed. New York, New York: McGraw-Hill, Inc. 1992.

4.3 Hazard Assessment, Exposure Assessment, Corrective Action Assessment, and Compliance Monitoring for Alternate Concentration Limits

4.3.1 Areas of Review

The staff shall review the following elements of an alternate concentration limit application to determine regulatory compliance with 10 CFR Part 40, Appendix A, Criterion 5B(6):

(1) Hazardous constituent(s) and the associated human and environmental risks of those constituent(s), including human cancer risk and environmental hazards. Characterization of the hazardous constituent source term and the extent of ground-water contamination.

(2) Assessment of hazardous constituent transport in the ground water and hydraulically connected surface waters, and its adverse effects on water quality, including present and potential health and environmental consequences of exposure to the identified hazards.

(3) A demonstration that a hazardous constituent concentration will not pose substantial present or potential hazard to human health or the environment at the point of exposure, and that the proposed alternate concentration limit is as low as is reasonably achievable, considering practicable corrective actions.

In addition, the implementation of the proposed alternate concentration limit and any modifications to the compliance monitoring program must be reviewed.

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.3.2 Review Procedures

Appendix K provides a description of a standardized content and format for an alternate concentration limit application. Strict conformance with the standard format is not a requirement, but review effectiveness and efficiency should be enhanced through its use. The proposed alternate concentration limit should be supported by a hazard assessment, an exposure assessment, and a corrective action assessment. Although separately listed, the information contained within each assessment should be integrated with the information that is developed in the subsequent assessment, so that all three assessments will collectively support the proposed alternate concentration limit. Appropriate portions of standard review plan Section 4.1 should also be consulted when performing a review of an alternate concentration limit application. The reviewer shall examine the provided information and assessments to determine that:

(1) The source term has been adequately characterized to provide a realistic estimate of the types, characteristics, and the release rates of constituents of concern, which have been, or are expected to be, released to the ground water.

(2) The risks and hazards that the released or potentially mobile constituents of concern may have on human health and the environment have been identified.

(3) The extent of existing and potential ground-water contamination from the source term has been defined. The rates and directions of hazardous constituent migration and transport in the ground water and hydraulically connected surface waters have been determined. The point of compliance and point of exposure are identified.

(4) The pathways for human and environmental exposure to the hazardous constituent(s) have been identified, and exposure magnitudes and consequences, including the human cancer risk, have been acceptably evaluated.

(5) The proposed alternate concentration limit(s) for the point of compliance will result in a hazardous constituent concentration that is protective of human health and the environment at the point of exposure. The attenuation capacity of the aquifer between the point of compliance and the point of exposure has been adequately considered. There will be no adverse effects on the ground-water or on surface-water quality that would cause unacceptable health or environmental hazards at or beyond the point of exposure.

The applicant’s assessment of ground-water corrective action alternatives shall be reviewed in conjunction with the hazard and exposure assessments. Previous, current, and potential future practicable corrective actions shall be evaluated against the costs and benefits of those actions to determine if the proposed alternate concentration limit is as low as is reasonably achievable. This demonstration should identify alternate corrective actions; assess their technical feasibility for implementation, and evaluate all associated costs and benefits of those corrective actions.

An alternate concentration limit must be protective of human health and the environment at the point of exposure, which is any location at or beyond the long-term care site boundary. A proposed alternate concentration limit that is not protective of human health and the environment, by itself, will not comply with the regulatory requirements for an alternate concentration limit. In this instance the applicant must submit the proposed numerical limit and any additional measures to protect human health and the environment to the Commission as an alternative to the specific requirements of 10 CFR Part 40, Appendix A, Criterion 5B (6), as permitted by section 84(c) of the Atomic Energy Act of 1954, as amended. The NRC staff will evaluate these alternatives on a case-by-case basis and determine the acceptability of the proposed alternative. A proposed alternate concentration limit that is not protective of human health and the environment and does not include additional alternate measures to provide such protection is not acceptable.

If the proposed alternate concentration limit is found acceptable, the compliance monitoring program must be evaluated before the license is terminated to determine that it is properly designed and implemented to ensure ground-water constituent concentrations in excess of the approved alternate concentration limit will be detected and that human health and the environment will be protected. Standard review plan Section 4.4 should be consulted.

4.3.3 Acceptance Criteria

The hazard assessment, exposure assessment, and corrective action assessment supporting a proposed alternate concentration limit will be acceptable if they meet the following criteria:

4.3.3.1 Hazard Assessment

The hazard assessment identifies all potential constituents of concern at a site. A potential constituent of concern is any compound that may be in or could be derived from the uranium mill tailings at a licensed site. A non-inclusive list of constituents of concern is in 10 CFR Part 40, Appendix A, Criterion 13. The risks and hazards to human health and the environment associated with those constituents are also identified and evaluated to determine whether an alternate concentration limit should be proposed for those constituents, if the subsequent exposure assessment concludes that an exposure is reasonably likely. Once a constituent of concern is released into the ground-water, it is classified as a hazardous constituent for the purpose of regulatory compliance, as described in 10 CFR Part 40, Appendix A, Criterion 5B(2). The hazard assessment should include the following:

(1) The source term for all constituents of concern is adequately characterized and the extent of existing and potential future ground-water contamination is determined.

    The source term characterization provides relevant information about the facility including: (a) the mechanical and chemical processes used to recover the uranium, (b) the types and quantities of the reagents used in milling, (c) the physical and chemical composition of the uranium-bearing ore, and (d) the historical and current waste and tailings management practices. This information is considered, in conjunction with the physical and chemical composition of the tailings and the type and distribution of existing contaminants, such as the location of waste discharge points, retaining structures for wastes, and waste constituents. The source characterization should provide reliable estimates of the release rates of hazardous constituents as well as constituent distributions.

(2) The assessment identifies and evaluates the risks and hazards presented by the identified constituents of concern, including the human cancer risk caused by exposure to radioactive and non-radioactive constituents of concern, along with other health hazards that may be caused by the chemical toxicity of those constituents. The human cancer risk should be evaluated for individual constituents, including radioactive and carcinogenic chemicals, and compared with the maximum permitted risk level. The health effects of non-radioactive and non-carcinogenic constituents that are chemically toxic will be evaluated considering their risk-specific dose levels. It may be necessary to calculate a hazard index using the reference doses for those chemicals that have threshold effects. The hazard index is the ratio of calculated intake to the reference dose. An acceptable hazard index must be less than one. These evaluations distinguish between the health effects associated with threshold and non-threshold constituents. Mutagenic, teratogenic, and synergistic effects are considered in the analysis, if applicable, based on toxicological testing, or structure-activity relationships.

The following additional information on constituent properties is provided, as applicable: (a) density, solubility, valence state, vapor pressure, viscosity, and partitioning coefficient; (b) presence and effects of complexing ligands and chelating agents that may enhance constituent mobility; (c) potential for a constituent to degrade because of biological, chemical, and physical processes; and (d) constituent attenuation properties, considering such processes as ion exchange, sorption, precipitation, dissolution, and ultrafiltration. This information would also be applied in the exposure assessment.

(3) The assessment provides a reasonably conservative or best estimate of the potential health effects caused by human exposure to the hazardous constituent. The potential health effects for each constituent with a proposed alternate concentration limit must be identified, and related to appropriate exposure limits and dose-response relationships from available literature or databases. Sources of exposure limit and dose-response information include the EPA's maximum concentration limits for drinking water, reference doses, or risk-specific doses. Reference doses are the amounts of chemically toxic constituents to which humans may be daily exposed without suffering adverse effects.

Risk-specific doses are the amounts of proven or suspected carcinogenic constituents to which humans can be daily exposed, without increasing their risk of contracting cancer above a specified risk level. The reference dose and risk-specific dose assessment assume a human mass of 70 kg [154 lb] and consumption of 2 liters of water per day [0.53 gal/day]. More stringent criteria may apply if sensitive populations are exposed to hazardous constituents. Maximum concentration limits, reference doses, and/or risk-specific doses, can be used to show compliance with the risk level and hazard indexes. The technical basis for a risk assessment can be based on the dose-response relationships described in the scientific literature searches or toxicological research, in the absence of applicable maximum concentration limits, reference doses, or risk-specific doses. The exposure analysis should distinguish between threshold (toxic) and non-threshold (carcinogenic) effects associated with human exposure, as well as teratogenic, fetotoxic, mutagenic, and synergistic effects.

The maximum concentration limits, reference doses, and risk-specific doses for most hazardous constituents can be obtained from the EPA (http://www.epa.gov), the Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/atsdrhome.html), or other government institutions and universities. Effects from radioactivity can be obtained from the International Commission on Radiological Protection, and the National Council on Radiation Protection and Measurement.

Previously established and documented health-based constituent concentration limits are used in the hazard assessment as a basis for proposing alternate concentration limit values at specific sites.

(4) The assessment identifies and evaluates the risks posed by the hazardous constituents to environmental populations. Adverse effects on aquatic and terrestrial wildlife, plants, agricultural crops, livestock, and physical structures should be considered. Examples of these adverse effects are: (a) contaminant-induced changes in the biota, (b) loss or reduction of unique or critical habitats, and (c) jeopardy to endangered or threatened species. The NRC must initiate special consultation with the U.S. Fish and Wildlife Service, in accordance with 50 CFR Part 17, if endangered or threatened species occur on the site or could be impacted by site activities. NUREG–1748 (NRC, 2001) should be consulted for initiating this consultation.

Similar to the human risk evaluation, the environmental risk evaluation identifies any acute and sub-chronic effects on environmental populations caused by exposure to the hazardous constituents. Bioaccumulation and food chain interactions are considered when evaluating adverse effects. A comparison of the estimated constituent concentrations to the appropriate federal or State water-quality criteria should be part of the evaluation of potential effects on aquatic wildlife.

When appropriate, the hazard assessment considers potential damage to physical structures such as foundations, underground pipes, and roads. The applicant should demonstrate that the forecasted constituent concentrations will not result in any significant degradation or loss of function, as a result of contamination exposure. As an example, excessive concentrations of dissolved salts could result in accelerated corrosion of underground utility piping.

4.3.3.2 Exposure Assessment

The purpose of the exposure assessment is to evaluate the potential harm to human health and the environment from the hazards identified in the hazard assessment. The exposure assessment takes into account site-specific circumstances that may reduce or enhance the potential for exposure to hazardous constituents. This assessment identifies and evaluates hazardous constituent exposure pathways, and provides forecasts of human and environmental population responses, based on the projected constituent concentrations, dose levels, and available information on the radiological and chemical toxicity effects of the constituents. The assessment also addresses the underlying assumptions, variability, and uncertainty of the projected health and environmental effects. Exposure pathways should be identified and evaluated using water classification and water use standards, along with existing and anticipated water uses. Agricultural, industrial, domestic, municipal, environmental, and recreational water uses should also be considered, as they pertain to the site and surrounding areas. The exposure assessment must provide adequate information regarding potential effects on ground-water resources, and the above water uses, to support NRC's environmental review under 10 CFR Part 51. NUREG–1748 (NRC, 2001) should be consulted for the details of this review.

The exposure assessment must identify the point of compliance, where the proposed alternate concentration limit will be measured; and the points of exposure, where the human health and environmental exposures could occur. The assessment identifies the maximum permissible levels of hazardous constituents at the point of compliance that are protective of human health and the environment at the point of exposure. This is accomplished by evaluating human and environmental exposure to each of those constituents evaluated in the hazard assessment, and then showing the proposed alternate concentration limit will not result in an unacceptable exposure of human health or the environment to those hazards. The exposure assessment should include the following:

(1) The exposure assessment evaluates the pathways the hazardous constituents will likely follow and the concentration or dose those constituents will likely produce at the location where humans or environmental populations could be reasonably exposed. All likely pathways that could transport significant amounts of hazardous constituents in the ground water and hydraulically connected surface water should be identified and evaluated. The hazardous constituent concentrations and projected distributions for each pathway should be best estimates or reasonably conservative representations of the rate, extent, and direction of the constituent transport.

    The ground-water pathway evaluation provides projected contaminant distributions, including contaminant transport, degradation, and attenuation mechanisms between the point of compliance and the point of exposure. The evaluation generally provides information on: (a) site hydrogeologic characteristics, including ground-water flow direction and rates; (b) background water quality; and (c) estimated transport rates, geochemical attenuation, and concentrations of hazardous constituents in the ground water and hydraulically connected surface water. Projections should be calibrated on the basis of site-specific information. The projected attenuation rate may rely on constituent concentration measurements at the point of compliance and the point of exposure, taken over an adequate period of time, when there is great uncertainty in the attenuation rate derived from laboratory measurements or literature sources.

(2) The pathway evaluation provides the spatial distribution of the various hazardous constituents of existing contaminant plumes. This information can be used to calibrate contaminant fate and transport models in the exposure assessment and also identifies the components of the source term that have already been released from the tailings. The contaminant extent characterization includes: (a) the type and distribution of hazardous constituents in the ground water and the source(s) of the contamination; (b) the monitoring program used to delineate and characterize hazardous constituent distribution; and (c) supporting documentation of the sampling, laboratory analysis, and quality assurance programs that show the fulfillment of the site monitoring programs. Such information is used to assess present human and environmental population exposure to elevated concentrations of hazardous constituents, calibrate contaminant

transport models, and evaluate projected future exposures. Computer codes may be used to evaluate the pathways for hazardous constituent transport. The acceptance criteria for ground-water fate and transport computer modeling are contained in standard review plan Section 4.4.3.

(3) The human exposure evaluation considers two potential exposure pathways: (a) ingestion of contaminated water and (b) ingestion of contaminated foods. Other pathways that may impact human health, such as dermal contact and inhalation, are also to be considered, but need not always be assessed, unless it is determined that these exposures could result in significant hazards to human health or the environment.

Human exposure is evaluated primarily on the basis of the extent to which people are using, and are likely to use, contaminated water from the site. Site-specific water uses are determined on the basis of the following considerations: (a) ground-water quality in the site area and present water uses; (b) statutory or legal constraints and institutional controls on water use in the site area; (c) federal, state, or other ground-water classification criteria and guidelines; (d) applicable water-use criteria, standards, and guidelines; and (e) availability and characteristics of alternate water supplies.

Exposure determinations should consider existing and potential water uses. Potential uses include those that are reasonably expected to occur (i.e., anticipated use) and uses that are compatible with the untreated background water quality (i.e., possible use). Past water uses may be included as existing or potential uses. Water resource classification of existing and potential water use should include (a) domestic and municipal drinking water use; (b) fish and wildlife propagation, (c) special ecological communities uses: and (d) industrial, agricultural, and recreational uses. The classification of existing and potential water uses at the facility should be consistent with federal, state, and local water use inventories.

The cumulative effects of human exposure to hazardous constituents at the proposed alternate concentration limits, and to other constituents present in contaminated ground water, will be maintained at a level adequate to protect public health. The combined effects from both radiological and non-radiological constituents should be considered. Guidance for cumulative impact assessment is contained in NUREG–1748 (NRC, 2001) and additional guidance is found in Council on Environmental Quality (1997).

(4) Potential responses of environmental or non-human populations to the various hazardous constituents are evaluated if such populations can realistically be exposed to contaminated ground water or hydraulically connected surface water. Terrestrial and aquatic wildlife, plants, livestock, and crops are included in this evaluation. A detailed environmental exposure evaluation should be performed in the absence of available information that could readily be used to show there will be no substantial environmental impacts caused by ground-water contamination from the site. The evaluation should provide: (a) inventories of potentially exposed environmental populations; (b) recommended tolerance or exposure limits; (c) contaminant interactions and their cumulative effects on exposed populations; (d) projected responses of environmental populations that result from exposure to hazardous constituents; and (e) anticipated

changes in populations, independent of the hazardous constituent exposure. Alternatively, the evaluation may demonstrate that environmental hazards are not anticipated, because exposure will not occur.

The potential for adverse effects, such as (a) contamination-induced biotic changes; (b) loss or reduction of unique or critical habitats; and (c) jeopardizing endangered species, should also be described. Aquatic wildlife effects are evaluated by comparing estimated constituent concentrations with federal and state water quality criteria. Terrestrial wildlife exposure to constituents through direct exposure and food-web interactions should be considered. The NRC must initiate special consultation with the U.S. Fish and Wildlife Service, in accordance with 50 CFR Part 17, if endangered or threatened species occur on the site or could be impacted by site activities. NUREG–1748 (NRC, 2001) should be consulted for initiating this consultation.

Agricultural effects from both direct and indirect exposure pathways, crop impacts, reduced productivity, and bioaccumulation of constituents should be considered. Reasonably conservative estimates of constituent concentrations are compared with federal and state water quality criteria to estimate agricultural effects associated with constituent exposure. Additionally, crop exposures through contaminated soil, shallow ground-water uptake, and irrigation, along with livestock exposure through direct ingestion of contaminated water and indirect exposure through grazing, should be assessed.

(5) Points of exposure are identified. A point of exposure is any location where people, wildlife, or other species could reasonably be exposed to hazardous constituents from ground water contaminated by uranium mill tailings. For example, the point(s) of exposure may be represented by one or more domestic wells that might withdraw contaminated ground water; or it may be represented by springs, rivers, streams, or lakes into which contaminated ground water might discharge. The point of exposure is used to assess the potential hazard(s) to human health and the environment and effects on the ground-water resource.

An alternate concentration limit for a hazardous constituent is established at the point of compliance. The point of exposure may be situated at some distance from the point of compliance, allowing hazardous constituent concentrations to diminish through dispersion, attenuation, or sorption within the aquifer. As a result, an alternate concentration limit may be set at a concentration that is higher at the point of compliance location than a limit that would be protective of human health and environment, as long as the hazardous constituent will not result in an unacceptable hazard to human health and the environment at the point of exposure. In most cases, the point of exposure is located at the downgradient edge of land that will be transferred to either the federal government or the state for long-term institutional control.

The applicant for an alternate concentration limit should make every reasonable effort to keep the point of exposure at the long-term care site boundary. If this cannot be achieved, a good-faith effort must be made to acquire the land between the license area boundary and the point of exposure, for ultimate transfer to the long-term custodian. If the land cannot be acquired through a good-faith effort, then institutional controls other than ownership by the long-term custodian may be initiated. These institutional controls must be enforceable, durable, and legally defensible; and will be applied in addition to the numerical limits of the proposed alternate concentration limit. This approach must be reviewed as an alternative to the specific regulatory requirements contained in 10 CFR Part 40, Appendix A, Criterion 5B(6).

A distant point of exposure[3] may be justified when human or environmental exposure is effectively impossible. This option could be justified on the basis that extremely rugged terrain cannot be physically accessed or the long-term care custodian would ensure that ground water from the contaminated aquifers between the disposal site and the point of exposure would not be used. In some rare instances, a distant point of exposure could be established without invoking land ownership by a long-term custodian. Under these circumstances, the previously described institutional controls should be invoked. Human and environmental exposure are considered effectively impossible when the ground water is inaccessible or unsuitable for use. Land ownership or long-term custody will not be an issue for establishing a distant point of exposure if human and environmental exposure are effectively impossible.

When a distant point of exposure is involved, the applicant must coordinate the use of this option with the NRC. The NRC and the applicant must verify whether the state or the federal government will be the long-term site custodian, after the license is terminated. The applicant must then secure a commitment from that party to take custody of the site. The applicant or the NRC must then secure written assurance that the appropriate federal or state agency will accept the transfer of the specific property, including land in excess of that needed for tailings disposal. Alternate concentration limits may not be established at sites involving a distant point of exposure until the licensee agrees to transfer the title to the land, and the appropriate federal or state government commits to take such land, including the land between the point of compliance and point of exposure that is in excess of the land used for disposal of byproduct material.

If the licensee chooses to keep the mill property under a specific license and apply for an alternate concentration limit as part of a compliance monitoring program, the licensee must still coordinate the use of a distant point of exposure with the NRC as described above.

(6) The likelihood of human and environmental exposure is determined. The probability of human and environmental exposure is often difficult to establish quantitatively. Consequently, defensible qualitative estimates of the exposure likelihood are often necessary. These can be characterized as either:

[3]A distant point of exposure refers to a point of exposure that is spatially beyond the area that the appropriate federal or State agency is required to accept for perpetual care under the land transfer provisions of the Uranium Mill Tailings Radiation Control Act of 1978, as amended.

(a) Reasonably likely—when exposure has or could have occurred in the past, or available information indicates that exposure to contamination may reasonably occur during the contamination period.

(b) Reasonably unlikely—when exposure could have occurred in the past, but will probably not occur in the future, either because initial incentives for water use have been removed, or because available information indicates that no incentives for water use are currently identifiable, based on foreseeable technological developments.

(7) Exposure impacts are adequately evaluated through time. It is acceptable to project impacts at the point of exposure during a 1,000-year time frame. This is consistent with the design standard of 10 CFR Part 40, Appendix A, Criterion 6(1).

4.3.3.3 Corrective Action Assessment

The applicant's assessment of ground-water corrective action alternatives should be reviewed in conjunction with the hazard assessment and the exposure assessment. Past, current, and proposed practicable corrective actions are identified and evaluated against the costs and benefits associated with implementing each corrective action alternative. The corrective action assessment should demonstrate that the proposed alternate concentration limit is as low as is reasonably achievable, considering practicable corrective actions, as required by 10 CFR Part 40 Appendix A, Criterion 5B(6). A principal way of demonstrating this is by estimating and comparing the benefits imparted by a corrective action measure against the cost of implementing that measure.

For some sites, a corrective action assessment may have already been completed, as part of a ground-water corrective action program under Criterion 5D of Appendix A to 10 CFR Part 40, as described in standard review plan Section 4.4.3. A ground-water corrective action assessment typically (a) identifies several practicable corrective action alternatives; (b) assesses the technical feasibility, costs, and benefits of each alternative; and (c) selects an appropriate corrective action for achieving compliance with the ground-water protection standards established at the site. The corrective action assessment should include the following:

(1) A complete range of realistic and reasonable corrective action alternatives for achieving compliance with the ground-water standards currently in the license and the proposed alternate concentration limit is described and evaluated. The identified alternatives should be comprehensive, including all engineering-feasible alternatives, both passive and active, or any appropriate sequential combination of alternatives. The analyzed corrective action alternative should not simply be a compendium of the most elaborate and expensive alternatives. The description of each alternative should be conceptual in nature, but contain sufficient detail so the reviewer can independently verify the reasonableness of each corrective action measure. Although conceptual, the alternate descriptions should also contain sufficient detail for completing a coarse cost estimate of each alternative for the cost and benefit analysis.

    For past and current corrective actions, site-specific operational and monitoring data should be included to show the effectiveness of those measures. The evaluation may include information from literature sources or documented experience from other sites for those corrective actions that have not been implemented at the site but appear to be practicable. The evaluation should also include projections of the hazardous constituent concentration that each corrective action would likely produce at specific times at the point of compliance and the point of exposure. It is important that the reviewer assure that the range of reasonable corrective actions listed in the application is complete. The suitability of a corrective action should be determined strictly on the technical and engineering information needed to design and implement a particular measure. The economic constraints for implementing a particular measure should not be used to eliminate a corrective action method from the evaluation.

(2) The direct benefits of implementing the corrective actions have been determined by estimating the current and projected resource value of the pre-contaminated ground water. Estimates of pre-contaminated ground-water value should be based on water rights, availability of alternate water supplies, and forecasted water use demands. The value of a contaminated water resource is generally equal to the cost of a domestic or municipal drinking water supply or the cost of water supplied from an alternate source to replace the contaminated resource. The absence of available alternate water supplies increases the relative value of a potentially contaminated water resource. The indirect benefits are determined by assessing the avoidance of adverse health effects from exposure to contaminated water, the prevention of land value depreciation, and any benefits accrued from performing the corrective action, including timeliness of remediation. The reviewer should verify the water yields; costs for developing alternate water supply sources; and legal, statutory, or other administrative constraints on the use and development of the water resources.

(3) The costs associated with performing a corrective action alternative to achieve the target concentrations include (a) the capital costs for designing, and constructing the alternative; (b) operation and maintenance costs; (c) costs associated with demonstrating compliance with the standards; and (d) decommissioning costs after the corrective action is completed.

(4) The “as low as is reasonably achievable” analysis is performed on target concentration levels that are at or below the limit determined to be protective of human health and the environment. At least three target concentration levels that can reasonably be attained by the practicable corrective actions should be evaluated. The goals should be (a) meaningfully different, (b) reasonably attainable by practicable corrective action, and (c) at or below the levels identified in the hazard assessment.

The “as low as is reasonably achievable” analysis typically considers (a) the direct and indirect benefits of implementing each corrective action to achieve the target concentration levels; (b) the costs of performing the corrective action to achieve the target concentrations; and (c) a determination whether any of the evaluated corrective action alternatives will reduce contaminant levels below the proposed alternate concentration limit, considering the benefits and costs of implementing the alternative.

The applicant should also provide a comparison among the costs associated with performing the various corrective action alternatives to achieve the target concentrations, the value of the pre-contaminated ground-water resource, and the benefits of achieving each target concentration. A proposed alternate concentration limit is considered as low as is reasonably achievable if the comparison of the costs to achieve the target concentrations lower than the alternate concentration limit are far in excess of the value of the resource and the benefits associated with performing the corrective action alternative. If the value and benefits clearly exceed the costs or the comparison is nearly equal, the proposed alternate concentration limit should be revised to the lower target concentration providing the greatest value and benefit compared to the cost.

The cost and benefit analysis should not be limited to a simple financial accounting of the costs for each corrective action alternative. Costs and benefits should also be discussed for qualitative subjects, such as environmental degradation or enhancement. The cost and benefit analysis is not simply a mathematical formula from which to justify economic parameters. Other qualitative factors should be discussed and weighed in the decision. The cost and benefits analysis provides input to determine the relative merits of various corrective action alternatives; however, the proposed alternate concentration limit must ultimately assure protection of public health and the environment.

The as low as is reasonably achievable analysis for non-radiological constituents should be similar to the as low as is reasonably achievable analysis for radiological constituents except a “dollar per person-rem avoided” value would not be calculated. Additionally, once nonradiological constituent are below regulatory maximum concentration levels, the licensee ha no further obligation to reduce the constituent concentrations.

4.3.3.4 Examination of the Compliance Monitoring Program

Standard review plan Section 4.4.3 provides the acceptance criteria for corrective action assessments, corrective action monitoring, and compliance monitoring. The reviewer should examine the existing compliance monitoring program at a licensed mill tailings facility, if a proposed alternate concentration limit is found acceptable.

Specifically, the compliance monitoring program should monitor all ground-water exposure pathways to assure that any potential exceedances of the proposed alternate concentration limit will be detected before the license is terminated. The compliance monitoring well locations should not be restricted solely to the point of compliance. Some locations between the point of compliance and the points of exposure should be included to assure the identified aquifer attenuation mechanisms are reducing the hazardous constituent concentrations to the predicted levels. The applicable maximum contaminant level, background concentration, or other maximum permissible limit should be used as the compliance monitoring limit for wells at the points of exposure, in those cases where compliance monitoring is conducted at the points of exposure.

4.3.4 Evaluation Findings

The following conclusions may be presented in the technical evaluation report, if the staff review, as described in standard review plan Section 4.3 results in the acceptance of the hazard assessment, exposure assessment, and corrective action assessment supporting the proposed alternate concentration limit:

The staff completed its review of the proposed alternate concentration limit for ground-water compliance at the ______________ uranium mill tailings facility. This review included an evaluation using the review procedures in Section 4.3.2 and the acceptance criteria outlined in Section 4.3.3 of this standard review plan.

The licensee conducted an acceptable hazard assessment by considering present and potential human health and environmental hazards, including human cancer risk from exposure to radioactive and non-radioactive constituents and other health hazards resulting from the chemical toxicity of the constituents. The source term for constituents of concern and the extent of ground-water contamination have been acceptably characterized.

The licensee conducted an acceptable exposure assessment. The point of exposure has been identified and is acceptably sited at the downgradient edge of the affected land. When a distant point of exposure is used, written assurance has been secured, either by the licensee or NRC, that the appropriate federal or state agency will accept the transfer of the specific property, including land in excess of that needed for tailings disposal. The transport of the hazardous constituent in ground water and surface water has been defined and any adverse effects on water quality, including present and future impacts have been assessed.

The human cancer risk and other health and environmental hazards from exposures to hazardous constituents have been evaluated and are acceptable, including (a) identification of maximum levels permissible at the point of compliance; (b) evaluation of health and environmental hazards using water classification and use standards and existing and anticipated water uses; (c) appropriate consideration of impact, based on site-specific water uses; (d) consideration of ingestion of contaminated water and food; (e) consideration of response of environmental and non-human populations to the various hazardous constituents, including terrestrial and aquatic wildlife, plants, livestock, and crops; and (f) consideration of potential damage to physical structures.

The acceptable corrective action assessment includes (1) an assessment of ground-water corrective actions dealing with identification of practicable corrective action alternatives; (2) an evaluation of ability of corrective action to reduce contaminant levels appropriately; (3) a demonstration that action will achieve desired concentration levels; and (4) demonstration that practicable corrective actions are not likely to result in reduction of contamination below the proposed alternate concentration limit, and that alternate concentration limits are, therefore, as low as is reasonably achievable.

The NRC staff concludes that the information submitted to support the proposed alternate concentration limit(s) at the _________________ uranium milling facility is acceptable and complies with the following criteria in 10 CFR Part 40, Appendix A, Criterion 5B, which requires NRC to establish a list of hazardous constituents, concentration limits, a point of compliance, and a compliance period; Criterion 5C, which contains a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5F, which requires that where ground-water impacts from seepage are occurring at an existing site, action must be taken to alleviate the conditions that lead to seepage, and ground-water quality must be restored, including technical specifications for the seepage control system and implementation of a quality assurance program; Criterion 5G, which requires licensees/operators to perform site characterization; Criterion 6(1), which provides performance lifetime and radioactive material release standards; and Criterion 7A, which establishes detection, compliance and corrective action monitoring programs in support of a tailings disposal system proposal. The information also complies with 10 CFR 40.31(f), which requires inclusion of an environmental report in the license application, and 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

4.3.5 References

Council on Environmental Quality. “Considering Cumulative Effects Under the National Environmental Policy Act.” Washington, DC: Council on Environmental Quality. 1997.

NRC. NUREG–1748, “Environmental Review Guidance for Licensing Actions Associated with NMSS Programs.” Washington, DC: NRC. 2001.

4.4 Ground-Water Corrective Action and Compliance Monitoring Plan

The staff should review any ground-water corrective action and compliance monitoring plans that may be presented by the licensee either as a part of the reclamation plan, or as a separate licensing submittal. A separately submitted corrective action and compliance monitoring plans will contain much of the same information that is required for the reclamation plan (e.g., a site characterization plan). Any information that was presented in a previously approved reclamation plan may be incorporated by reference. For review of some information, the reviewer may use review procedures in other chapters of this standard review plan.

4.4.1 Areas of Review

In determining compliance, the reviewers should consider the information specified in Criteria 1–8 of Appendix A of 10 CFR Part 40 that is relevant to the technical adequacy of the ground-water corrective action and compliance monitoring plans. Models of unsaturated flow and transport can be used if the tailings pile is located in the unsaturated zone. A reactive transport model of the plume of hazardous constituents for the saturated zone away from the mill tailings pile should be constructed if the licensee takes credit for chemical processes that may mitigate the spread of contaminants. The technical adequacy of any detailed models should be reviewed. Findings from detailed models (that incorporate complexities not treated in any large-scale numerical models) can be used as input to a large-scale numerical model of ground-water flow and transport for the site. Models should be calibrated using site data.

The staff should review the following aspects of ground-water corrective action and compliance monitoring plans.

(1) The sufficiency of data and parameters.

(2) The technical bases for parameter ranges.

(3) Descriptions of features and physical phenomena.

(4) Use of alternate models.

(5) Consistency of models.

(6) Waste management practices.

(7) Site access controls.

(8) Ground-water monitoring plans.

(9) Design, operation, and inspection of surface impoundments.

(10) Surety.

4.4.2 Review Procedures

In conducting the review of the technical adequacy of the ground-water corrective action and complaince monitoring plans, the staff should recognize that review procedures and models used in the technical assessment of the selected ground-water cleanup methods, cleanup time, and sureties may range from detailed, small-scale process models to large-scale, simplified models. The small-scale process models incorporate the important complexities and mechanisms that govern the evolution of the hazardous constituent plume, while the large-scale simplified models do not consider all the important complexities. Model adequacy should be evaluated regardless of the level of complexity. The following areas should be evaluated:

(1) The staff should evaluate the sufficiency of the data and parameters supporting models considered in any site-scale numerical model used to estimate the cleanup time. The staff should also evaluate the technical basis for data on design features, physical phenomena, geology, hydrology, geotechnical engineering, and geochemistry used to model or assess ground-water cleanup. This basis may include a combination of techniques such as laboratory experiments and site-specific field measurements.

    The reviewer should evaluate whether additional data are likely to provide new information that could invalidate the modeling results and significantly affect the corrective action and compliance monitoring plans.

(2) The reviewer should evaluate the technical bases for parameter ranges, probability distributions, or bounding values. The reviewer should determine whether the parameter values are derived from site-specific data or, alternatively, an analysis is

included to show that the assumed parameter values lead to a conservative assessment of performance.

The staff should examine the initial conditions and boundary conditions used in sensitivity analyses for consistency with available data. The staff should also consider the temporal and spatial variations in boundary conditions and source terms used to support the ground-water corrective action and compliance monitoring plan.

The staff should evaluate the licensee assessment of uncertainty and variability in parameters used in the modeling. The reviewer should determine whether uncertainty in data due to both temporal and spatial variations in conditions affecting the ground-water cleanup and estimation of cleanup time was incorporated into parameter ranges.

(3) The staff should examine the descriptions of features and physical phenomena and the descriptions of the geological, hydrological, geotechnical, and geochemical aspects of the mill tailings and the underlying aquifer. The staff should verify that the descriptions are adequate and that the conditions and assumptions used in the modeling are realistic or reasonably conservative and are supported by the body of data presented in the descriptions. The staff should assess the technical bases for these descriptions and for incorporating them in the numerical model of the site.

The reviewer should examine the technical bases for the identification of hazardous constituents from the mill tailings that have entered the underlying aquifer and surface water bodies. The staff should evaluate how these constituents have been incorporated into any detailed models. The staff should also verify that, given the concentrations and locations of the hazardous constituents, estimates of cleanup time and surety amounts are reasonable.

The reviewer should examine the assumptions used to develop any model of reactive transport that accounts for site geochemical processes. These processes may include phase changes induced by interaction of contaminants with ground water and surface water. The modeling should consider available data about the native ground-water downgradient of the tailings pile, the geochemical environment, hydraulic and transport properties, and the spatial variations of properties of aquifers and ground-water volumetric fluxes along the flow paths.

The staff should evaluate the initial and boundary conditions and how they have been propagated through the models. For example, the reviewer should determine whether the conditions and assumptions used in the site-scale model are consistent with other conditions and assumptions used in any model that describes the flow and transport of hazardous constituents from the mill tailings.

(4) The staff should evaluate models used for the ground-water cleanup and estimation of cleanup time. The staff should examine the model parameters in the context of available site characterization data, laboratory experiments, and field measurements.

Where appropriate, and when surety estimates are highly uncertain, the reviewer should use an alternate site model to evaluate the effects on the technical assessment of ground-water cleanup and estimation of cleanup time.

(5) The staff should evaluate the output from any site model of ground-water cleanup and the estimation of cleanup time and compare the results with an appropriate combination of site characterization and design data.

The staff should examine the model results obtained by the licensee against comparable mathematical models to judge their robustness. The reviewer should use an alternate model to evaluate selected parts of the licensee model results, as appropriate. The reviewer should evaluate whether the licensee has appropriately reduced the dimensionality and complexity of models. The dimensionality of models, heterogeneity of aquifer parameters, and significant process couplings may be reduced if it is shown that the simplified model bounds the prediction of the more complex model. The staff should evaluate the acceptability of the sensitivity analyses used to support the model of the ground-water cleanup and the estimation of cleanup time.

(6) The staff should verify that waste management practices are in compliance with environmental protection regulations.

(7) The reviewer should assess whether site access controls during the cleanup period are sufficient to prevent significant hazards to human health and the environment.

(8) The staff should evaluate whether the ground-water monitoring system is sufficient to verify the performance of the selected cleanup strategy, and to monitor the long-term performance of any on-site tailings disposal cells.

(9) The staff should ensure that any surface impoundments constructed as part of the program are designed to meet the requirements of 10 CFR Part 40, Appendix A criteria and are included in the dam safety program, if appropriate. The reviewer should also verify that adequate inspection, documentation, and reporting procedures exist for tailings or waste retention systems.

(10) The staff should confirm that the applicant has provided adequate financial surety. This confirmation may be conducted using cost estimating software such as the RACER 2000™ computer code (Talisman Partners, Ltd., 2000). Guidance on the preparation of sureties and cost estimates is available in Appendix C of this standard review plan and in NRC (1988, 1997).

4.4.3 Acceptance Criteria

In 10 CFR Part 40, Appendix A, Criterion 5D, NRC requires tha,t if the ground-water protection standards established under Criterion 5B(1) of 10 CFR Part 40, Appendix A are exceeded at a licensed site, a corrective action program must be put into operation as soon as is practicable, and in no event later than 18 months after the Commission finds that the standards have been exceeded. Unless otherwise directed by the Commission, before putting the program into operation, the licensee should submit the supporting rationale for the proposed corrective action program. The objective of the program is to return hazardous constituent concentration levels in ground water to the concentration limits set as standards. The licensee should provide an assessment of practicable corrective actions available for returning contaminant concentrations to the standards established in the license. The corrective action assessment incorporates information and findings from the site characterization activities, which are described in standard review plan Section 4.1.3. Site specific characteristics may have a strong influence on which corrective action alternative will be practicable for a particular site. If additional site characterization is needed, details of the characterization plan should be included.

The corrective action should result in conformance with the established concentration limits, address either removing the hazardous constituents or treating them in place, and should include a program to monitor compliance with cleanup standards. Regulations do not require any specific designs or methods to be used for the ground-water corrective action program. Because of the nearly limitless possibilities for designing and implementing ground-water corrective actions, staff reviewers should focus on the technical feasibility from an engineering perspective and evaluate whether the proposed design is likely to result in timely compliance with established concentration limits and whether the monitoring program is adequate to verify the effectiveness of the design. Useful guidance for the application of ground-water flow and transport modeling can be obtained from American Standard for Testing and Material D 5447, D 5490, D 5609, D 5611, D 5718, D 5880, and D 5981.

The ground-water corrective action and compliance monitoring plans are acceptable if they meet the following criteria.

(1) Sufficient data are available to adequately define relevant parameters and to support models, assumptions, and boundary conditions necessary for developing detailed and site-scale models of the ground-water cleanup and the estimation of cleanup time. The data are also sufficient to assess the degree to which processes related to the ground-water cleanup that affect compliance with the technical criteria in Appendix A of 10 CFR Part 40 have been characterized. Information required for site-scale reactive transport models can include:

   (a) Site description.

      (i) Chronology/history of uranium milling operations.

      (ii) List of known leaching solutions and other chemicals used in the milling process.

      (iii) Summary of known impacts of the site activities on the hydrologic system and background water quality.

      (iv) Quantity and chemical/textural characteristics of wastes generated at the mill site.

      (v) Information pertaining to surrounding land and water uses.

- (vi) Meteorological data for the region including precipitation and other data to support estimates of evapotranspiration.

(b) Description of hydrogeologic units.

- (i) Hydrostratigraphic cross sections/maps.
- (ii) Hydrogeologic units that constitute the aquifer(s).
- (iii) Description of perched aquifers (areal/volumetric extent).
- (iv) Description of the unsaturated zone (thickness, extent).
- (v) Geologic characteristics (presence of layers, continuity, faults).

(c) Data on the hydraulic and transport properties of each aquifer.

- (i) Hydraulic conductivity.
- (ii) Thickness of each unit.
- (iii) Hydraulic head contour maps (of each aquifer).
- (iv) Information on background horizontal and vertical hydraulic gradients and temporal variations to determine flow directions.
- (v) Vertical hydraulic gradients and inter-aquifer flow within and between multiple aquifer systems.
- (vi) Effective porosity
- (vii) Storativity or specific yield (for transient simulations).
- (viii) Longitudinal, vertical and horizontal transverse dispersivity.
- (ix) Retardation factors.

(c) Data on regional recharge rates and ground-water/surface-water interactions with nearby streams, rivers, or lakes.

- (i) Areal recharge rates.
- (ii) Information on water fluxes to and from rivers, aquifers, and surface water bodies.
- (iii) Data on surface water bodies (e.g., stream flow rates, dimensions of nearby surface water bodies).

(iv) Concentration of hazardous constituents in surface water bodies

(d) Characteristics of the mill tailings.

(i) Identification of contaminant source terms.

(ii) Hydraulic properties of mill tailings material.

(iii) Unsaturated flow and transport parameters of mill tailings material.

(iv) Design and materials for mill tailings cover.

(v) Information on the spatial and temporal distribution of seepage fluxes from the mill tailings to the upper-most aquifer (including the historical variation in rates).

(vi) Information on mill tailings draining mechanisms and drainage volume.

(vii) Geotechnical properties of the mill tailings and their temporal variation due to drainage of leachates

(viii) Tailings volume.

(ix) Data on the volume, chemical and mineralogical characteristics, and concentration of mill tailings and tailings solution/leachate.

(x) Mass of hazardous constituents placed in the tailings pile and other disposal or storage areas.

(e) Data on geochemical conditions and water quality.

(i) Concentration of hazardous constituents.

(ii) Background (baseline) ground-water quality.

(iii) Delineation of the nature and extent of the hazardous constituent plume.

(iv) Characterization of subsurface geochemical properties.

(v) Identification of attenuation mechanisms and estimation of attenuation rates.

(vi) Mass of hazardous constituents in the aquifer.

(f) Site cleanup data.

(i) Information on grout curtains, slurry walls, drains, interceptor ditches, and other facilities designed to reduce the spreading of the hazardous constituent plume (if used).

(ii) Information on pumping, injection, and sampling wells (coordinates, depths, completion diagrams, flow rates).

(iii) Pumping/injection rates and rate history for each well (if pumping has been ongoing).

(iv) Information on the presence or the absence of liners for the mill tailings pile and evaporation ponds.

(v) Mass of hazardous constituents recovered to date.

Sufficient data are available to justify models used to validate the ground-water corrective action plan. American Standard for Testing and Materials D 5490 provides acceptable guidance for comparing model simulations to site-specific information. Alternatively, in the case of sparse data and/or low confidence in the quality of available data or data interpretations, the licensee demonstrates by sensitivity analyses or other methods that the proposed ground-water corrective action plan is appropriate, and the contingency built into the surety is compatible with the uncertainties. American Standard for Testing and Materials D 5611 provides acceptable guidance for conducting sensitivity analyses on ground-water flow models. Guidance on preparing cost estimates and establishing sureties for uranium mills is provided in the “Technical Position on Financial Assurances and Reclamation, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities” (NRC, 1988).

Sufficient information is provided to substantiate that any mathematical flow and transport modeling approach is appropriate for site conditions considering (i) factors pertaining to the specific purpose or intended use of the model(s); (ii) the flow media at the site and along the flow path from the mill tailings to the point of compliance, and downgradient to it, including aquifer properties and transport parameters (e.g., porous media versus fracture flow, aquifer confinement, the number of active layers); (iii) modeling assumptions (e.g., steady-state versus transient flow, assignment of initial and boundary conditions); and (iv) model-related factors (e.g., underlying flow equations; solution methods; model history; model verification, validation and calibration; expertise and experience of the personnel responsible for model development; and quality of model documentation). Amiercan Standard for Testing and Materials D 5718 provides guidance for documenting ground-water flow model applications.

An adequate assessment is provided of the low and high permeability features (heterogeneities), their spatial distributions, and statistical properties; and the available and acquired data are suitable and sufficient for modeling based on observations, independent analyses, or published reports and databases of those features.

Initial and boundary conditions used by the licensee in modeling the ground-water cleanup are justified by the available data, are used consistently throughout the modeling process, and are adequately documented. American Standard for Testing and Materials D 5609 provides acceptable guidance for defining boundary conditions for ground-water flow models.

Where sufficient data do not exist, the definition of parameter values and conceptual models are based on appropriate sources from the literature or are otherwise technically justified.

Adequate site geochemical data are provided. Contaminants are identified sufficiently to support the ground-water corrective action plan and models. In addition to helping set cleanup goals, background water chemical data support assessments of geochemical evolution as ambient ground water is restored in the subsurface. Generally, a three-dimensional delineation of contaminant distribution and a source term are necessary for defining needed actions and for model development. The important geochemical parameters that should be delineated for both contaminated and background waters are pH, Eh, dissolved oxygen, temperature, major cation and anion concentrations, and concentrations of potential contaminants. Host rock properties affect both the water chemistry and the specific geochemical mechanisms affecting contaminants. Identifying possible attenuation mechanisms ensures that cleanup is based on reasonable models for contaminant transport.

(2) Parameter values, assumed ranges, probability distributions, and/or bounding assumptions used in the modeling of ground-water cleanup are technically defensible and reasonably account for uncertainties and variabilities. The technical bases for each parameter value, ranges of values, or probability distributions used in the modeling of the ground-water cleanup are provided.

Sensitivity analyses are provided that (i) identify aquifer flow and transport parameters that are expected to significantly affect the site model outcome; (ii) test the degree to which the performance of the ground-water cleanup may be affected if a range of parameter values must be used as input to the model due to sparsity of, or uncertainty in, available data; and (iii) test for the need for additional data.

Sufficient bases are provided for parameter values, representative parameter values are taken from the literature, and the bounds and statistical distributions are provided for hydrologic and transport parameters that are important to the estimation of cleanup time and that are included in the modeling of the ground-water cleanup.

Site data fitted to theoretical models compare reasonably well. American Standard for Testing and Materials D 5490 provides guidance for comparing ground-water flow model simulations to site-specific information. If there is departure of site data from the theoretical model, then an alternate model is considered. The assumptions used in modeling are consistent with site data and observations.

Models used to describe local phenomena, such as the fluxes through the tailings pile, are based on consistently applied conditions.

(3) Important design features, physical phenomena, and consistent and appropriate assumptions are identified and described sufficiently for incorporation into any modeling that supports the ground-water cleanup, including the estimate of cleanup time, and the technical bases are provided. Detailed models and site-scale models used to support the corrective action plan, or other supporting documents, and identify and describe aspects that are important to the cleanup and the estimate of cleanup time.

The licensee delineates the extent of the hazardous constituent plume, contaminant flow paths in the aquifer considering natural site conditions, any effects that can be expected to result from construction of additional facilities and operations (i.e., tailings ponds, evaporation ponds, excavations), and events that may affect the spatial and temporal distribution of the hazardous constituent plume. More specifically, the licensee's models of the ground-water cleanup consider and are consistent with (i) natural climatic, geologic, and hydrologic conditions at the site and in the vicinity of the site; (ii) tailings pile design and construction features and their potential impact on local recharge and consequent flow paths in the aquifer; (iii) geochemical and other processes that can affect the performance of the ground-water cleanup and estimation of cleanup time; and (iv) future events, including additional construction and changes of plans for operations that may occur at the site. The licensee also has determined the range of concentrations of hazardous constituents that can be expected in the aquifer and their changes with time during the ground-water cleanup.

The licensee estimates the total mass of hazardous constituents produced by the leaching process and the quantity of the mass that is in the mill tailings, the aquifer, in surface water bodies (including evaporation ponds, disposal cells, nearby ponds, and rivers) and the portion that has been removed by means of the ground-water cleanup, and accounts for the mass that will be removed for final disposal.

The licensee makes reasonable assumptions, if taking credit for dispersion of hazardous constituents and consequent reduction of concentrations during transport from the mill tailings to the point of compliance, for such processes as mechanical dispersion and mixing with native ground water and surface water. These assumptions are based on available data about the hydraulic and transport properties of the site and the spatial variations of properties of aquifers and ground-water volumetric fluxes along the flow paths.

The licensee provides an adequate basis for considering the effect of any reactive transport and geochemical processes in simulating the ground-water cleanup operation, if taking credit for sorption or any other geochemical reaction of hazardous constituents and consequent reduction or retardation of concentrations during transport from the mill tailings. Predicting the effects of proposed ground-water cleanup actions may include forward, site-specific contaminant transport modeling. Often, such modeling has taken a simple approach employing a retardation factor to describe all geochemical effects on contaminant concentration. This approach may be too simplistic. The use of a constant retardation factor and the neglect of speciation and water-mineral reactions is likely to lead to prediction errors. Reactive transport models using codes such as PHREEQC Version 2 (Parkhurst and Appello, 1999) are acceptable for constructing a geochemical model for the site. Hostetler and Erickson (1993) discuss examples of the effect of extending reactive transport models beyond simply including retardation in advective-dispersive models. In one example involving cadmium transport at a uranium mill tailings site, concentration profiles from the site suggest the importance of otavite ($CdCO_3$) solubility control on aqueous cadmium in the low-pH zones near the tailings pond, and the inadequacy of modeling sorption alone.

Reactive transport models incorporate thermodynamic data on solid phases and aqueous species, allowing the mass action calculations that determine estimated aqueous concentrations and solid phase evolution. Thermodynamic parameters constitute a major source of uncertainty in geochemical modeling [see Murphy and Shock (1999) for a discussion of uranium], with potentially large effects on predicted aqueous ion concentrations. Therefore, geochemical modeling supporting ground-water corrective action plans includes sensitivity analyses that provide assurance that contaminant concentrations will not be underestimated. Likewise, any kinetic models employed are subjected to critical analysis because of the large influence of kinetic effects at low temperatures.

Reactive transport model results are subject to the assumptions and limitations of the conceptual and numerical models employed. For example, Zhu et al.[4] list model limitations and briefly discuss how they may affect predictions. Geochemical limitations include:

(a) The assumption of local equilibrium (i.e., kinetic rates were not employed).

(b) Modeled porosity not being affected by reactions affecting the solid phase.

(c) Omitting colloidal transport.

(d) Neglecting density effects due to varying total dissolved solids.

(e) Simplifying the mineralogical suite.

(f) Neglecting surface reactions such as ion exchange.

(g) Relying on bulk mineralogy rather than on mineral surface compositions.

Limitations such as these are typically due to factors such as lack of data, inadequate computational equipment, or insufficient model development. Consideration of model limitations and their effects on uncertainty is an important component of the review by the NRC.

The numerical model of the site constructed by the licensee incorporates site-specific information, is adequately validated and calibrated, and reasonably represents the

[4]Zhu C., F.Q. Hu, and D.S. Burden. "Multi-Component Reactive Transport Modeling of Natural Attenuation of an Acid Ground-Water Plume at a Uranium Mill Tailings Site." *Journal of Contaminant Hydrology*. 2001. Accepted for publication.

physical system. American Standard for Testing and Materials Reports D 5490 and D 5981 provide guidance for ground-water flow model validation and calibration. The professional experience and judgment of the reviewer should be applied in assessing these aspects of the analyses.

The licensee identifies and properly integrates factors that are expected to affect, or that are affected by, the ground-water cleanup. These include, but are not limited to, the spatial and temporal variation of the flux of leachates from the mill tailings to the underlying aquifer, drainage mechanisms of leachates from the mill tailings, spatial variability in flow and transport properties of the aquifer underlying the mill tailings, and geochemical processes that may affect the concentrations of hazardous constituents.

The licensee evaluates and documents the degree of conservatism in modeling the ground-water cleanup, and the level of conservatism presumed by the licensee is commensurate with the data and conceptual model uncertainty.

(4) Alternate modeling approaches consistent with available data and current scientific understanding are investigated where necessary, and results and limitations are appropriately factored into the ground-water corrective action plan. The licensee provides sufficient evidence that relevant site features have been considered, that the models are consistent with available data and current scientific understanding, and that the effects on cleanup time have been evaluated. Specifically, the licensee adequately considers alternate modeling approaches where necessary to incorporate uncertainties in site parameters and ensure they are propagated through the modeling.

Uncertainty in data interpretations is considered by analyzing reasonable conceptual models that are supported by site data, or by demonstrating through sensitivity studies that the uncertainties have little impact on the ground-water corrective action plan.

(5) The site-scale model for ground-water cleanup provides results consistent with the output of detailed or site data. Specifically, the site model is consistent with detailed models of geological, hydrological, and geochemical processes for the site. For example, for flow and transport through the aquifer, hydraulic conductivity distributions are reasonably consistent with sensitivity studies of the range of hydraulic conductivities and varying statistical distributions, field observations, and laboratory tests, when applicable.

The licensee documents how the model output is validated in relation to site characteristics.

Where appropriate, in developing the site model for ground-water cleanup, the licensee considers and evaluates alternate models that are reasonably justified by the available database, with reasonable values assigned to distribution statistics to compensate for limited data availability.

The licensee uses numerical and analytical modeling approaches reflecting varying degrees of complexity consistent with information obtained from site characterization.

The licensee employs the upper and lower bounds of input parameter ranges to examine the robustness of the modeling.

(6) Adequate waste management practices are defined.

The disposition of effluent generated during active remediation is addressed in the corrective action plan. Appendix F to this standard review plan contains NRC staff policy for effluent disposal at licensed uranium recovery facilities for conventional mills. When retention systems such as evaporation ponds are used, design considerations from erosion protection and stability along with construction plans reviewed by a qualified engineer are included. Evaporation and retention ponds should meet the design requirements of 10 CFR Part 40, Appendix A, Criterion 5A. Ideally, the ponds should have leak detection systems capable of reliably detecting a leak from the pond into the ground water and should be located where they will not impede the timely surface reclamation of the tailings impoundment.

If water is to be treated and reinjected, either into an upper aquifer or into a deep disposal well, the injection program is approved by the appropriate state or federal authority. If effluent is to be discharged to a surface-water body, licensees obtain a National Pollutant Discharge Elimination System permit for discharge to surface water. If plans to manage effluents are in place from earlier operations, they may be included in the corrective action plan by reference.

(7) Appropriate site access control is provided by the licensee.

Site access control should be provided by the licensee until site closure to protect human health and the environment from potential harm. Site access is controlled by limiting access to the site with a fence and by conducting periodic inspections of the site.

(8) Effective corrective action and compliance monitoring programs are provided.

Licensees are required, by Criterion 7 of Appendix A to 10 CFR Part 40, to implement corrective action and compliance monitoring programs. The licensee monitoring programs are adequate to evaluate the effectiveness of ground-water cleanup and control activities, and to monitor compliance with ground-water cleanup standards. The description of the monitoring program includes or references the following information:

(a) Quality assurance procedures used for collecting, handling, and analyzing ground-water samples.

(b) The number of monitor wells and their locations.

(c) A list of constituents that are sampled and the monitoring frequency for each monitored constituent.

(d) Action levels that trigger implementation of enhanced monitoring or revisions to cleanup activities (i.e., timeliness and effectiveness of the corrective action).

For corrective action monitoring:

> The same wells used to determine the nature and extent of contamination may be used to monitor the progress of ground-water corrective action activities. However, once the extent of contamination is delineated, it may be possible to adequately monitor compliance with fewer wells. Once selected, major changes to monitored locations are avoided, because it is important to be able to directly compare measurements made at different times.
>
> Licensees choose a monitoring interval that is appropriate for monitoring corrective action progress. Not all hazardous constituents need to be monitored at each interval. It is generally acceptable for licensees to choose a list of more easily measured constituents that serve as good indicators of performance. These indicators include conservative constituents that are less likely to be attenuated, such as chloride, total dissolved solids, and alkalinity. However, if a hazardous constituent is causing a demonstrated risk to human health or the environment, that constituent must be monitored during the corrective action. Ground water at designated monitor wells is sampled for all hazardous constituents at the end of each major phase of corrective action and again before license termination and transfer of the site to the custodial agency for long-term custody.
>
> For compliance monitoring, after a corrective action program has been terminated, compliance monitoring at the point of compliance will resume for the duration of the compliance period, until license termination, as defined in 10 CFR Part 40, Appendix A, Criterion 7A.

(9) Design of Surface Impoundments.

The reviewer should verify that any impoundment built as part of the corrective action program to contain wastes is acceptably designed, constructed, and installed. The design, installation, and operation of these surface impoundments must meet relevant guidance in Regulatory Guide 3.11, Section 1 (NRC 1977). Materials used to construct the liner should be reviewed to determine that they have acceptable chemical properties and sufficient strength for the design application. The reviewer should confirm that the liner will not be overtopped. The reviewer should also confirm that a proper quality control program is in place.

The review should ensure that the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 5(A) have been met. If the waste water retention impoundments are located below grade, the reviewer should determine that the surface impoundments have an acceptable liner to ensure protection of ground water. The location of a surface impoundment below grade will eliminate the likelihood of embankment failure that could result in release of waste water. The reviewer should determine that the design of associated dikes is such that they will not experience massive failure.

The design of a clay or synthetic liner and its component parts should be presented. At a minimum, design details, drawings, and pertinent analyses should be provided.

Expected construction methods, testing criteria, and quality assurance programs should be presented. Planned modes of operation, inspection, and maintenance should be discussed in the application. Deviations from these plans should be submitted to the staff for approval before implementation.

The liner for a surface impoundment used to manage uranium and thorium byproduct material must be designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the subsurface soil, ground water, or surface water at any time during the active life of the surface impoundment. The liner may be constructed of materials that allow wastes to migrate into the liner provided that the impoundment decommissioning includes removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate.

The liner must be constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure caused by pressure gradients, physical contact with the waste or leachate, climatic conditions, and the stresses of installation and daily operation. The subgrade must be sufficient to prevent failure of the liner caused by settlement, compression, or uplift. Liners must be installed to cover all surrounding earth that is likely to be in contact with the wastes or leachate.

Tests should show conclusively that the liner will not deteriorate when subjected to the waste products and expected environmental and temperature conditions at the site. Applicant test data and all available manufacturers test data should be submitted with the application for this purpose. For clay liners, tests, at a minimum, should consist of falling head permeameter tests performed on columns of liner material obtained during and after liner installation. The expected reaction of the impoundment liner to any combination of solutions or environmental conditions should be known before the liner is exposed to them. Field seams of synthetic liners should be tested along the entire length of the seam. Representative sampling may be used for factory seams. The testing should use state-of-the-art test methods recommended by the liner manufacturer. Compatibility tests that document the compatibility of the field seam material with the waste products and expected environmental conditions should be submitted for staff review and approval. If it is necessary to repair the liner, representatives of the liner manufacturer should be called on to supervise the repairs.

Proper preparation of the subgrade and slopes of an impoundment is very important to the success of the surface impoundment. The strength of the liner is heavily dependent on the stability of the slopes of the subgrade. The subgrade should be treated with a soil sterilant. The subgrade surface for a synthetic liner should be graded to a surface tolerance of less than 2.54 cm [1 in.] across a 30.3-cm [1-ft] straightedge. NRC Regulatory Guide 3.11, Section 2 (NRC, 1977) outlines acceptable methods for slope stability and settlement analyses, and should be used for design. If a surface impoundment with a synthetic liner is located in an area in which the water table could rise above the bottom of the liner, underdrains may be required. The impoundment will be inspected in accordance with Regulatory Guide 3.11.1 (NRC, 1980).

To prevent damage to liners, some form of protection should be provided, such as (a) soil covers, (b) venting systems, (c) diversion ditches, (d) side slope protection, or (e) game-proof fences. A program for maintenance of the liner features should be developed, and repair techniques should be planned in advance.

The surface impoundment must have sufficient capacity and must be designed, constructed, maintained, and operated to prevent overtopping resulting from (a) normal or abnormal operations, overfilling, wind and wave actions, rainfall, or run-on; (b) malfunctions of level controllers, alarms, and other equipment; and (c) human error. If dikes are used to form the surface impoundment, they must be designed, constructed, and maintained with sufficient structural integrity to prevent their massive failure. In ensuring structural integrity, the applicant must not assume that the liner system will function without leakage during the active life of the impoundment.

Controls should be established over access to the impoundment, including access during routine maintenance. A procedure should be developed that ensures unnecessary traffic is not directed to the impoundment area. A program should be established to ensure that daily inspections of tailings or waste impoundment systems are conducted and recorded and that failures or unusual conditions are reported to the NRC.

In addition, the reviewer should evaluate the proposed surface impoundment to determine if it meets the definition of a dam as given in Regulatory Guide 3.11 (NRC, 1977). If this is the case, the surface impoundment should be included in the NRC dam safety program, and be subject to Section 215, “National Dam Safety Program,” of the Water Resources Development Act of 1996. If the reviewer finds that the impoundment conforms to the definition of a dam, the dam ranking (low or high hazard) should be evaluated. If the dam is considered a high hazard, an emergency action plan is needed consistent with Federal Emergency Management Agency requirements. For low hazard dams, no emergency action plan is required. For either ranking of dam, the reviewer should also verify that the licensee has an acceptable inspection program in place to ensure that the dikes are routinely checked, and that performance is properly maintained.

A quality control program should be established for the following factors: (a) clearing, grubbing, and stripping; (b) excavation and backfill; (c) rolling; (d) compaction and moisture control; (e) finishing; (f) subgrade sterilization; and (g) liner subdrainage and gas venting.

(10) Financial Surety Is Provided.

The licensee must maintain a financial surety, within the specific license, for the cleanup of ground water, with the surety sufficient to recover the anticipated cost and time frame for achieving compliance, before the land is transferred to the long-term custodian. The financial surety must be sufficient to cover the cost of corrective action measures that will have to be implemented if required to restore ground-water quality to the established site-specific standards (including an alternate concentration limit standard) before the site is transferred to the government for long-term custody. Guidance on establishing financial surety is presented in NRC (1988, 1997). Appendix C to this standard review plan provides an outline of the cost elements appropriate for establishing surety amounts for conventional uranium mills. Any staff assessment of surety amounts is reasonably consistent with the applicant's.

4.4.4 Evaluation Findings

If the staff review, as described in standard review plan Section 4.4, results in the acceptance of the ground-water corrective action plan and compliance-monitoring plans, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the ground-water corrective action and compliance monitoring plans at the ________________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.4.2 and the acceptance criteria outlined in Section 4.4.3 of this standard review plan. The ground-water corrective action program should achieve the goal of returning hazardous constituent concentration levels in ground water to the concentration limits set as standards in 10 CFR Part 40, Appendix A, Criterion 5D. The monitoring program will provide reasonable assurance that, after the corrective actions have been taken, the ground-water protection standard will not be exceeded.

The licensee has established a ground-water compliance strategy that is acceptable for the site. The strategy consists either of no remediation or active remediation when contaminants are present at concentrations above background levels, maximum concentration limits, or alternate concentration limits. When active remediation is necessary, the remedial action design and implementation are acceptable. The licensee has acceptably presented pumping/injection rates, treatment methods, equipment and maintenance requirements, and plans and schedules for construction, and has produced maps showing locations of remediation equipment. An analysis has been conducted that demonstrates (1) the chosen active remediation system technology is appropriate for the site conditions, (2) design pumping rates are sustainable and will control migration of contaminants away from the site, and (3) the natural heterogeneity of the system has been acceptably accounted for in a conservative remediation strategy. The licensee has identified acceptable waste management practices. Qualified engineers, state authorities, and national agencies have provided appropriate oversight. Institutional controls are appropriate for the site, including (1) controlling access to the site, (2) conducting periodic inspections, and (3) periodically monitoring cleanup performance. The monitoring program includes (1) a description of quality assurance procedures; (2) the number of monitoring wells and their locations; (3) a list of constituents that will be sampled, along with the sampling frequency for each monitored constituent; and (4) action levels for triggering enhanced monitoring or revisions to cleanup activities. The licensee has described an acceptable scheme for cleanup and compliance monitoring. The licensee will sample ground water at the point of compliance for all hazardous constituents of concern. An adequate surety mechanism and fund has been established to support the ground-water cleanup.

On the basis of the information presented in the application and the detailed review conducted of the ground-water corrective action and compliance monitoring plans for the _______________ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in 10 CFR Part 40, Appendix A: Criteria 5A(4) and 5A(5), which require proper operation of impoundments and design of dikes;

Criterion 5B, which requires NRC to establish a list of hazardous constituents, concentration limits, a point of compliance, and a compliance period; Criterion 5C, which provides a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5(D), which provides requirements for a ground-water corrective action program; Criterion 5E, which requires licensees conducting ground-water protection programs to consider the use of bottom liners, recycle of solutions and conservation of water, dewatering of tailings, and neutralization to immobilize hazardous constituents; Criterion 5F, which requires that, where ground-water impacts from seepage are occurring at an existing site, action must be taken to alleviate the conditions that lead to seepage, and ground-water quality must be restored, including providing technical specifications for the seepage control system and implementation of a quality assurance program; Criterion 5G, which requires licensees to perform site characterization in support of a tailings disposal system proposal; Criterion 5H, which requires steps be taken during stockpiling of ore to minimize penetration of radionuclides into underlying soils; Criterion 7A, which provides for establishment of three types of monitoring systems: detection, compliance, and corrective action; Criterion 8A, which requires proper inspection and documentation of the operation of tailings and waste retention systems; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

If surface impoundments are to be used at the facility to manage byproduct material, the design of dikes used to construct surface-water impoundments has been demonstrated to comply with Regulatory Guide 3.11, Sections 2 and 3 (NRC, 1977) and, therefore, comply with requirements of 10 CFR Part 40, Appendix A, Criterion 5(A)5. In addition, because the impoundment dikes may conform to the definition of a dam as given in the Federal Guidelines for Dam Safety, they are subject to the NRC dam safety program, and to Section 215, “National Dam Safety Program, of the Water Resources Development Act of 1966.”

Surety funds and funding methods proposed by the applicant comply with 10 CFR Part 40, Appendix A, Criteria 9 and 10, which establish financial requirements for conventional uranium mills.

4.4.5 References

American Society for Testing and Materials Standards

D 5447, “Standard Guide for Application of a Ground-Water Flow Model to a Site-Specific Problem.”

D 5490, “Standard Guide for Comparing Ground-Water Flow Model Simulations to Site-Specific Information.”

D 5609, “Standard Guide for Defining Boundary Conditions in Ground-Water Flow Modeling.”

D 5611, “Standard Guide for Conducting a Sensitivity Analysis for a Ground-Water Flow Model Application.”

D 5718, “Standard Guide for Documenting a Ground-Water Flow Model Application.”

D 5880, “Standard Guide for Subsurface Flow and Transport Modeling.”

D 5981, “Standard Guide for Calibrating a Ground-Water Flow Model Application.”

Hostetler, C.J. and R. L. Erickson. “Coupling of Speciation and Transport Models.” *Metals in Groundwater*. H.E. Allen, E.M. Perdue, and D.S. Brown, eds. Chelsea, Michigan: Lewis Publishers. pp. 173–208. 1993.

Murphy, W.M. and E.L. Shock. “Environmental Aqueous Geochemistry of Actinides.” *Uranium: Mineralogy, Geochemistry, and the Environment*. P.C. Burns and R. Finch, eds. San Antonio, Texas: Center for Nuclear Waste Regulatory Analyses. 1999.

Parkhurst, D.L. and A.A.J. Appello. “User’s Guide to PHREEQC (Version 2)—A Computer Program for Speciation, Batch-Reaction, One Dimensional Transport, and Inverse Geochemical Modeling.” 99-4259. Washington, DC: U.S. Geological Survey. 1999.

Talisman Partners, Ltd. “Introduction to RACER 2000™ (Version 2.1.0). A Quick Reference.” Englewood, Colorado: Talisman Partners, Ltd. 2000.

NRC. “Technical Position on Financial Assurances for Restoration, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities.” Washington DC: NRC. 1988.

———. Regulatory Guide 3.11.1, “Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings.” Rev. 1. Washington, DC: NRC, Office of Standards Development. 1980.

———. Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1977.

5.0 RADIATION PROTECTION

This chapter of the standard review plan establishes the guidelines for NRC staff to perform and document its review of the proposed radiation protection design for disposal cell covers, for the cleanup of soil and structures contaminated with byproduct material (soil removal, building demolition and disposal or decontamination), and for the proposed radiation safety controls and monitoring during reclamation and decommissioning activities. The radiation standards to be addressed in the evaluation of the reclamation plan include 10 CFR Part 40, Appendix A, Criterion 6(1), which establishes a long-term radon flux limit and direct gamma exposure (background) level for the tailings disposal cell cover, and Criterion 6(5), which requires that the radioactivity of near-surface cover materials be essentially the same as surrounding surface soils. Also, the decommissioning plan, whether submitted as part of the reclamation plan or provided in detail as a separate document, should comply with 10 CFR 40.42(g)(4) and (5,) which requires a description or procedures indicating how the licensee will demonstrate that the residual radioactivity levels in land and on structure surfaces meet Appendix A, Criterion 6(6) (see Appendix H guidance in this standard review plan on the radium benchmark dose approach for cleanup of residual radionuclides other than radium). In the review, the staff should consider any licensee-proposed alternatives to Appendix A criteria as described in the Introduction of Appendix A to 10 CFR Part 40.

5.1 Disposal Cell Cover Radon and Gamma Attenuation and Radioactivity Content

5.1.1 Areas of Review

The areas of review for radon attenuation (radon barrier design) are the radiological and physical properties of the contaminated and cover materials and the application of the computer code or other methods used for calculating the estimated long-term radon flux from the completed disposal cell. The areas of review for the control of gamma radiation from the disposed waste and for the radioactivity content of the cover are the proposed methods to demonstrate compliance with the regulations. This area would also include consideration of disposal of wastes from processing alternate feed materials and non-11e.(2) byproduct material in uranium mill tailings impoundments, if such action is proposed.

The radon barrier portion of the disposal cell cover is the layer or layers designed to reduce radon flux from the cell. Other cover layers contribute to radon attenuation and may be considered in the flux calculation.

For the radon barrier design, the staff should review (1) the bases, assumptions, and procedures for determining the input parameter values of the tailings and other wastes and radon barrier materials (such as the sampling and testing programs); (2) procedures for materials placement in the disposal cell, as presented in the reclamation plan construction specifications; (3) the description of the model (numerical or analytical) used to approximate the average long-term radon flux at the cover surface; and (4) if the standard computer codes for estimating radon flux (RADON, RAECOM) are not used, references for the methodology used to calculate the long-term radon flux from the cover.

Radiation Protection

For cover gamma attenuation, the staff reviews the proposed procedure to calculate or measure the gamma level (exposure rate or count rate) on the cover. For the radioactivity content, the staff should review the proposal for measurements in the upper 61 cm [2 ft] of cover. Alternatively, the staff should review proposed control measures on the cover material before placement to demonstrate that the average radioactivity content of this layer is not distinguishable from local surface soil and to demonstrate that it does not include waste or rock containing elevated levels of radium.

5.1.2 Review Procedures

5.1.2.1 Radon Attenuation

The radon barrier design, as presented in the reclamation plan, should be reviewed along with the data supporting the design. Chapter 2.0 of this standard review plan presents review areas, procedures, and acceptance criteria for geotechnical information related to material properties and cell stability. The staff members assigned the health physics and geotechnical reviews should coordinate the review of the radon attenuation design and analysis. The geotechnical properties of the cover layers will be considered in the context of their influence on the cover integrity by considering long-term moisture content of the radon barrier. Materials underlying the radon barrier are evaluated for stability so that the cover will not experience cracking from settlement or subsidence, as discussed in Chapter 2.0.

In addition, the health physics reviewer should:

(1) Evaluate the basis for selection of parameter values for tailings and cover material properties to determine if the values are based on appropriate measurements or estimates and will lead to a reasonably conservative estimate of the radon flux. The scope and techniques used for site investigations should be examined to ensure that the field investigation (boring, sampling, and surveying) and testing programs will produce representative data needed to support the conclusions of the analyses.

(2) Assess whether parameter values are consistent with anticipated construction specifications and reflect expected long-term conditions at the site. The radon flux estimate must represent the average flux, for periods of more than 1 year but less than 100 years, and consider that the cell design life is 1,000 years.

(3) Determine whether the parameter values reflect the meteorological and hydrological conditions at the disposal site, bulk density, type of material, and the influence of overlying material layers. The cover material moisture content must be determined by accurately measured values or reasonably conservative estimates. Preferably more than one method is utilized, as there are limitations to each method and the long-term moisture content of the radon barrier is one of the most important parameters in the flux model.

(4) Determine that the radium (Ra-226) activity concentration in picocuries per gram (pCi/g) within the tailings cell has been, or will be, measured directly from representative tailings

samples, and other large-volume sources of contaminated material, utilizing an acceptable method. If the tailings were placed so that specific areas in the pile contain higher Ra-226 content (e.g., slime tailings), then Ra-226 values and the modeling should represent the layering or localization of the significantly elevated Ra-226 levels in the upper 3.6 m [12 ft], as deeper material generally has little effect on the radon flux. This approach is necessary because modeling higher concentrations of Ra-226 in the upper few feet of the pile would result in a higher radon flux estimate than using an average Ra-226 value for the entire upper 3.6 m [12 ft]. Also, if large quantities of material containing thorium-230 (Th-230) levels significantly higher than the Ra-226 levels are placed in the upper portion of the pile, the 1,000-year Ra-226 concentration (Ra-226 remaining from the residual Ra-226 and from the decay of Th-230) should be considered for that layer of material in the modeling.

In accordance with Footnote 2 of Criterion 6(1), the radon emissions from covering materials should be estimated as part of developing a closure (reclamation and decommissioning) plan. If any layer of the cover will contain material with above-background levels of Ra-226 or Th-230, the licensee should model that layer with a conservatively high estimated Ra-226 level, or should commit to measure the cover radionuclide level(s) during or after placement to confirm the adequacy of the radon attenuation design. A commitment from the licensee to confirm the cover Ra-226 content in the reclamation completion report should be present if the borrow site measurements are limited and the possible cover Ra-226 level could prevent the radon flux from being in compliance.

(5) Evaluate each code input parameter value, keeping in mind that the code default parameter values are not always conservative, and then consider the set of parameter values as a whole (balance of conservatism and uncertainty). It is the total flux model that will be approved, not individual parameter values. Consider that the void ratio, the density, porosity, and moisture saturation values should be typical of the soil type in each layer of the cell. The radon flux model should result in a representative and a reasonably conservative (given the uncertainty in some values) long-term radon flux estimate.

(6) A measured, not a calculated, disposal cell average radon flux is required by Appendix A, Criterion 6(2), as soon as practical after placement of the radon barrier, and Criterion 6(3) stipulates that radon-222 release rates must be verified for each portion of the pile or impoundment as the final radon barrier for that portion is placed, when phased emplacement of the final radon barrier is included in the applicable reclamation plan required by 10 CFR Part 40, Appendix A, Criterion 6A(1). Therefore, the reviewer should document in the technical evaluation report whether the reclamation plan stipulates if the radon barrier is to be placed in phases or as a fairly continuous operation. In either case, the final radon barrier must be placed as expeditiously as practicable. However, some tailings cells have evaporation ponds on top that can’t be covered until the ground-water correct action is complete. A commitment to measure and document the radon flux on the final radon barrier, as required by Criterion 6(2) and (4), should be in the reclamation plan. Before the measurements are performed, a map of the disposal cell indicating the measurement locations and outline of tailings and

cover extent should be reviewed by the NRC staff before the measurements are performed.

(7) Guidance on the disposal of wastes from processing alternate feed materials and non-11e.(2) byproduct materials in uranium mill tailings impoundments is presented in Appendix I to this standard review plan. The staff should use this guidance when evaluating requests to dispose of such materials and consider their impact on the radon attenuation design.

5.1.2.2 Gamma Attenuation

Most radon barriers should be thick enough to reduce the gamma level of the disposal cell to background. To demonstrate compliance with this aspect of Criterion 6(1), the cover gamma attenuation can be calculated based on the shielding value of the cover soil. Alternatively, the licensee commits to (1) measure the gamma level at 1 meter above the completed cover (or radon barrier) with at least one measurement per acre and (2) demonstrate that the average gamma level for the cell is comparable to the local background value.

5.1.2.3 Cover Radioactivity Content

At some mill facilities, uranium deposits, open pit uranium mines, overburden piles (soil moved from the pit area), and/or reclaimed mining areas are on or near the site. All of these areas would contain elevated levels of uranium, radium, and the other radionuclides in the uranium decay chain. In determining what surrounding soil values may be compared to the radionuclide content of the disposal cell cover, the mining areas reclaimed/restored under state regulations may be included. Also, consideration of the low health risk of human exposure to the cell cover and the perpetual custody of the cell by the government may be part of the risk-informed approach. If the average radioactivity (mainly radium level) for the cover material exceeds the average value for surrounding soil, the reclamation plan should contain a statistical analysis of the distributions of surrounding soil (not necessarily undisturbed background) and cover radioactivity to demonstrate that they are not significantly different.

5.1.3 Acceptance Criteria

5.1.3.1 Radon Attenuation

The radon attenuation design will be acceptable if it meets the following criteria:

(1) The one-dimensional, steady-state gas diffusion theory for calculating radon flux and/or minimum cover thickness is used. An acceptable analytical method for determining the necessary cover thickness to reduce radon flux to acceptable limits or to determine the long-term radon flux from the proposed cover is the computer code RAECOM (NRC, 1984) and the comparable RADON code (NRC, 1989). The main difference between the two codes is that RADON does not have the optimization for cost benefit calculations. The staff will use the RADON code to verify the analysis. Other methods that estimate the average surface radon release from the covered tailings may be

acceptable, if it can be shown that these methods produce reliable estimates of radon flux.

(2) With the RAECOM and RADON computer codes, the radon concentration above the top layer is either set to a conservative value of zero or a measured background value is used. The precision number (the level of computational error that is acceptable) is set at 0.001.

(3) The estimates of the material parameters used in the radon flux calculations are reasonably conservative, considering the uncertainty of the values. For all site-specific parameters, supporting information describing the test method and its precision, accuracy, and applicability is provided. The basis for the parameter values and the methods in which the values are used in the analyses are adequately presented. Moisture-dependent parameter values (e.g., radon emanation coefficient and diffusion coefficient) are based on the estimated long-term moisture content of the materials at the disposal site.

The materials testing programs employ appropriate analytical methods and sufficient and representative samples were tested to adequately determine material property values for both cover soils and contaminated materials. In the absence of sufficient test data, conservative estimates are chosen and justified. The quality assurance program for parameter data is adequate and the data are available for inspection. All parameter values are consistent with anticipated construction specifications and represent expected long-term conditions at the site.

(4) The contaminated material thickness is determined from estimates of total tailings production or waste placement and the areal extent, from boring logs, or changes in elevation from pre- to post-operation. Either the estimated thickness of a tailings source is used, or alternatively, the RADON code default value of 500 cm [16.4 ft] is used (NRC, 1989).

(5) Dry bulk densities of the cover soils and tailings material are determined from Standard Proctor Test data (American Society for Testing and Materials D 698) or Modified Proctor Test data (American Society for Testing and Materials D 1557). Radon barrier materials are usually compacted to a minimum of 95 percent of the maximum dry density as determined by American Society for Testing and Materials D 698 or to a minimum of 90 percent of the maximum dry density as determined by American Society for Testing and Materials D 1557. Field or placement densities to be achieved based on the construction specifications are used in the calculations. If the pile is stabilized in place, the *in situ* bulk density for the tailings is used in the analysis.

Porosities are measured by mercury porosimetry or another reliable method, or the method for estimating the porosity of cover soils and tailings materials using the bulk density and specific gravity given in Regulatory Guide 3.64 (NRC, 1989) is used.

If a portion of the modeled cover (radon attenuation layers) could be affected by freeze-thaw events, that portion is represented in the model with lower density and corresponding higher porosity values than the unaffected portion. The U.S. Army Corps of Engineers (1988) and the DOE (1988) have demonstrated that freeze-thaw cycles can increase the permeability of compacted clay by 40 to 300 times the original value. For fine-grained soils with some sand (50-percent fines), the DOE conservatively estimated that freeze-thaw cycles could lower the density by 14 percent (DOE, 1992). Also see the discussion in Section 2.5.3 of this standard review plan.

(6) The long-term moisture content that approximates the lower moisture retention capacities of the materials or another justified value is used. Estimated values for the long-term moisture content can be compared with present *in situ* values to assure that the assumed long-term value does not exceed the present field value. Borrow samples can be taken at a depth of 120 to 500 cm (3.9 to 16.4 ft), but not close to the water table, and the borrow site conditions should be correlated to conditions at the disposal site.

The following methods are acceptable for estimating the long-term soil moisture, but each has limitations:

(a) Laboratory procedures American Society for Testing and Materials D 3152 (fine-textured soils) and American Society for Testing and Materials D 2325 (coarse and medium-textured soils) for capillary moisture test (15-bar suction) corresponding to the moisture content at which permanent wilting of plants occurs (Baver, 1956).

(b) The empirical relationship (Rawls and Brakensiek, 1982) that predicts water retention values of a soil on a volume basis (appears to be more suitable to sandy and silty soil than to clayey soil) and is represented by:

$$c = 0.026 + 0.005x + 0.0158y$$

where

c = predicted 15-bar soil water-retention value (volumetric moisture content)
x = percent clay in the soil
y = percent organic matter in the soil

This method takes into consideration the particle-size distribution of the soil. Clay particle sizes are defined here as those less than 0.002 mm in diameter. Organic content measurement is generally determined by reaction with hydrogen peroxide or by exposure to elevated temperature. The volumetric moisture content value derived from this equation should be converted to a weight percentage for application in the RAECOM and RADON codes. Other empirical correlations (Section 7.1.3 of DOE, 1989), if adequately justified, may be acceptable.

(7) Values for Ra-226 activity (pCi/g) are measured directly from tailings samples and other large volume sources of contaminated material, by radon equilibrium gamma spectroscopy (allow at least 10 days for the sealed sample to equilibrate), wet chemistry alpha spectrometry, or an equivalent procedure. If the tailings are fairly uniform in Ra-226 content and the Ra-226 and uranium (U-238) in the ore were approximately in equilibrium, the Ra-226 activity can be estimated from the average ore grade processed at the site, as discussed in Regulatory Guide 3.64 (NRC, 1989). Generally, tailings should be sampled at 90-cm [3-ft] intervals to a depth of 366 cm [12 ft], including representative sampling of slime tailings. More than one layer of contaminated material is represented in the flux model if there are significant differences in Ra-226 content with depth.

Since the disposal cell performance standard deals only with radon generated by the contaminated material, it is acceptable to neglect the Ra-226 activity in the cover soils for modeling flux, provided the cover soils are obtained from materials not associated with ore formations or other radium-enriched materials. If deep {below 61 cm [2 ft]} cover layers contain elevated Ra-226 or Th-230, that material layer and its Ra-226 level is represented in the flux model.

(8) The emanation coefficient has been obtained by using methods provided in Nielson, et al. (1982) and properly documented, or otherwise set to the reasonably conservative (for most soils) code default value of 0.35. A value of 0.20 may be estimated for tailings based on the literature, if supported by limited site-specific measurements.

(9) The radon diffusion coefficient, D, represents the long-term properties of the materials. The D value is determined from direct measurements or appropriately calculated. The soil should be tested at the design compaction density, with a range of moisture content values that includes the lower moisture retention capacity of the soil so that a radon breakthrough curve can be obtained (DOE, 1989). The calculation of the diffusion coefficient, based on the long-term moisture saturation, and porosity, as proposed in Regulatory Guide 3.64, Section C.1.1.5 (NRC, 1989), and the optional calculation in the RADON code, are acceptable.

(10) The soil cover thickness proposed in the reclamation design is such that the calculated average long-term radon flux is reduced to a level that meets the requirement in 10 CFR Part 40, Appendix A, Criterion 6(1).

5.1.3.2 Gamma Attenuation

The proposed cover will reduce the gamma radiation from the byproduct material to local soil background levels, and the licensee proposed an acceptable method to demonstrate this. The data will appear in the reclamation completion report.

5.1.3.3 Cover Radioactivity Content

At least the upper 61 cm [2 ft] of the disposal cell cover will contain levels of radioactivity essentially the same as surrounding soils, as demonstrated by an appropriate procedure. The data will be in the reclamation completion report if not available for the reclamation plan.

5.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radon and gamma attenuation and cover radioactivity content assessments, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the disposal cell cover radiation control at the _________________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.1.2, and the acceptance criteria outlined in Section 5.1.3 of this standard review plan.

The licensee has presented an acceptable radon attenuation design, and the staff evaluation determines that (1) the method used for calculating radon flux or minimum cover thickness is based on the one-dimensional, steady-state gas diffusion theory and appropriate input values; (2) input values of the material parameters lead to a reasonably conservative estimate of the long-term radon flux; (3) material parameters are consistent with construction specifications and expected long-term conditions; (4) the long-term attenuating capability of cover materials is justified using acceptable results of relevant tests or conservative estimates; (5) estimates of contaminated materials thickness are determined utilizing a sufficient number of data or by use of the default value; (6) if not measured, the estimated porosity of cover soils and tailings materials is based on the method in Regulatory Guide 3.64; (7) soil moisture values represent long-term moisture retention capacities; (8) Ra-226 activity has been measured in the tailings and other large volume sources of contaminated materials using acceptable procedures; (9) the emanation coefficient is obtained by either the equilibration method or the prediction method, or is set to a reasonably conservative value of 0.35; (10) the radon diffusion coefficient of the cover soil is determined from direct measurements or from a calculation based on Regulatory Guide 3.64; and (11) the cover gamma level and radioactivity content will be correctly determined and documented.

On the basis of the information presented in the application and in detailed review conducted of the site characterization for the _________________ uranium mill facility, the NRC staff concludes that the disposal cell cover radon and gamma attenuation and radioactivity content are in compliance with 10 CFR Part 40, Appendix A, Criterion 6(1), which requires placement of an earthen cover (or approved alternative) over tailings and wastes at the end of the milling operations while providing assurance of control of radiological hazards for 1,000 years, to the extent reasonably achievable (but no less than 200 years); and which limits releases of radon-222 from uranium byproduct materials to the atmosphere so as not to exceed an average rate of 20 picocuries per square meter per second (pCi/m^2-s); Criterion 6(2), which requires demonstration of the effectiveness of the final radon barrier prior to emplacement of erosion protection measures or other features; Criterion 6(3), which requires demonstration of the effectiveness of phased placement of radon barriers as each phase is completed if phased placement is in the plan; and Criterion 6(5), which requires that radon exhalation is not significantly above background because of the cover material.

5.1.5 References

American Society for Testing and Materials Standards:

D 698-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

D 1557-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

D 2325-68, "Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus."

D 3152-72, "Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-membrane Apparatus."

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DOE. 1988. "Effect of Freezing and Thawing on UMTRA Covers." Albuquerque, New Mexico: DOE, Uranium Mill Tailings Remedial Action Project. 1988.

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Nielson, K.K., et al. "Radon Emanation Characteristics of Uranium Mill Tailings." Proceedings of the Symposium on Uranium Mill Tailings Management December 9–10. Ft. Collins, Colorado: Colorado State University. 1982.

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———. Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers." Washington, DC: NRC. 1989.

Rawls, W.J. and D.L. Brakensiek. "Estimating Soil Water Retention From Soil Properties." Proceedings of the American Society of Civil Engineers. *Journal of the Irrigation and Drainage Division*. Vol. 108, No. IR2. 1982.

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U.S. Army Corps of Engineers. "Effects of Freezing and Thawing on the Permeability of Compacted Clay." Hanover, New Hampshire: Cold Regions Research and Engineering Laboratory. 1988.

5.2 Decommissioning Plan for Land and Structures

5.2.1 Areas of Review

The areas of review for the decommissioning (radiological cleanup and restoration) of land and structures (e.g., towers and buildings) are the site conditions (nature and extent of the contamination, soil background radioactivity, etc.); planned decommissioning activities (how and what measurements will be made, quality assurance quality control program, gamma guideline levels for soil cleanup, how "as low as is reasonably achievable" will be demonstrated); methods to be used to protect workers, the public, and the environment; verification (final status survey) plan with procedures; and the decommissioning cost estimate and surety amount. Often, the detailed mill decommissioning plan and the soil cleanup and verification plan are submitted for NRC approval a year before decommissioning is scheduled to begin. However, the reclamation plan must describe the expected decommissioning activities in enough detail to support the cost estimate needed for surety purposes. The preliminary decommissioning plan in the reclamation plan should include commitments to provide a detailed plan and cost estimate for NRC approval at least 9 months before decommissioning is expected to begin.

5.2.2 Review Procedures

(1) Site Conditions (Characterization)

Based on the operational history (including radiation surveys) of the facility, the reviewer determines that the plan describes the likely source and locations of residual byproduct material such as spills, releases, waste burial, haul roads, diversion ditches, process and yellowcake storage areas, ore stockpile areas, areas likely to be affected by windblown tailings, and tailings solution evaporation ponds. Determine that the extent of contamination (area and depth for soil) has been or will be established from adequate representative sampling and surveying. Sample analysis should include uranium where yellowcake or ore dust was present and thorium (Th-230) for acidic tailings pond residue. The radiological analysis for the ore processed at the site should also be reviewed for the ratios of Ra-226/U-238 and Ra-226/Th-230 to determine if non-equilibrium conditions could exist in the contaminated soil. The U-238 activity can be estimated by dividing the U-nat (total uranium) value by two. The reviewer should also determine from this data if Th-232 could be elevated above background due to windblown tailings and whether additional characterization data should be provided.

(2) Soil Background Radioactivity

Determine that the background level of Ra-226 (and U-nat, Th-230 and Th-232, as needed) in surface {15 cm [6 in.]} soil has been estimated using representative soil samples from nearby {within 3.2 km [2 mi] of site boundary} undisturbed areas that are not affected by site activities and are geologically and chemically similar to the contaminated areas. The number of samples will depend partly on the variability in background values, but at least 30 samples should be obtained at the typical site to determine the average value, standard deviation, and distribution. The arithmetic mean of the sample data is used in the cleanup criteria unless appropriate statistical analysis demonstrates a log normal distribution (three tests) of the data.

Several different background values may be required if contaminated areas have distinctly different soil types. For example, if a portion of the site has a natural uranium and/or radium mineralization zone in/near the surface, the cleanup criterion for that area would use a background (reference) U-238 or Ra-226 value from a similarly mineralized area. A geologic site map with the background values placed on the sample location can be used to help identify whether more than one background value should be considered.

If the plan indicates that *in situ* ore is in the clean-up area, it should be characterized by Ra-226/U-238 ratios, visual criteria, and/or other means.

(3) Cleanup Requirements

For land cleanup, the residual Ra-226 [and/or Ra-228 if thorium (Th-232) byproduct material is present] in soil must meet the concentration limits in 10 CFR Part 40, Appendix A, Criterion 6(6), in areas that are not evaluated by the radon flux criterion (i.e., areas other than the disposal cell). If the plan indicates that the subsurface 15 pCi/g Ra-226 standard will be used, its use should be justified. For structures to remain on site, the staff reviews the proposed cleanup of mill-related radionuclides (byproduct material) on surfaces (e.g., walls, floors, drains) as well as in underlying soil.

For NRC uranium recovery licensees that did not have a decommissioning plan approved by June 11, 1999, [Appendix A, Criterion 6(6) was expanded effective that date], or that subsequently submit a revised plan, the radium benchmark dose applies for cleanup of residual radionuclides other than radium [primarily uranium (U-nat) and thorium (Th-230)] in soil and for surface activity on structures. For such licensees, the reviewer should refer to Appendix H of this document for guidance on the benchmark approach. This approach would also be evaluated if proposed by other uranium recovery licensees to derive cleanup limits in order to demonstrate compliance with 10 CFR 40.42(k)(2).

Determine that the plan indicates that residual contamination will be reduced to “as low as is reasonably achievable levels.” Usually, a low gamma guideline level is chosen so that most grids are cleaned to near background levels of radiation, an approach that has proven less costly for licensees than more extensive soil sampling and analysis. It is a method acceptable to the staff to demonstrate compliance with the “as low as is reasonably achievable” principle. The administrative limit for surface activity (10 to

25 percent of the criteria) has been considered an “as low as is reasonably achievable” level in the past but current policy should be confirmed by staff. The “as low as is reasonably achievable” approach discussed in NUREG–1727 (NRC, 2000b), also may be considered.

(4) Gamma Guideline Level

Because gamma measurements (in terms of exposure or count rates) can substitute for some Ra-226 analyses [as recommended in 40 CFR 192.20(b)(1)] and such measurements are not very reliable, the reviewer must be sure that the proposed gamma guideline value is conservative, considering the measurement uncertainties involved. Determine that the radium-gamma correlation that is used to derive the gamma guideline was performed with at least 30 soil Ra-226 values from approximately 2 to 25 pCi/g and that the corresponding gamma values adequately represent the grid (100-square-meter area) sampled. The proposed gamma guideline level must reliably (95 percent confidence) result in grids meeting the 5 pCi/g [0.19 Bq/g] Ra-226 plus background standard.

Confirm that the plan contains a commitment to perform a radium-gamma correlation on the verification data, to track soil samples that fail the Ra-226 criteria, and to perform additional cleanup after a verification soil sample exceeds the Ra-226 standard. Just cleaning the failed grid is not adequate because the failed sample could indicate that the gamma value may not be conservative and that some of the unsampled grids may also fail to meet the standard. For example, the plan could indicate that neighboring grids would also be analyzed for Ra-226 or, if the number of failed grids is excessive, the gamma guideline would be adjusted downward and areas further remediated, as necessary.

(5) Instruments and Procedures

Determine that the instruments and procedures used to determine the soil background radioactivity and the radium-gamma correlation are the same or very similar to those proposed for verification of compliance with Criterion 6(6) (final status survey). See NUREG–1505, Section 4.5 (NRC, 1998a). Instrument sensitivity should be adequate to reliably identify the proposed guideline levels [NUREG–1507 (NRC, 1998b)]. Survey instruments are specified and will be properly calibrated and tested, including daily checks during operations. The reviewer considers national standards (American Society for Testing and Materials, American National Standards Institute, and National Council on Radiation Protection as listed in Section 5.2.5) and the “Multi-Agency Radiation Survey and Site Investigation Manual” [NUREG–1575 (NRC, 2000a)] that contains general principles of soil sampling, determination of background, and gamma surveying to be acceptable.

Soil samples for uranium recovery sites can be composite samples (5 to 11 samples per grid have been approved). Evaluate sampling procedures for completeness (ensure proper depth, identification of sample and location, cleaning of equipment, chain-of-custody, etc). Determine that soil preparation procedures indicate that rocks and vegetation should not be included in the sample to the extent that the additional volume would dilute the soil sample. Generally, rocks greater than or equal to 1.27 cm [0.5 in.] in diameter are excluded. Acceptable sample mixing, drying, and splitting methods are specified.

Evaluate the methods for soil radionuclide analysis. Standard analytical methods should be used. Portions of each sample verifying compliance should be archived until the NRC approves the decommissioning completion (final survey) report, as staff may want to do confirmatory analysis on selected soil samples. The plan for the final disposal of these archived samples should also be reviewed.

As required by 10 CFR 40.42(j)(2)(i), the gamma levels to be reported in the final survey are as mSv (μR) per hour at 1m [39.4 in.] from the surface. Measurements at 1 m [39.4 in.] would allow calculation of an exposure dose, but the goal of the gamma survey is to demonstrate compliance with the radium in soil criterion. Therefore, the staff has approved alternate methods such as meter readings (counts/minute) taken near the ground or at 0.45 m [18 in.]. These methods improve the quality of the gamma-radium correlation by reducing “shine” and they allow the survey meter and equipment associated with a global positioning system to be mounted on an all-terrain vehicle. Typically, measurements are made over the spot to be sampled, or the grid (100 m^2) is scanned with 9 to 12 measurements. Integrated count rate gamma scan values have also been approved if taken for at least one (1) minute within each grid.

Determine that gamma survey procedures indicate the speed, pattern, and spacing of the measurements or scan path. The procedure should allow demonstration of compliance with the radium standard. The reviewer should consider the thoroughness of the gamma scan (remedial action survey) to be done during soil removal, such as 1.5-m [5-ft] scan path, when evaluating the final survey procedures and the percentage of grids proposed for soil sampling.

Determine that procedures for measuring alpha or beta-gamma radiation on structure surfaces are detailed, reflect industry standards, and consider that smears for alpha activity generally have an efficiency of 10 percent or less. Measurements of smears are difficult to interpret quantitatively and should not be used for determining compliance but for determining if further investigation is necessary [NUREG–1575, Sections 6.4.2 and 8.5.3 (NRC, 2000a)].

(6) Quality Assurance and Quality Control

Determine that the quality assurance/quality control program addresses all aspects of decommissioning. The plan should indicate a confidence interval or that one will be specified before collection of samples. At least 10 percent of the soil samples should be split and a portion sent to an outside laboratory for quality assurance. To properly assess the adequacy of radiological data, the uncertainties associated with the data should be estimated statistically [NUREG–1501, Sections 3.2 and 5.2 (NRC, 1994)].

Evaluate the criteria for validating that the data to be used to demonstrate compliance and the quality assurance procedures to confirm that compliance data are precise and accurate (e.g., laboratory will analyze spiked and duplicate samples, etc.). Confirm that management will ensure that approved procedures are followed (e.g., commitment to check gamma surveyor and data management).

(7) Final Status Survey

Evaluate the details of the proposed final status survey (radiation surveys and soil analyses) as discussed in Items 3–6 above, and determine whether the survey plan complies with 10 CFR 40.42(j)(2). The reviewer should also determine that enough data of the proper quality can be provided after decommissioning to demonstrate compliance with Criterion 6(6) of Appendix A and 10 CFR 40.42(k)(2). For example, determine that the proposed number and pattern of grids to be soil sampled and analyzed for Ra-226 are justified. Based on the degree of uncertainty (level of error in the measurements, number of measurements), the gamma guideline level, and implementation procedures, the staff has considered soil samples from 0.5 to 10 percent of the grids acceptable. Some verification soil sampling and surveying should be planned in presumably uncontaminated areas (buffer zone of about 30 meters beyond excavated areas). [Refer to Section 3 in Inspection Procedure 87654 (NRC, 2002) for additional information.]

Confirm that the licensee proposes to use the same instruments and procedures for the verification (final status) survey as were used in determining background and for the radium-gamma correlation, or justifies that they are comparable.

If buildings or other structures are to remain on site after license termination, determine whether adequate measurement of the surface activity is planned. Preliminary modeling by staff has indicated, that for habitable buildings, the average total (fixed plus removable) alpha level should be below 2,000 dpm/100 cm^2 in order to achieve 0.25 mSv/yr [25 mrem/yr].

(8) Preliminary Versus Final Decommissioning Plan

A preliminary decommissioning plan shall be submitted with the reclamation plan and may be updated for license renewal in order for the staff to better evaluate the decommissioning cost estimate provided for surety purposes. Since the actual site decommissioning may be years in the future and continued operation could change the cleanup design, or evolving technology and Agency rules or guidance could change the evaluation of procedures, the review of the preliminary plan should not be technically rigorous. However, the reviewer should determine whether sufficient detail has been provided in the plan to justify that the surety amount for decommissioning activities is adequate.

Confirm that both the preliminary and final plans identify a location to keep the records of information important to the decommissioning, as required by 10 CFR 40.36(f). These records would include documentation of spills or cleanup of contamination, drawings or descriptions of modification of structures in the restricted area, and locations of possible inaccessible contamination.

When a final decommissioning plan is submitted, the reviewer should determine whether the plan addresses the technical aspects discussed above [basically 10 CFR 40.42(g)(4) requirements] and whether it indicates that decommissioning will be completed as soon as practicable. The reviewer follows Section 5.3 of this standard review plan for the evaluation of the health and safety protection aspects of decommissioning. The reviewer should also consider recommendations in Regulatory Guide 3.65 (NRC, 1989) during the evaluation of the final decommissioning plan.

(9) Non-Radiological Hazardous Constituents

The decommissioning plan must address the non-radiological hazardous constituents of the byproduct material according to 10 CFR Part 40, Appendix A, Criterion 6(7). For windblown tailings areas, meeting the surface Ra-226 standard should be adequate to control these constituents in soil. A tailings cell cover that meets Appendix A criteria should control, minimize, or eliminate postclosure escape of non-radiological hazardous constituents into surface water and the atmosphere. However, any unusual or extenuating circumstances related to such constituents should be discussed in the reclamation plan or decommissioning plan in relation to protection of public health and the environment and should be evaluated by staff. The control of these substances in ground water is addressed under Chapter 4.0 of this standard review plan.

(10) Decommissioning Cost Estimate

Determine whether the cost estimate is itemized in sufficient detail such that values for soil sampling and preparation, Ra-226 analysis, gamma surveying, and data management are presented. The items should reflect the proposed activities in the plan. Also, the basis for each cost should be provided and verified by staff to be within the range of current charges for such activities in the site region. The staff should verify that adequate surety funds will be provided to cover these costs. Guidance on cost estimates for sureties is provided in Appendix C of this standard review plan.

5.2.3 Acceptance Criteria

The decommissioning plan will be acceptable if it meets the following criteria:

(1) The plan contains procedures to identify and place within the disposal cell, all soils on and adjacent to the processing site that are in excess of the standards in 10 CFR Part 40, Appendix A, Criterion 6(6), due to site activities. The plan is substantiated by the radiological characterization data and site history.

(2) Appropriate soil background values (different geological areas may need separate background values) for Ra-226, and for U-nat, Th-230, and/or Th-232, as appropriate, have been proposed with supporting data.

(3) If elevated levels of uranium or thorium are expected to remain in the soil after the Ra-226 criteria have been met, the licensee has used the radium benchmark dose approach in Appendix H for developing decommissioning criteria for these radionuclides.

(4) To ensure consistency of measurement data, instrumentation and procedures used for soil background analyses and the radium-gamma correlation are the same or very similar to those proposed to provide verification data. The instrumentation has the appropriate sensitivity, and procedures are adequate to provide reliable data.

(5) A detailed quality assurance and quality control plan for all aspects of decommissioning is provided. In addition to the basis for accepting or rejecting data, a procedure for sampling additional grids when a verification Ra-226 sample fails to meet the standard is provided.

(6) Final verification (status survey) procedures are adequate to demonstrate compliance with the soil and structure cleanup standards. Survey instruments are specified and will be properly calibrated and tested. The proposed verification soil sampling density takes into consideration detection limits of sample analyses, the extent of expected contamination (unaffected area could have fewer measurements than affected areas), and limits to the gamma survey for the potentially contaminated area to be sampled. The gamma guideline value to be used for verification has been appropriately chosen. Also, there is a commitment to provide the verification soil radium-gamma correlation and the number of verification grids that had additional removal because of excessive Ra-226 values, to confirm that the gamma guideline value was adequate. The plan provides for adequate data collection beyond the excavation boundary (buffer zone).

For structures to remain onsite, adequate plans/procedures to demonstrate compliance with the limits for the surface activity dose in Appendix H of this standard review plan have been developed.

(7) The plan indicates the location of records important to decommissioning procedures for protection of health and safety and demonstrates that decommissioning will be completed as soon as practicable, as required by 10 CFR 40.42 and Appendix A, Criterion 6A.

(8) The decommissioning cost estimate is itemized in sufficient detail and a basis (source) for each cost is provided. The total cost is reasonable for the area of the site and the expected decommissioning activities.

(9) The plan adequately describes the control of non-radiological hazards associated with the wastes as required by 10 CFR Part 40, Appendix A, Criterion 6(7).

(10) As required by Appendix A, Criteria 9 and 10, the licensee must maintain a financial surety, within the specific license, for the surface reclamation and decommissioning, with the surety sufficient to recover the anticipated cost and time frame for achieving compliance, and include the long-term surveillance. Guidance on establishing financial surety is presented in NRC (1988, 1997). Appendix C to this standard review plan provides an outline of the cost elements appropriate for establishing surety amounts for conventional uranium mills. Any staff assessment of surety amounts is reasonably consistent with the applicant’s assessment.

5.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the processing site (soil and structures) decommissioning plan, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the site decommissioning plan for soil and structures at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.2.2, and the acceptance criteria outlined in Section 5.2.3 of this standard review plan.

The licensee has provided an acceptable site decommissioning plan, including (1) appropriately substantiated site characterization data or plans to identify contaminated areas; (2) plans to clean up and place within the disposal cell, all materials that are in excess of the standards and approved guidelines, including hazardous material; (3) sufficient information concerning instrumentation and procedures; (4) plans for post-reclamation survey and sampling for verification that the soil and structures meet radiological limits; (5) location for retention of records important to decommissioning; (6) methods to protect workers, the public, and the environment; and (7) a cost estimate for all proposed decommissioning activities.

On the basis of the information presented in the reclamation plan and the detailed review conducted of proposed decommissioning activities for the _______________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which requires that any portion of a licensed uranium mill site not designed to control radon releases, contain a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material, does not exceed the background levels by more than (i) 5 pCi/g of Ra-226 averaged over the first 15 cm [6 in.] below the surface, and (ii) 15 pCi/g of Ra-226 averaged over 15-cm-thick layers more than 15 cm below the surface. Also, the cleanup of other residual radionuclides in soil and residual surface activity on structures to remain on site, meet the criteria developed with the radium benchmark dose approach, including a demonstration of “as low as is reasonably achievable” radiation levels and application of the unity test where applicable. For cases in which the licensee has proposed an alternative to the requirements of Criterion 6(6) or the approved guidance, the staff determines that the resulting level of protection is equivalent to that required by this criterion. In addition, the plan demonstrates compliance with 10 CFR Part 40, Appendix A, Criterion 6(7), which requires prevention of threats to human health and the environment from non-radiological hazards associated with the wastes.

The decommissioning plan specifies the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and meets the criteria of 10 CFR 40.42(g)(4) and (5). The plan sufficiently demonstrates that the proposed decommissioning activities will result in compliance with 10 CFR 40.42(j)(2) requirements to conduct a radiation survey. The plan complies with the 10 CFR 40.42(k)(1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination. The decommissioning cost estimate meets the requirements of 10 CFR 40.42(g)(4)(v) and Appendix A, Criterion 9.

5.2.5 References

American National Standards Institute Standards:

N42.17A–1989, "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions."

N42.12–1994, "American National Standard Calibration and Usage of Thallium-Activated Sodium Iodide Detector Systems for Assay of Radionuclides."

American Society for Testing and Materials Standards:

C 998-90 (reaffirmed 1995), "Standard Practice for Sampling Surface Soil for Radionuclides."

D 5283-92, "Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation."

E 181-93, "Standard Test Methods for Detector Calibration and Analysis of Radionuclides."

E 1893-97, "Standard Guide for Selection and Use of Portable Survey Instruments for Performing *In Situ* Radiological Assessments in Support of Decommissioning."

National Council on Radiation Protection and Measurements. "Calibration of Survey Instruments Used in Radiation Protection for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination." Report No. 112. 1991.

NRC. "Uranium Mill *In-Situ* Leach Uranium Recovery, and 11e(2) byproduct Material Disposal Site Decommissioning Inspection." Inspection Manual—Inspection Procedure 87654. Washington DC: NRC. March 2002.

———. NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual." Rev. 1. Washington DC: NRC. 2000a.

———. NUREG–1727, "NMSS Decommissioning Standard Review Plan." Washington, DC: NRC. 2000b.

———. NUREG–1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys." Rev. 1. Washington DC: NRC. 1998a.

———. NUREG–1507, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions." Washington DC: NRC. 1998b.

———. "Annual Financial Surety Update Requirements for Uranium Recovery Licensees." Generic Letter 97-03. Washington, DC: NRC. July 9, 1997.

———. Regulatory Guide 3.65, “Standard Format and Content of Decommissioning Plans Under 10 CFR Parts 30, 40, and 70.” Washington DC: NRC, Office of Standards Development. 1989.

———. “Technical Position on Financial Assurances for Restoration, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities.” Washington, DC: NRC. 1988.

5.3 Radiation Safety Controls and Monitoring

5.3.1 Areas of Review

The areas of review for radiation safety for protecting the site worker, the public, and the environment during reclamation and decommissioning are the control of releases, the radiation exposure and environmental monitoring programs, and the contamination control program. Decommissioning activities at mill sites involve occupational, and possibly public, exposures to radioactive materials that may require different or additional monitoring and control procedures than during site operation or standby status. Potential sources of exposure from working with tailings material are caused by airborne particulate contamination, radon gas, and external gamma radiation. Surface activity or dust on equipment and structures to be dismantled or decontaminated could also be a source of exposure.

The reclamation and final decommissioning plans should contain the licensee’s evaluation of the site current radiation safety/protection plan or program and any proposed changes to the program for reclamation and decommissioning operations. The proposed measures should keep exposures as low as is reasonably achievable and in compliance with the requirements of 10 CFR Part 20. Key components of the program should address hazards unique to the reclamation or decommissioning work environment. Any new activities that could increase hazards to general health and safety (e.g., cleanup in confined spaces, or removal of hazardous or flammable chemicals) should be identified, considering the NRC Memorandum of Understanding with the Occupational Safety and Health Administration.

5.3.2 Review Procedures

Determine that the proposed radiation safety controls and all monitoring programs and procedures are sufficient to comply with the regulatory requirements during decommissioning and reclamation. A licensee will already have an approved radiation safety program in place; therefore, the focus of the review should be to ensure that the reclamation plan addresses those aspects of worker and public protection that require special consideration in planning reclamation and decommissioning activities. The environmental impacts of these activities will be addressed in the environmental assessment, but any concerns requiring mitigation should be addressed in the reclamation plan. The reclamation plan should confirm the applicability of the radiation protection and monitoring programs to reclamation and decommissioning activities or should propose changes to address new program needs based on review of the following:

Radiation Protection

(1) Control of Releases

Determine whether the proposed systems and procedures (e.g., tailings stabilization, dust control) are sufficient to minimize environmental emissions from the tailings impoundment construction activities or structure demolition, taking into consideration important release mechanisms such as wind resuspension and surface erosion. Radon gas emanating from the tailings pile is also a radiation safety concern for workers and downwind off-site populations. However, because control of the source is not possible during tailings recontouring or cleanup, the reviewer should examine the means proposed to limit the worker inhalation hazard (i.e., limiting exposure time, or using dust masks or respirators if required) and to establish an acceptable environmental monitoring program for measuring off-site airborne concentrations. Also, liquid releases can be created by rainwater runoff. Therefore, the review of the reclamation plan should include an evaluation, taking all exposure pathways into account, of proposals for ensuring off-site exposures are as low as is reasonably achievable.

(2) External Radiation Exposure Monitoring Program

Determine if changes to the existing program are needed or if proposed changes are adequate. The reviewer should consider the types of surveys conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. Also, consider if changes are required in the program for personal/personnel monitoring (dosimeters and air samplers), including the criteria for placing workers in the program.

(3) Airborne Radiation Monitoring Program for Work Areas

Evaluate whether the proposed sampling locations, frequencies, procedures, and equipment are adequate to determine concentrations of airborne radioactive materials (including radon) in work areas during construction, demolition, and cleanup activities. Action levels, audits, and corrective action requirements should also be evaluated.

(4) Bioassay Program

Review the existing bioassay program or proposed changes to determine whether the proposed bioassay program is sufficient to protect employees performing decommissioning activities in yellowcake processing areas.

(5) Contamination Control Program

Evaluate the occupational radiation survey program. This review should include proposed housekeeping and cleanup requirements and specifications for clean areas to control contamination. Action levels for clean areas and for the release of materials, equipment, and work clothes from clean areas and/or the site should be evaluated.

(6) Environmental Monitoring Program

Determine whether the environmental monitoring program proposed for measuring concentrations and quantities of both radioactive and non-radioactive materials released to, and in, the environs of the proposed facility, are sufficient to protect employees and the public. Potential releases during disposal cell construction and cleanup activities will be primarily from resuspended tailings material and radon gas. The reviewer should focus on the frequency of sampling and analysis, the types and sensitivity of analyses, action levels, corrective action requirements, and the required number of effluent and environmental monitoring stations (including criteria for determining monitor station locations considering the reclamation work). The guidance in Regulatory Guide 4.20 (NRC, 1996) should be considered.

(7) Record Keeping

Determine whether the record keeping requirements for the radiation protection program have been addressed; that is, records of the provisions of the program and audits or other reviews of content and implementation are maintained for at least 3 years. Other records are maintained according to Subpart L of 10 CFR Part 20 and 10 CFR Part 40, Appendix A, Criterion 6(4).

5.3.3 Acceptance Criteria

The radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning will be acceptable if they meet the following criteria:

(1) The reclamation plan identifies the radiation safety concerns that are unique to reclamation and decommissioning activities. These concerns include characterization of radiation hazards associated with inhalation of resuspended tailings material or yellowcake, gamma exposure from working close to tailings, and inhalation of radon gas and its progeny (decay products) emanating from tailings material.

(2) The reclamation plan describes any changes to an existing radiation safety or monitoring program that would be necessary to ensure worker or public safety during reclamation or decommissioning activities.

(3) Standard dust control measures such as regular wetting and/or phased stabilization are to be used for control of windblown tailings material or yellowcake dust.

(4) Any proposed changes to the established bioassay program will meet criteria of the applicable parts of Regulatory Guide 8.22, “Bioassay at Uranium Mills” (NRC, 1988) and Regulatory Guide 8.9, Revision 1, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program” (NRC, 1993), or an acceptable justification is provided for selecting an alternate approach.

(5) Any proposed workplace airborne radiological monitoring program will support the proposed bioassay program and is consistent with applicable parts of Regulatory Guide 8.25, “Air Sampling in the Workplace” (NRC, 1992) and Regulatory Guide 8.30, “Health

Physics Surveys in Uranium Mills" (NRC, 2002), or an acceptable justification is provided for selecting an alternate approach. The monitoring program will provide adequate protection of workers from radon gas or particulate exposures to maintain compliance with the inhalation limits in 10 CFR Part 20. If sampling locations will be revised, the reclamation plan contains one or more maps of the site that indicate the location of samplers for airborne radiation and provide the justification for determining the revised locations.

(6) Any proposed contamination control program is consistent with the guidance on conducting surveys for contamination of skin and of personal clothing presented in Regulatory Guide 8.30 (NRC, 2002).

(7) Any proposed environmental radiological monitoring program is consistent with applicable parts of Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC, 1980), or an acceptable justification is provided for selecting an alternate approach. The licensee has adequately considered site-specific aspects of climate and topography in determining locations of off-site airborne monitoring stations and environmental sampling areas so that detection of maximum off-site concentrations of windblown tailings material and contamination from any other significant transport pathways applicable to the site is ensured.

(8) Any proposed radiation protection program contains plans for documentation of exposures to all monitored workers and contractors and for availability of exposure records in a single location for inspection. The program provides for recordkeeping that meets the requirements of 10 CFR 20.2102; at least annual review of the program content and implementation; and implementation of the "as low as is reasonably achievable" requirements of 20.1101(d).

5.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiation safety controls and monitoring for site worker, public, and environmental protection during disposal cell construction and site cleanup, the following conclusions may be presented in the technical evaluation report:

The staff has completed its review of the radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning at the ________________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.3.2 and the acceptance criteria outlined in Section 5.3.3 of this standard review plan.

The licensee has provided an acceptable evaluation of radiation safety controls and monitoring required for worker, public, and environmental protection during reclamation and decommissioning activities, including (1) identification of the radiation safety concerns that are unique or likely to increase during reclamation construction and site decommissioning; (2) any necessary changes and associated justifications in the radiation safety program, such as personnel and environmental monitoring; (3) identification and discussion of any changes in an existing radiation protection program; (4) control of potential contamination from windblown tailings by regular wetting and/or phased stabilization; and (5) the monitoring and contamination control programs will allow compliance with applicable portions of 10 CFR Parts 20 and 40.

On the basis of the information presented in the reclamation plan and the detailed review conducted of the radiation safety controls and monitoring for worker, public, and environment protection during reclamation and decommissioning for the _______________ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with 10 CFR 20.1101, which requires development, documentation, and implementation of a radiation protection program ensuring compliance with 10 CFR Part 20 requirements and the use of procedures and engineering controls to achieve occupational and public doses that are as low as is reasonably achievable. The 10 CFR Part 40, Appendix A, Criterion 8, requirements for implementation of control measures to limit dust emissions from tailings that are not covered by standing liquids, including wetting or chemical stabilization, will be met. [This requirement may be relaxed for tailings impoundments that have surfaces that are sheltered from wind exposure (i.e., below grade) or that have an interim cover.] The requirements in 10 CFR 40.42(g)(4)(iii), to describe methods that ensure protection of workers and the environment against radiation hazards during decommissioning, have been met.

5.3.5 References

NRC. Regulatory Guide 8.30, “Health Physics Surveys in Uranium Mills.” Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002

———. Regulatory Guide 4.20, “Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors.” Washington, DC: NRC, Office of Standards Development. 1996.

———. Regulatory Guide 8.9, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program.” Rev. 1. Washington DC: NRC, Office of Standards Development. 1993.

———. Regulatory Guide 8.25, “Air Sampling in the Workplace.” Rev. 1. Washington, DC: NRC, Office of Standards Development. 1992.

———. Regulatory Guide 8.22, “Bioassay at Uranium Mills.” Rev. 1. Washington, DC: NRC, Office of Standards Development. 1988.

———. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Rev. 1. Washington, DC: NRC, Office of Standards Development. 1980.

APPENDIX A

RELATIONSHIP OF 10 CFR PART 40, APPENDIX A REQUIREMENTS TO STANDARD REVIEW PLAN SECTIONS

This appendix identifies the specific standard review plan sections where the criteria of 10 CFR Part 40, Appendix A are addressed.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1620 Where the Criterion is Addressed
Criterion 1: Optimize site selection to achieve permanent isolation of tailings without maintenance.	2.1.4, 3.1.4, 3.2.4, 3.3.4, 3.4.4, 3.5.4
Criterion 2: Avoid proliferation of small waste disposal sites.	Not applicable to this standard review plan.
Criterion 3: Dispose of tailings below grade or provide equivalent isolation.	2.1.4
Criterion 4: Adhere to siting and design criteria.	
(a) Minimize upstream rainfall catchment areas.	3.2.4
(b) Select topographic features that provide good wind protection.	3.5.4
(c) Provide relatively flat embankment and cover slopes.	2.2.4, 2.4.4, 2.5.4, 2.6.4, 2.7.4, 3.4.4, 3.5.4
(d) Establish a self-sustaining vegetative cover or rock cover considering stability, erosion potential, and geomorphology.	2.2.4, 2.6.4, 3.4.4
(e) Locate away from faults capable of causing impoundment failure.	1.1.4, 1.2.4, 1.4.4, 2.1.4, 2.2.4
(f) Design to promote deposition, where feasible.	3.4.4
Criterion 5A: Meet the primary ground-water protection standard.	
(1) Design, construct, and install an impoundment liner that prevents migration of wastes to subsurface soil, ground water, or surface water.	Not applicable to this standard review plan.
(2) Construct liner of suitable materials, place it on an adequate base, and install it to cover surrounding earth likely to be in contact with wastes or leachate.	Not applicable to this standard review plan.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1620 Where the Criterion is Addressed
(3) Apply alternate design or operating practices that will prevent migration of hazardous constituents into ground water or surface water.	Not applicable to this standard review plan.
(4) Design, construct, maintain, and operate impoundments to prevent overtopping.	4.4.4
(5) Design, construct, and maintain dikes to prevent massive failure.	2.2.4, 4.4.4
Criterion 5B: Conform to the secondary groundwater protection standards.	
(1) Prevent hazardous constituents from exceeding specified concentration limits in the uppermost aquifer beyond the point of compliance.	4.1.4, 4.2.4, 4.3.4, 4.4.4
(2) Define hazardous constituents as those expected to be in or derived from the byproduct material, those detected in the uppermost aquifer, and those listed in Criterion 13.	4.1.4, 4.2.4, 4.3.4, 4.4.4
(3) Exclude hazardous constituents if they are not capable of posing a substantial present or potential hazard to human health or the environment.	4.1.4, 4.2.4, 4.3.4, 4.4.4
(4) Consider identification of underground sources of drinking water and exempted aquifers.	4.1.4, 4.2.4, 4.3.4, 4.4.4
(5) Ensure hazardous constitutents at the point of compliance do not exceed the background concentration, the value in Paragraph 5C, or an approved alternate concentration limit.	4.1.4, 4.2.4, 4.3.4, 4.4.4
(6) Establish alternate concentration limits, if necessary, after considering practical corrective actions, as low as is reasonably achievable requirements, and potential hazard to human health or the environment.	4.1.4, 4.2.4, 4.3.4, 4.4.4
Criterion 5C: Comply with maximum values for ground-water protection.	4.1.4, 4.2.4, 4.3.4, 4.4.4

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1620 Where the Criterion is Addressed
Criterion 5D: Implement a ground-water corrective action program if secondary ground water protection standards are exceeded.	4.4.4
Criterion 5E: Consider appropriate measures when developing and conducting a ground-water protection program.	
(1) Incorporate leak detection systems for synthetic liners and conduct appropriate testing for clay/ soil liners.	4.1.4, 4.4.4
(2) Use process designs that maximize solution recycling and water conservation.	4.1.4, 4.4.4
(3) Dewater tailings by process devices or properly designed and installed drainage systems.	4.1.4, 4.4.4
(4) Neutralize hazardous constituents to promote immobilization.	4.1.4, 4.4.4
Criterion 5F: Alleviate seepage impacts where they are occurring and restore ground-water quality.	4.1.4, 4.3.4, 4.4.4
Criterion 5G: Provide appropriate information for a tailings disposal system.	
(1) Define the chemical and radioactive characteristics of waste solutions.	4.1.4, 4.3.4, 4.4.4
(2) Describe the characteristics of the underlying soil and geologic formations.	1.1.4, 2.1.4, 4.1.4, 4.3.4, 4.4.4
(3) Define the location, extent, quality, capacity, and current uses of ground water.	4.1.4, 4.3.4, 4.4.4
Criterion 5H: Minimize penetration of radionuclides into underlying soils when stockpiling.	4.1.4, 4.4.4
Criterion 6: Install an appropriate cover and close the waste disposal area.	
(1) Ensure the cover meets lifetime and radon flux	1.1.4, 1.2.4, 1.3.4, 1.4.4, 2.1.4,

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1620 Where the Criterion is Addressed
release specifications.	2.2.4, 2.3.4, 2.4.4, 2.5.4, 2.6.4, 2.7.4, 3.2.4, 3.3.4, 3.4.4, 3.5.4, 4.3.4, 5.1.4
(2) Demonstrate the effectiveness of the final radon barrier prior to placement of erosion protection barriers or other features.	5.1.2.1(b)
(3) Demonstrate the effectiveness of phased emplacement of radon barriers as each section is completed, if applicable.	5.1.4
(4) Document verification of radon barrier effectiveness to the U.S. Nuclear Regulatory Commission (NRC) and maintain records of this verification.	2.7.4
(5) Ensure that radon exhalation is not significantly above background because of the cover material.	5.1.4
(6) Clean up residual contamination from byproduct material consistent with the radium benchmark dose.	5.2.4
(7) Prevent threats to human health and the environment from non-radiological hazards.	5.2.4
Criterion 6A: Ensure expeditious completion of the final radon barrier.	
(1) Complete the radon barrier as expeditiously as practical after ceasing operations in accordance with a written, Commission-approved reclamation plan.	2.6.4, 5.2.4
(2) Extend milestone completion dates if justified by radon release levels, cost considerations consistent with available technology.	Requirement on Commission.
(3) Authorize disposal of byproduct materials or similar materials from other sources if appropriate criteria are met.	Requirement on Commission.

10 CFR Part 40, Appendix A Criterion		Locations in NUREG–1620 Where the Criterion is Addressed
Criterion 7:	Conduct pre-operational and operational monitoring programs.	4.1.4
Criterion 7A:	Establish a detection monitoring program to set site-specific ground-water protection standards, a compliance monitoring system once ground-water protection standards have been established, and a corrective action monitoring program in conjunction with a corrective action program.	4.1.4, 4.2.4, 4.3.4, 4.4.4
Criterion 8:	Conduct milling operations, including ore storage, tailings placement, and yellowcake drying and packaging operations so that airborne releases are as low as is reasonably achievable .	Not applicable to this standard review plan.
Criterion 8A:	Conduct and record daily inspections of tailings or waste retention systems and report failures or unusual conditions to NRC.	4.4.4
Criterion 9:	Establish appropriate financial surety arrangements for decontamination, decommissioning, and reclamation.	4.4.4, 5.2.4
Criterion 10:	Establish sufficient funds to cover the costs of long-term surveillance and control.	4.4.4
Criterion 11A:	Comply with effective date for site and byproduct material ownership requirements.	Requirement on Commission.
Criterion 11B:	Establish license conditions or terms to ensure that licensees comply with ownership requirements prior to license termination for sites used for tailings disposal.	Requirement on Commission.
Criterion 11C:	Transfer title to byproduct material and land to the United States or the state in which the land is located.	Not applicable to this standard review plan.

10 CFR Part 40, Appendix A Criterion		Locations in NUREG–1620 Where the Criterion is Addressed
Criterion 11D:	Permit use of surface and subsurface estates if the public health, safety, welfare, or environment will not be endangered.	Requirement on Commission.
Criterion 11E:	Transfer material and land to the United States or a State without cost other than administrative legal costs.	Not applicable to this standard review plan.
Criterion 11F:	Follow specific requirements for land held in trust for or owned by Indian Tribes.	Requirement on Commission.
Criterion 12:	Minimize or avoid long-term active maintenance and conduct and report on annual inspections.	3.2.4, 3.3.4, 3.4.4, 3.5.4
Criterion 13:	Establish standards for constituents reasonably expected to be in or derived from byproduct materials and detected in ground water.	4.1.4, 4.2.4, 4.4.4

APPENDIX B

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF FOR REVIEWING HISTORICAL ASPECTS OF SITE PERFORMANCE FOR LICENSE RENEWALS AND AMENDMENTS

For license renewals and amendments, the historical record of site operations contains valuable information for evaluating the licensing actions. Following are specific areas in which a compliance history or record of site operations and changes should be presented for review:

- Amendments and changes to operating practices or procedures.
- License violations identified during U.S. Nuclear Regulatory Commission (NRC) or Agreement State site inspections.
- Cleanup histories or status.
- Exceedances of any regulatory standard or license condition pertaining to radiation exposure, contamination, or release limits.
- Exceedances of any regulatory standard or licenses condition pertaining to non-radiation contaminant exposure or release limits.
- Changes to any site characterization information important to the evaluation of the reclamation plan, such as changes to site location and layout, uses of adjacent lands and waters, meteorology, seismology, the geologic or hydrologic setting, ecology, background radiological or non-radiological characteristics, and other environmental features.
- Results of site operations such as data on radiological and non-radiological effects, accidents, and the economic effects of operations.
- Changes to factors that may cause reconsideration of alternatives to the proposed action.
- Changes to the economic costs and benefits for the facility since the last application.

If, after reviewing these historical aspects of site operations, the staff concludes that the site has been operated so as to protect health, safety, and the environment, and that no unreviewed safety-related concerns have been identified, only those changes proposed by the license renewal or amendment or application should be reviewed, using the appropriate sections of this standard review plan. Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined.

APPENDIX C

OUTLINE RECOMMENDED BY THE U.S. NUCLEAR REGULATORY COMMISSION STAFF FOR PREPARING SITE-SPECIFIC FACILITY RECLAMATION AND STABILIZATION COST ESTIMATES FOR REVIEW

As required by Criteria 9 and 10 of 10 CFR Part 40, Appendix A, the licensee shall supply sufficient information for the U.S. Nuclear Regulatory Commission (NRC) to verify that the amount of coverage provided by the financial assurance will permit the completion of all decontamination, decommissioning, and reclamation of sites, structures, and equipment used in conjunction with byproduct material. Cost estimates for the following items (where applicable) should be submitted to NRC with the initial license application or reclamation plan, and should be updated annually as specified in the license. Cost estimates must be calculated on the basis of completion of all activities by a third party. Unit costs, calculations, references, assumptions, equipment and operator efficiencies, *et cetera*, must be provided. The annual surety estimate must be prospective of all work to be performed at the site. The licensee must provide estimated costs for all decommissioning, reclamation, and ground-water cleanup work remaining to be performed at the site, not simply deduct the cost of work already performed from the previous surety estimate [see NRC Generic Letter 97-03 (NRC, 1997)]. The licensee can propose to deduct for work done and approved by NRC as meeting specifications.

The detailed cost information necessary to verify the cost estimates for the preceding categories of closure work is summarized in the recommended outline that follows. For each area, estimates should the include costs for equipment; materials; labor and overhead; licenses, permits, and miscellaneous site-specific costs; and any other activity or resource that will require expenditure of funds.

(I) Facility Decommissioning

This includes dismantling and decontamination, or disposal of all structures and equipment. This work may be done in two phases. In the first phase, only the equipment not used for ground-water cleanup (including the stability monitoring period) is removed. Removal of the remaining equipment would be performed in a second phase, after the approved completion of ground-water cleanup. The buildings may be decontaminated and released for unrestricted use.

(A) Salvageable building and equipment decontamination. For each building or piece of equipment listed, the following data should be provided:

(1) Area of contamination

(2) Survey costs

(3) Decontamination costs

(B) Non-salvageable building and equipment demolition and disposal:

(1) List of major categories of building and equipment to be disposed of and their corresponding quantities:

(a) Structures (list each major), metric tons [tons(short)] of material, and building volume cubic meters (cubic yards)

(b) Foundation concrete [cubic meters (cubic yards)]

(c) Process equipment [metric tons (tons (short)]

(d) Piping and insulation (lump sum)

(e) Electrical and instrumentation (lump sum)

(2) Disposal of chemical solutions within the facility.

(C) Cleanup of contaminated areas (ore storage pad, access roads, process area, evaporation pond residues, etc.).

Reclamation—This entails recontouring the tailings disposal cell and evaporation ponds and placing top soil or other materials acceptable to NRC. Reclamation may also include cleanup of windblown materials and revegetation, including:

(1) Cleanup of windblown materials (e.g., volume and area, unit cost/cubic yard).

(2) Placement of borrow materials removal (e.g., rental rate, cost/cubic yard).

(3) Dust suppression and site maintenance.

(4) Monitoring and testing of construction.

(5) Regrading.

(6) Placement of the frost barrier.

(7) Placement of the radon barrier.

(8) Installation of erosion protection and armor.

(9) Installation of any vegetative cover.

(10) Design and construction of drainage ditches.

(11) Recontouring of land surfaces.

(12) Revegetation.

(II) Ground-Water Cleanup and Well Decommissioning

Ground-water cleanup is done in accordance with an approved corrective action plan. The costs include water treatment equipment, operation, maintenance, and component replacement.

(A) Method of cleanup

(B) Volume of aquifer required to be restored, area and thickness of aquifer, number of required pumping cycles, and cycling time

(C) Verification sample analysis

(D) Well decommissioning:

(1) Number of drill holes to be plugged

(2) Depth and size of each drill hole

(3) Material to be used for plugging including acquisition, transportation, and plugging

(III) Radiological Survey and Monitoring

Radiological Survey—Surveys and soil samples for radium in areas to be released for restricted use. Soils around the tailings disposal cell, evaporation ponds, and process buildings should be analyzed for radium content. A gamma survey of all areas should be made before release for unrestricted use. All equipment released for unrestricted use should be surveyed and records maintained.

(A) Soil samples for radium (and uranium and thorium, if needed) (e.g., number, cost to collect, and analyze)

(B) Decommissioning equipment and building smear samples and alpha surface surveys

(C) Gamma survey frequency, location, and techniques (e.g., type, number, unit cost)

(D) Environmental monitoring

(E) Personnel monitoring

(IV) Project Management Costs and Miscellaneous

Itemize estimated costs associated with project management; engineering design, review, and change; mobilization; legal expenses; power during reclamation; quality control; radiological safety; and any costs not included in other estimation categories. costs should include preparation of completion report and license termination activities.

Potential needs for future well maintenance or replacement are identified. If periodic well replacement is projected, an increase in the long-term care payment is included (American Society for Testing and Materials Standard D 5978).

(V) Labor and Equipment Overhead, Contractor Profit

Overhead costs for labor and equipment and contractor profit may be calculated as separate items or loaded into hourly rates. If included in hourly rates, the unit costs must identify the percentages applied for each area.

(VI) Long-term Surveillance Fee

The fee required by 10 CFR Part 40, Appendix A, Criterion 10, to include cost of any required long-term monitoring (e.g., ground water) or maintenance (e.g., fences, vegetation control).

(VII) Contingency

The licensee should add a contingency amount to the total cost estimate for the final site closure. The staff currently considers a 15 percent contingency to be an acceptable minimum amount.

(VIII) Adjustments to Surety Amounts

The licensee is required by 10 CFR Part 40, Appendix A, Criterion 9, to adjust cost estimates annually to account for inflation and changes in reclamation plans. The submittal should be in the form of a request for amendment to the license.

(A) Adjustments for inflation: The licensee should submit a revised surety incorporating adjustments to the cost estimates for inflation 90 days before each anniversary of the date on which the first reclamation plan and cost estimate was approved. The adjustment should be made using the inflation rule indicated by the change in the Urban Consumer Price Index published by the U.S. Department of Labor, Bureau of Labor Statistics.

(B) Changes in Plans:

(1) Changes in the process, such as size or method of operation.

(2) Licensee-initiated changes in reclamation plans or reclamation/ decommissioning activities performed.

(3) Adjustments to reclamation plans required by NRC.

(4) Proposed revisions to reclamation plans must be thoroughly documented and cost estimates and the basis for cost estimates must be detailed for NRC review and approval.

To avoid unnecessary duplication and expense, NRC shall take into account surety arrangements required by other federal agencies, state agencies, or other local governing bodies. However, the Commission is not required to accept such sureties if they are not sufficient. Similarly, no reduction to surety amounts established with other agencies shall be effected without NRC approval. Copies of all correspondence relating to the surety between the licensee and the state should be submitted to NRC. If authorized by NRC to maintain a surety with the state as the beneficiary, it is the responsibility of the licensee to give NRC verification of that surety; ensure that the agreement with the State specifically identifies the financial surety's application, uranium mill tailings site, and decommissioning/reclamation requirements; and transfer the long-term surveillance and control fee to the U.S. Department of the Treasury before license termination.

All costs (unit and total) are to be estimated on the basis of third party independent contractor costs (include overhead and profit in unit costs or as a percentage of the total). Equipment owned by the licensee and the availability of licensee staff should not be considered in the estimate to reduce cost calculations. All costs should be based on current-year dollars. Credit for salvage value is generally not acceptable on the estimated costs.

NRC staff review may include a comparison of unit cost estimates with standard construction cost guides (e.g., R.S. Means, Dodge Guide, Data Quest) and discussions with appropriate state or local authorities (e.g., highway cost construction). The licensee should provide supporting information or the basis for selection of the unit cost figures used in estimates. The staff may elect to use a publicly available computer code such as RACER™ (Talisman Partners, Ltd., 2000) or spreadsheet to assess these costs.

References:

American Society for Testing and Materials Standards

D 5978, "Standard Guide for Maintenance and Rehabilitation of Ground-water Monitoring Wells."

NRC. "Annual Financial Surety Update Requirements for Uranium Recovery Licensees." Generic Letter 97-03. Washington, DC: NRC. July 1997.

Talisman Partners, Ltd. "Introduction to RACER 2000™ (Version 2.1.0)—A Quick Reference." Englewood, Colorado: Talisman Partners, Ltd. 2000.

APPENDIX D

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF FOR REVIEWING LONG-TERM SURVEILLANCE PLANS

D1.0 BACKGROUND

The Atomic Energy Act of 1954, as amended (hereafter, the Act), contains the statutory requirements for transfer of the title and custody of byproduct material and any land used for the disposal of such byproduct material from a uranium mill licensee to either federal or state control, before termination of the licensee-specific license. These requirements are codified in 10 CFR Part 40, at Section 40.28, "General license for custody and long-term care of uranium or thorium byproduct materials disposal sites." Section 40.28, along with pertinent requirements stated in Appendix A to 10 CFR Part 40 (hereafter Appendix A), requires the completion of certain licensing actions before the transfer of the land and byproduct material to the United States or the appropriate state for long-term care. As part of the license termination process, the intended custodial agency, federal or state government, will prepare a long-term surveillance plan for review and concurrence/acceptance by the U.S. Nuclear Regulatory Commission (NRC). The long-term surveillance plan must document the general licensee's plan for long-term care, including inspection, monitoring, maintenance, and emergency measures necessary to protect public health and safety. This document presents guidance to the NRC staff on review of the long-term surveillance plan. Standard review plan Appendix E presents guidance on the license termination process, and presents the role of the long-term surveillance plan in the overall context of the license termination process.

Review and acceptance of long-term surveillance plans is the sole responsibility of the NRC. However, Agreement State comments prepared using this guidance are welcomed and will be considered, if provided.

D2.0 REVIEW OF LONG-TERM SURVEILLANCE PLAN

D2.1 Areas of Review

In accordance with 10 CFR 40.28(b), the long-term surveillance plan should present the following information:

(1) A legal description of the disposal site to be transferred and licensed

(2) A detailed description of the final conditions of the disposal site, including existing ground-water characterization

(3) A description of the long-term surveillance program, including proposed inspection frequency and reporting to the Commission; frequency and extent of ground-water monitoring, if required; appropriate constituent limits for ground water; inspection personnel qualifications; inspection procedures; record keeping; and quality assurance procedures

(4) The criteria for followup inspections in response to unusual observations from routine inspections or extreme natural events

(5) The criteria for instituting maintenance or emergency measures

D2.2 Information Reviewed

D2.2.1 Legal Description and Ownership of the Land

The reviewer should examine the documents to ensure that the ownership and legal description of the land are satisfactory. The review should include review of (1) the legal description of the disposal site; (2) a brief narrative of the disposal area land ownership, including the number of acres involved and the type of real estate instruments associated with the acquisitions; (3) information associated with the land transaction [i.e., book, page, county, State, and date of deeds; and agreement number and date associated with DOE/tribe agreement (waiver of liability from tribe when land is part of a reservation or has trust status)]; and (4) a statement that real estate correspondence and instruments are maintained and filed by the property management branch of the pertinent custodial agency. The documentation should clearly establish the custodial agency's land ownership when the land transfer takes place.

D2.2.2 Final Condition of the Disposal Site

The reviewer should examine the following: (1) documentation of defined and characterized final closure site condition; (2) as-built drawings; (3) description of disposal cell design; (4) final topographic maps; (5) vicinity maps; (6) ground and aerial photographs; (6) number, location, and condition of survey monuments, site markers, and signs; and (7) existing ground-water characterization and protection activities (if necessary), ground-water monitoring well network to detect changes in ground-water quality from tailings (including evaluating the monitoring data to quantify the rate and magnitude of change). Some of the information may be referenced to the information already submitted to NRC (such as the completion report), and the staff findings on the previously submitted information may be used in this review. It is noted that the final disposition of the tailings residual radioactive material, or wastes at the milling site, should be such that ongoing active maintenance is not necessary to preserve isolation. The descriptions of the final disposal site condition, the ground-water condition, and the proposed ground-water monitoring program should be of sufficient detail that future inspectors have a baseline to determine changes to the site.

D2.2.3 Long-Term Surveillance Program

The staff should review the surveillance (inspection and monitoring) program for:

(1) Frequency of Inspection—The physical condition of the site (fence, site markers, drains/ditches, rock-mulch/vegetative cover, etc.) should be inspected annually to determine any need for maintenance or monitoring or both. In addition, an inspection should follow an unusual event, such as a heavy storm or an earthquake. On the basis of a site-specific evaluation, NRC may require more frequent site inspections because of the particular features of a disposal site.

(2) Reporting to the Commission—Results of the inspections for all the sites under the licensee's jurisdiction will be reported to NRC annually within 90 days of the last site inspection in that calendar year. However, any site at which unusual damage or

disruption is discovered during the inspection requires a preliminary site inspection report to be submitted within 60 days.

(3) Ground-Water Monitoring—The reviewer should examine long-term surveillance plans to ensure that a ground-water monitoring program is in place to verify that the ground-water quality at the site will continue to meet applicable standards. In particular, the reviewer should determine whether:

(a) Background, point of compliance, and, if applicable, point of exposure wells have been located as described in the existing license. Wells should be correctly placed as to surface locations and aquifer completions. Well locations should be surveyed and located on site maps drawn to scale.

(b) The same ground-water protection standards (point of ground-water protection standards or alternate concentration limits) as in the existing license continue to apply. If there has been no leakage from the impoundment into the ground-water, appropriate ground-water parameters should be monitored and detection concentrations should be established that will give early warning of leakage. Appropriate parameters should be indicative of the tailings material and not significantly affected by retardation reactions. For acid tailings, appropriate detection parameters might include total dissolved solids, chloride, or sulfate.

(c) The sampling frequency is sufficient to protect the public and environment at the point of exposure and sufficient to ensure that the ground-water downgradient of the point of compliance will not be degraded to any great extent before contamination is detected. This will require a knowledge of potential contaminant plume velocities. It is anticipated that the calculation of potential contaminant plume velocities will be based on advective calculations (e.g., American Society for Testing and Materials Standards D 5447, D 5490, D 5609, D 5610, D 5611, D 5718, E 978; and Anderson and Woessner, 1992). However, more complex calculations that include such processes as dispersion and retardation may be performed if site conditions warrant them. For sites with alternate concentration limits, the sampling frequency should be sufficient to detect a potential contaminant plume, well before ground water at the point of exposure is degraded.

It is anticipated for most sites that routine monitoring once every 3 years will be acceptable unless site-specific conditions warrant an increased or decreased frequency of monitoring. If more frequent monitoring is required, the reviewer should assess the increase in the long-term care payment that must be made to support the more frequent monitoring. This increase should be included in the existing surety in addition to the long-term care payment made at the time of license termination.

(d) Water quality sampling and analysis procedures use appropriate American Society for Testing and Materials or equivalent standards. Wells are constructed to prevent surface-water contamination and are capped and secured to prevent tampering (American Society for Testing and Materials Standard D 5787).

(e) Actions that the long-term custodian would take should ground-water protection standards be exceeded are described.

If the staff review results in acceptance of the long-term surveillance plan, the staff may conclude that the DOE will conduct long-term surveillance that will confirm that constituents of concern will remain below the relevant standards in 10 CFR Part 40, Appendix A, Criteria 5B(5) and (6). The staff may also conclude that enough funds are available to cover the costs of long-term surveillance and control as required in 10 CFR Part 40, Appendix A, Criterion 10, and that site inspections are planned as required in 10 CFR Part 40, Appendix A, Criterion 12.

(4) Inspection Personnel Qualifications—The inspection team should be qualified to inspect such site features as subsidence and cracking; erosion by surface water; degradation of erosion protection (rock mulch cover or vegetative cover); integrity of site markers, fences, and settlement plates; and monitoring to verify the presence and concentration limits of hazardous constituents in the ground water. For inspections that follow unusual events, the team should consist of technical personnel of appropriate disciplines.

(5) Inspection Procedures—The long-term surveillance plan should present details of the inspection procedures such as checklists of items to be inspected, measurements or observations to be made, procedures for documenting the inspection data (photo, video, aerial photo as needed); and duration of inspection (1 to 2 days).

(6) Recordkeeping and Quality Assurance Procedures—Inspection data should be retained in a format suitable for future retrieval on a long-term basis. The quality assurance aspect of the collection of site and ground-water data, interpretation of the collected data, report preparation, and long-term retention of data should be reviewed.

D2.2.4 Criteria for Followup Inspections

The criteria for followup inspections in response to unusual observations from routine inspections or extreme natural events should be reviewed.

(1) If any unusual observation from the inspection warrants a detailed evaluation, then an unscheduled inspection (followup inspection) will be conducted for a detailed evaluation of the unusual observation encountered in the earlier inspection. The plan should discuss the level of physical distress to the site (settlement/crack magnitude, extent of subsidence, extent of degradation of erosion protection, etc.) and limits of the constituents not to be exceeded in the ground-water that would warrant a further detailed evaluation of the problem to determine the need for a cleanup activity.

(2) Occurrence of extreme natural events, such as large-magnitude storms and earthquakes or drought, warrants an inspection to verify the physical condition/integrity of the disposal site. The plan should present the magnitude of the natural events that would trigger this inspection.

D2.2.5 Criteria for Instituting Maintenance or Emergency Measures

The plan should present the criteria or the events that will trigger the initiation of maintenance and other emergency measures to restore the integrity of the disposal site and to protect the health and safety of the public. Quantitative and, if not practical, qualitative criteria that would trigger these measures should be discussed in the long-term surveillance plan.

D3.0 CONCLUSIONS

On the basis of its review of the long-term surveillance plan, the staff should be able to conclude that the long-term surveillance plan is in compliance with (1) the content requirements in 10 CFR 40.28(b), (2) the ownership of site and byproduct material requirement in Criterion 11 of Appendix A, and (3) the surveillance plan requirement in Criterion 12 of Appendix A. If the long-term surveillance plan is in compliance with these requirements, the staff can accept it.

D4.0 REFERENCES

American Society for Testing and Materials Standards

D 5447, “Standard Guide for Application of a Ground-water Flow Model to a Site-Specific Problem.”

D 5490, “Standard Guide for Comparing Ground-water Flow Model Simulations to Site-Specific Information.”

D 5609, “Standard Guide for Defining Boundary Conditions in Ground-water Flow Modeling.”

D 5610, “Standard Guide for Defining Initial Conditions in Ground-water Flow Modeling.”

D 5611, “Standard Guide for Conducting a Sensitivity Analysis for a Ground-water Flow Model Application.”

D 5718, “Standard Guide for Documenting Ground-water Flow Model Application.”

D 5787, “Standard Practice for Monitoring Well Protection.”

E 978, “Standard Practice for Evaluating Mathematical Models for the Environmental Fate of Chemicals.”

Anderson, M.P. and W.W. Woessner. *Applied Ground-Water Modeling: Simulation of Flow and Transport.* New York, New York: Academic Press. 1992.

APPENDIX E

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF ON THE LICENSE TERMINATION PROCESS FOR LICENSEES OF CONVENTIONAL URANIUM MILLS

E1.0 BACKGROUND

The Atomic Energy Act of 1954, as amended, contains the statutory requirements for the transfer of the title and custody to byproduct material and any land used for the disposal of such byproduct material from a uranium mill licensee to either Federal or State control, before termination of the licensee's specific license. These requirements are codified in 10 CFR Part 40, at Section 40.28, "General license for custody and long-term care of uranium or thorium byproduct materials disposal sites." Section 40.28, along with pertinent requirements stated in Appendix A to 10 CFR Part 40 (hereafter Appendix A), provides for the completion of certain licensing actions before the transfer of the land and byproduct material to the United States or the State where the disposal site is located for long-term care.

This document gives the U.S. Nuclear Regulatory Commission (NRC) staff specific directions to be applied in the course of the license termination process for Uranium Mill Tailings Radiation Control Act of 1978 Title II sites that are under NRC jurisdiction. For the license termination of Title II sites that are under Agreement State jurisdiction, guidance is provided in the Office of State and Tribal Programs SA–900 Procedure (NRC, 2001). The license termination process, including the roles of the respective agencies and organizations involved in this process, is discussed in general. Various relevant issues are addressed in greater detail. This is the initial version of this guidance document, and as specific uranium mill licenses are terminated and title to the land and byproduct material is transferred to the appropriate government agency, future revisions are likely to be necessary. These revisions will address not only issues yet to be identified, but also will provide any additional necessary clarification of issues discussed herein.

E2.0 ROLES OF INVOLVED ORGANIZATIONS

E2.1 NRC

In accordance with Section 83c of the Atomic Energy Act, as amended, NRC determines whether the licensee has met all applicable standards and requirements or whether a licensee-proposed alternative meets the standards. This will involve NRC review of licensee submittals relative to the completion of decommissioning, reclamation, and, if necessary, ground-water cleanup.

In addition, the staff should review the site long-term surveillance plan submitted by the custodial agency, for both NRC and Agreement State sites. On NRC acceptance of the long-term surveillance plan, NRC terminates the specific license and places the long-term care and surveillance of the site by the custodial agency under the general license provided at 10 CFR 40.28.

A final NRC responsibility is the determination of the final amount of long-term site surveillance funding. Criterion 10 of Appendix A specifies a minimum charge of $250,000 (1978 dollars), revised to reflect inflation, which may be escalated on a site-specific basis because of surveillance and long-term monitoring controls beyond those specified in Criterion 10 of Appendix A. Detailed discussion of the bases used in developing the minimum charge and any escalated costs appears in Section E3.4 (below).

E2.2 Uranium Mill Licensees

Before license termination, licensees are required by license conditions to complete site decontamination and decommissioning and surface and ground-water remedial actions consistent with decommissioning, reclamation, and ground-water corrective action plans.

Licensees must document the completion of these remedial actions in accordance with procedures developed by NRC. As discussed in Section E3.1 (below), this information will include a report documenting completion of tailings disposal cell construction, as well as radiation surveys and other information required under 10 CFR 40.42.

Because the long-term surveillance plan must reflect the remediated condition of the site, the licensee will work with the custodial agency in preparing the long-term surveillance plan. Most likely, this will involve supplying the custodial agency with appropriate documentation (e.g., as-built drawings) of the remedial actions taken and reaching agreements (formal or informal) with the custodial agency regarding the necessary surveillance control features of the site (e.g., boundary markers, fencing). It is the custodial agency responsibility to submit the long-term surveillance plan to NRC for approval. However, the licensee may elect to help prepare the long-term surveillance plan, to whatever degree is agreed between the licensee and the custodial agency.

Finally, the licensee provides the funding to cover long-term surveillance of the site, in accordance with Criterion 10 of Appendix A. NRC will determine the final amount of this charge on the basis of final conditions at the site.

After termination of the existing license and transfer of the site and byproduct materials to the custodial agency, the licensee remaining liability extends solely to any fraudulent or negligent acts committed before the transfer to the custodial agency, as provided for in Section 83b(6) of the Atomic Energy Act, as amended.

E2.3 Custodial Agency

Section 83 of the Atomic Energy Act, as amended, states that before termination of the specific license, title to the site and byproduct materials should be transferred to either (1) the U.S. Department of Energy (DOE); (2) a Federal agency designated by the President; or (3) the state in which the site is located, at the option of the State. It is expected that the DOE will be the custodial agency for most, if not all, of the sites.

It is the responsibility of the custodial agency to submit the long-term surveillance plan to NRC for review and acceptance. Provisions and activities identified in the final long-term surveillance plan will form the bases of the custodial agency long-term surveillance at the site. The NRC general license in 10 CFR 40.28(a) becomes effective when the licensee’s current specific license is terminated and the Commission accepts the long-term surveillance plan. Custodial agencies are required, under 10 CFR 40.28(c)(1) and (c)(2), to implement the provisions of the long-term surveillance plan. These activities could include not only those reflected in the long-term surveillance plan, but also activities voluntarily committed to by the custodial agency.

E2.4 States

As discussed in Section 2.3 (above), the State in which the disposal site is located has the option of becoming the custodial agency. This “right of first refusal” may be exercised either on a site-by-site basis or generally, covering all sites within the State’s limits. This option should be exercised early enough in the license termination process so that termination of the specific license and transfer of the site to the appropriate custodial agency are not delayed unnecessarily. Written confirmation of a State decision should be documented in a letter to the DOE, from the governor of the State, or another State official to whom the authority for this decision has been appropriately delegated. A copy of this letter must be sent to NRC.

The NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of 11e.(2) byproduct material (NRC, 2000).

E3.0 THE LICENSE TERMINATION PROCESS

A licensee considering termination of its source material license should have in place an acceptable (by NRC) site decommissioning and reclamation plan and, if necessary, an acceptable ground-water corrective action program. This section describes the termination process that follows an NRC licensee completion of decommissioning, reclamation, and ground-water corrective action in accordance with the approved plans.

E3.1 Licensee Documentation of Completed Remedial and Decommissioning Actions

E3.1.1 Documentation of Completed Surface Remedial Actions

To ensure a timely and efficient NRC review, when reclamation of the tailings disposal cell is completed, the licensee should submit to NRC, for review, a report detailing the conduct and completion of the reclamation construction activities. This Construction Completion Report would consist primarily of a summary of quality assurance/quality control records and as-built drawings. A licensee may refer to the reports prepared by the DOE to document completion of remedial actions at Title I Project sites as guidance in developing its Construction Completion Report. However, some of the information presented in DOE reports (e.g., original design calculations) has been meant to ease the staff review rather than to meet documentation requirements.

If a Construction Completion Report or similar report is not submitted, it will be necessary for the staff to conduct a detailed technical review to meet its responsibilities under Section 83c of the Act. This review could involve several site visits and significant confirmation testing and would likely involve staff in the following technical disciplines: geotechnical engineering, surface water and erosion protection, radon barrier design, and soil radiation cleanup. Accurate quality assurance/quality control records and photographs kept by a licensee during cell construction will be important input into the staff determination that reclamation has been conducted and completed in accordance with the approved plan.

If the NRC determines, as part of its review of the Construction Completion Report or during a site inspection, that a licensee has neglected to compile quality assurance/quality control records or has inadequate records, it may require the licensee to conduct appropriate sampling of those portions of the completed cell that are in question (e.g., of the radon barrier). If a licensee is unwilling or unable to comply, the staff or NRC contractors will conduct the sampling, and the costs involved will be included in the licensing and inspection fees assessed under 10 CFR 170.31. In addition, if a requirement to maintain quality assurance/quality control records is part of an approved reclamation plan, a licensee's lack of such records may be interpreted as a violation of the relevant license condition. This situation will be evaluated as part of the NRC inspection program. Appropriate NRC action would be taken in such instances.

E3.1.2 Documentation of Completed Site Decommissioning

Licensees are also required, under 10 CFR 40.42(j), to document the results of site decommissioning, which is done by conducting a radiation survey of the premises where the licensed activities were carried out. The results of this survey, the contents of which are specified at 10 CFR 40.42(j)(2), are submitted to NRC for review. A licensee has the option of demonstrating that the premises are suitable for release in a manner other than that specified at 10CFR 40.42. Additional documentation pertinent to site decommissioning and soil cleanup may be required by a specific license condition.

E3.1.3 Documentation of Completed Ground-Water Corrective Actions

Criteria 5A–5D, along with Criterion 13, of Appendix A incorporate the basic ground-water protection standards imposed by the U.S. Environmental Protection Agency (EPA) in 40 CFR Part 192, Subparts D and E (48 FR 45926, October 7, 1983). These standards apply during operations and before the end of closure. At a licensed site, if these ground-water protection standards are exceeded, the licensee is required to put into operation a ground-water corrective action program (Criterion 5D of Appendix A). The objective of the corrective action program is to return the hazardous constituent concentration levels to the concentration limits set as standards.

For licensees with continuing ground-water cleanup, NRC approval is required for the termination of corrective action. A licensee should submit appropriate ground-water monitoring data and other information that produce reasonable assurance that the ground water has been cleaned to meet the appropriate standards. This may include an application for alternate concentration limits if the licensee concludes that some alternate concentration limits for certain constituents are necessary. The staff will review alternate concentration limits in accordance with the most current version of the NRC staff technical position, "Alternate Concentration Limits for Title II Uranium Mills: Standard Format and Content Guide, and Standard Review Plan for Alternate Concentration Limit Applications" (NRC, 1996).

E3.2 NRC Review of Completed Closure Actions

On receipt of the Construction Completion Report, decommissioning report, ground-water completion report, or alternate concentration limit monitoring data, the staff will review the document for completeness and level of detail. Given a favorable finding, the staff will then review the content of the report for documentation that the action has been conducted in accordance with the license requirements and regulations. If that is the case, NRC will notify the licensee by formal correspondence, and, if the licensee so requests, amend the specific license, by deleting applicable license requirements for reclamation, decommissioning, or ground-water cleanup, and identifying requirements for any disposal cell observational period and/or environmental monitoring. The staff may conduct site inspections, examining first-hand the closure actions taken, including the quality assurance/quality control records.

Additionally, the staff should conduct a final construction completion inspection, which is expected to consist of a site walk-over and an examination of construction records. No independent verification of completed actions (e.g., confirmatory coring of the radon barrier) is expected, except on a case-by-case basis, as discussed previously.

With respect to construction of the tailings cell, the staff review of the Construction Completion Report, coupled with site inspections, will ensure that disposal cells are constructed in accordance with the approved design and plan (e.g., a summary of quality assurance/quality control records shows the appropriate number of material lifts have been placed).

The staff will rely on site inspections as the primary means of determining acceptable implementation of the licensee's approved decommissioning plan, especially in regard to soil cleanup. These inspections will consist of (1) reviews of procedures, (2) evaluations of procedure implementation, (3) evaluations of records and quality assurance, and (4) limited gamma surveys and soil sampling. In this way, the staff will gain the needed level of confidence in the licensee's performance to support its evaluation of the final decommissioning survey report. Confirmatory sampling, either by NRC or its contractors, should be conducted at sites for which additional confirmation beyond inspections is necessary. Specific criteria will be employed to identify those sites requiring confirmatory sampling.

E3.3 Observation Periods

E3.3.1 Following Completion of Surface Remedial Actions

The length of an observation period following completion of surface remediation will be determined on a site-specific basis, with a minimum period of 1 year, commencing at the completion of the erosion cover. Licensees should report significant cell degradation (e.g., the development of settlement or erosional features) occurring during this period.

Sites employing a full self-sustaining vegetative cover (Criterion 4 of Appendix A) may have an observation period of at least 2 years, and possibly as long as 5 years, based on specific site conditions and the requirements of 10 CFR Part 40, Appendix A.

A *de facto* observation period may exist at most sites where cleanup of ground-water contamination continues following the completion of surface reclamation (i.e., construction of the tailings disposal cell).

E3.3.2 Following Ground-Water Remediation

The reviewer should examine (1) ground-water completion reports, (2) ground-water corrective action reports, or (3) alternate concentration limit applications to verify that ground-water quality corrective actions have produced a stable water quality and that ground-water monitoring and analysis have been done to confirm the concentration of these contaminants in the ground water and to verify that they meet applicable standards. This should be done at the end of the 1-year stability ground-water monitoring period.

Ground-water stability monitoring and confirmation of constituents of concern will be acceptable if:

(1) A one-time measurement of all constituents of concern has been collected and analyzed from all point-of-compliance wells. A constituent of concern is one that is (a) either (i) currently identified in 10 CFR Part 40, Appendix A, Criterion 13; or (ii) is not listed in Criterion 13, but is placed in a license condition as part of the staff review of the Corrective Action Plan; and (b) has been identified in the tailings liquor. NRC has flexibility to add other constituents not identified in Criterion 13. However, in identifying this second set of constituents, the staff should ensure that any additions are made based on a sound technical and regulatory basis. New constituents should be added in a timely manner, either when the corrective action plan is accepted for review, or at some time during the lifetime of the corrective action program. New constituents will not be required at the time of the license termination monitoring submittal.

Some examples of sound technical bases for new constituents follow:

(a) For the Homestake/Grants and United Nuclear Corporation/Churchrock sites, the NRC staff, the DOE, and the EPA will work together to develop an interagency policy on closure and postclosure issues that will comply with the statutory and regulatory missions and requirements of all three agencies. For the Cotter/Canon City and UMETCO/Uravan sites, the State of Colorado is the primary regulatory authority and the NRC has a more limited role. Once all applicable NRC requirements are met, the NRC will have no basis for denying a request to terminate any specific license. However, before the NRC terminates any license for a site that is on the National Priority List or that is subject to continuing regulation by the EPA, the NRC will inform the DOE of the pending action, and where possible, will provide additional time for the DOE to resolve site issues it may have with the EPA.

(b) Trends in ground-water contamination show that after several years of decreasing contamination, the levels of contamination begin to rise again.

(c) Surrogate parameters that cover a family of constituents show an increase in the concentration in ground water. Therefore, the staff may require licensees to monitor for all constituents found in that family.

(d) Some constituents used in the milling process, but not listed in Criterion 13, such as ammonia and nitrate, must be addressed.

Constituents should not be added just because an individual state regulatory body is concerned about that constituent. Having a state identify a constituent as one of concern to the state is not necessarily a proper basis for NRC to include that constituent.

(2) The results of the one-time measurement sampling should be compared with the pre-operational applicable standards as specified in Criterion 5(C) or the license. All hazardous constituents must be shown to meet the standards specified in Criterion 5(C) or the license. If this measurement is taken sometime before license termination (3 or more years), the reviewer should ensure that recontamination has not occurred. This may be done by taking additional measurements or making analytical calculations.

(3) The stability monitoring data should be inspected for any trends in increasing ground-water concentrations for those constituents of concern in the ground water that were being cleaned up by the corrective action plan.

If the staff reviews result in acceptance of confirmation and stability monitoring, the staff may conclude that:

(1) The licensee has monitored all previously identified constituents of concern at the points of compliance.

(2) The post-corrective action plan stability monitoring shows that the constituents of concern that were remediated will remain below compliance or alternate concentration limit standards.

(3) The one-time sampling for constituents of concern shows that constituents of concern are below, and will remain below, relevant standards in 10 CFR Part 40, Appendix A, Criteria 5B(5) and 5B(6).

(4) All ground-water corrective action programs have ceased operation.

(5) All identified constituents of concern for which compliance sampling is being conducted have been returned to the concentration limits set as standards.

E3.4 Long-Term Site Surveillance Funding

Before termination of the specific license, NRC will set the final amount of the long-term site surveillance charge to be paid by the licensee in accordance with Criterion 10 of 10 CFR Part 40, Appendix A. The NRC process for determining this amount will include consultations with the licensee and the custodial agency. This charge must be paid to the United States general treasury or to the appropriate state agency before the specific license can be terminated.

Notify NRC and custodial agency 2 years before estimated date of license termination. When a licensee has completed site reclamation, decommissioning, and, if necessary, ground-water corrective action, and is ready to terminate its specific source material license, it must formally notify NRC of its intentions. Such notification should be accompanied by a completed NRC Form 314, “Certificate of Disposition of Materials” or approved alternate.

E3.4.1 Bases for Determination of Surveillance Charge

The basic criterion for tailings disposal is to avoid dependance on perpetual human care and on-going maintenance to preserve the isolation of the tailings. NRC, in Criterion 1 of Appendix A, concludes that:

> The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance.

However, as further indicated in Criterion 1, for practical purposes, specific design and siting considerations must involve finite time limits. For this reason, Criterion 6 contains longevity standards for design of disposal cells.

In order that the isolation of the tailings and associated contaminants can be preserved to the extent possible, the Atomic Energy Act, as amended, provides that title to the byproduct material and associated land be transferred to the care of the United States, the State, or the tribe, as discussed previously. NRC has interpreted such long-term custody by a governmental agency, whether Federal or State, as “a prudent, added measure of control” (NRC, 1980), so that land uses that might contribute to the degradation of the cover or lead to direct human exposures can be prevented.

In the “Final Generic Environmental Impact Statement on Uranium Milling” (NRC, 1980), NRC staff developed the bases for the long-term surveillance charge, given the intent that no ongoing active maintenance of site conditions should be necessary to preserve waste isolation. In the final generic environmental impact statement, the following actions are assumed for the “passive monitoring” approach to surveillance of the site are as follows:

(1) An annual visual inspection of the site, either as a site visit or a visual inspection from an aircraft, should be conducted.

(2) No maintenance of equipment or facilities, no fence replacement, no sampling, and no airborne environmental monitoring would be expected.

(3) Essentially, the only costs for continued surveillance/maintenance would consist of time spent in preparing for the inspection, travel to the site, conduct of the inspection, and annual report writing.

(4) Minimal NRC oversight would be required.

Passive monitoring, thus, would not involve such activities as irrigation, hauling of fill, regrading, or seeding.

Finally, as discussed previously, licensees will contribute the funds necessary to cover the costs of long-term surveillance of their sites. The charge assessed is a one-time fee, which will yield interest on the funds, assuming a 1-percent annual real interest rate, sufficient to cover the annual costs of site surveillance. The final generic environmental impact statement contains more detailed discussion regarding the determination of this interest rate.

E3.4.2 Determination of Surveillance Charge Amount

On the basis of the assumptions discussed in Section E3.4.1 (above), NRC developed the minimum long-term surveillance charge of $250,000 (1978 dollars) as stated in Criterion 10 of Appendix A. It is this charge, adjusted to account for inflation, that the licensee is required to pay into the general treasury of the United States, or alternately, to the appropriate State agency (if the State is to become the long-term site custodian). The methodology the staff will use to determine the adjusted surveillance charge that accounts for inflationary increases since 1978 includes (1) using the Consumer Price Index available at the time the licensee requests termination and (2) applying the rate of increase for the last month for which it has been calculated to any following month leading to license termination. For example, in June 1996, NRC determined the final surveillance charge for the TVA/Edgemont site. In doing this, the staff used the April 1996 Consumer Price Index and applied the rate of increase between March and April to the following months.

Criterion 10 allows for the escalation of this minimum charge if, on the basis of a site-specific evaluation, the expected site surveillance or control requirements are determined to be significantly greater than those specified in Criterion 12 of Appendix A (i.e., annual inspections to confirm site integrity and determine the need, if any, for maintenance or monitoring).

Escalation could result from a licensee’s proposal of alternatives to the requirements in Appendix A, as allowed under Section 84c of the Atomic Energy Act, as amended. For example, a licensee could demonstrate by analysis that the only mechanism for achieving a minimum disposal cell design life of 200 years at its site is through the use of ongoing maintenance. NRC may approve such a design if it finds that the design will achieve a level of stabilization and containment for the site concerned, and a level of protection of public health and safety, and of the environment, that is equivalent to, to the extent practicable, or more stringent than, the level of protection that would be achieved by meeting NRC requirements. However, the licensee would likely be required to place additional funds in the long-term surveillance charge to cover the costs of the ongoing maintenance.

Another situation that may lead to the escalation of the minimum charge is the recognition that some degree of active care (e.g., vegetation control, maintenance of erosional control measures) is necessary to preserve the as-designed conditions of the site. This need should become apparent in the course of site observations during the reclamation and observational periods.

In any case, any escalation in the minimum charge will be discussed with the licensee and long-term custodian, before license termination. Any final variance in the funding requirements will be determined solely by NRC.

A situation may arise in which the custodial agency wants to have commitments in the long-term surveillance plan that are beyond those required in Appendix A and that NRC does not determine are necessary. In such a case, the amount of the long-term surveillance charge would not be affected (NRC, 1990, “Detailed Comment Analysis,” Comment 1.2). The custodial agency must identify a mechanism for funding these additional self-imposed requirements.

E3.4.3 Payment of Long-Term Surveillance Charge

Licensees may pay the final site surveillance charge to the NRC or the custodial agency. If paid to NRC, the funds will be deposited, in accordance with the Miscellaneous Receipts Act, in the U.S. General Treasury. A custodial agency receiving payment from the licensee will need to document receipt and subsequent deposition of the payment. Copies of such documentation should be sent to NRC.

E3.5 Preparation of the Long-Term Surveillance Plan

While surface remediation and ground-water cleanup activities are ongoing, it is in the best interest of the licensee to contact the custodial agency with regard to that agency preparation of the site long-term surveillance plan. The custodial agency responsibilities under the general license are defined in the long-term surveillance plan, the required contents of which are provided at 10 CFR 40.28 and in Criterion 12 of Appendix A, as follows:

- A legal description of the site to be transferred and licensed

- A detailed description of the site, as a baseline from which future inspectors can determine the nature and seriousness of any changes {licensees may reference previously submitted information, to the extent applicable, in providing this description [10 CFR 40.31(a)]}

- A detailed description of the long-term surveillance program, including (1) the frequency of inspections and reporting to the NRC; (2) the frequency and extent of ground-water monitoring, if required; (3) appropriate ground-water concentration limits; and (4) inspection procedures and personnel qualifications

- The criteria for follow-up inspections in response to observations from routine inspections or extreme natural events

- The criteria for instituting maintenance or emergency measures

In addition to these regulatory requirements (also see Appendix D of this standard review plan), NRC will also require that the long-term surveillance plan contain documentation of title transfer of the site from the licensee to the custodial agency. This requirement does not apply to sites located on tribal lands, since transfer does not occur for such sites (Criterion 11F of Appendix A).

Because the long-term surveillance plan must reflect the remediated condition of the site, it is expected that the existing licensee will work with the custodial agency to prepare the long-term surveillance plan. As discussed in Section E2.2 (above), this will likely involve supplying the custodial agency with appropriate documentation (e.g., as-built drawings) of the remedial actions taken and reaching agreements (formal or informal) with the custodial agency regarding the necessary surveillance control features of the site (e.g., boundary markers, fencing).

As the likely custodial agency for most, if not all, of the sites, the DOE has developed a generic long-term surveillance plan shell. For sites under the long-term care of the DOE, significant portions of the long-term surveillance plan will not change from site to site (e.g., criteria for followup inspections and for instituting maintenance or emergency measures). Therefore, the staff may focus its review on the site-specific information in the long-term surveillance plan. This information would include site-specific activities that are not to be reflected in the long-term care charge, but are voluntarily committed to by the custodial agency.

E3.6 Termination of the Specific License/Issuance of the General License

Actual termination of a licensee-specific license and the subsequent placement of the site under the general license provisions of 10 CFR 40.28 will involve a number of separate actions to be completed by the NRC. Significant internal coordination (and external, if Agreement State licensees are involved) will be required so that these actions will be completed in an efficient and timely manner, thereby ensuring that the byproduct material and any land used for the disposal of such byproduct material remain under NRC license throughout the process.

E3.6.1 NRC Determination Under Section 83c of the Act

Under Section 83c of the Atomic Energy Act, as amended, NRC must determine whether all applicable standards and requirements have been met by the licensee in the completion of site reclamation, decommissioning, and ground-water corrective action before a licensee’s license can be terminated. Necessarily, this determination will rely primarily on NRC reviews and acceptance of the documentation presented by the licensee. In addition, NRC site closure inspection activities, potentially including limited confirmatory radiological surveys, will provide supplemental information for NRC determination.

E3.6.2 NRC Review and Acceptance of the Long-Term Surveillance Plan

A long-term surveillance plan is required before termination of the specific license and placement of the site and byproduct material under the 10 CFR 40.28 general license. Review and acceptance of the long-term surveillance plan is the sole purview of NRC. Lack of NRC acceptance of a site long-term surveillance plan can delay termination of the specific license.

NRC staff acceptance of a long-term surveillance plan will be documented in written notification to the custodial agency, and, separately, by noticing the action in the *Federal Register*.

E3.6.3 Issuance of a Specific Order Under 10 CFR 40.28

If NRC has not received an acceptable long-term surveillance plan for a reclaimed site ready for transfer to the custodial agency, the agency has two options available to it. First, if appropriate, the Commission may choose not to terminate the existing license for a short period of time, while awaiting an acceptable long-term surveillance plan. Alternately, under 10 CFR 40.28, NRC may issue a specific order to the custodial agency to take custody of the site and to commence long-term surveillance, while the agency prepares the long-term surveillance plan for final NRC approval.

NRC would require substantial basis to support issuance of an order. The basis would include an understanding of the circumstances leading to the custodial agency inability to take the site. Factors that the NRC would consider include whether:

(1) Adequate notice (at least 16 months) has been provided by the existing licensee to allow the custodial agency to effect title transfer to the land and byproduct material.

(2) Sufficient time (at least 2 years) has been allowed for the custodial agency to prepare, and the NRC to review, the long-term surveillance plan.

(3) NRC has reviewed the Construction Completion Report, decommissioning report, and ground-water cleanup report and has conducted the final license-termination inspection and found that the closure actions were completed in an acceptable manner.

(4) Site degradation has occurred, and whether appropriate repairs have been completed.

(5) The required long-term surveillance funding payments have been made to the U.S. General Treasury or to the designated state agency.

(6) The custodial agency has an acceptable rationale for delaying inclusion of the site under the general license.

In cases in which the DOE or another presidentially designated Federal agency will be the long-term custodian and is unable to take custody of the site because of lack of funding, NRC may still order the agency to take custody. The intended custodial agency will have at most 1 year (i.e., the time by which an annual site inspection is to have been completed) in which to obtain the funds through the necessary appropriations process.

E3.6.4 Transfer of Site Control to the Custodial Agency

Given a determination that all applicable standards and requirements have been met and acceptance of the site long-term surveillance plan, NRC will need to complete the following remaining relevant licensing actions: (1) terminating the specific license by letter of termination addressed to the specific licensee, or concurring in the Agreement State termination of the specific license; (2) placing the site under the general license in 10 CFR 40.28; (3) noticing, in the *Federal Register,* the completion of these licensing actions; and (4) informing appropriate

Federal and State officials directly of the termination of the specific license and the placement of the site under the general license.

The long-term custodian, for its part, should be prepared to accept title to the land and byproduct material. These final actions should be completed within a relatively short period of time (i.e., within a week).

E4.0 ADDITIONAL ISSUES

E4.1 Uranium Mill Tailings Radiation Control Act of 1978, As Amended, Title II Sites on Tribal Lands

For Uranium Mill Tailings Radiation Control Act of 1978,, as amended, Title II disposal sites on tribal lands, long-term surveillance will be accomplished by the Federal government. The custodial agency is required to enter into arrangements with NRC to ensure this surveillance. The Uranium Mill Tailings Radiation Control Act of 1978, as amended, does not state explicitly which Federal agency is responsible for the disposal site. In addition, because these sites are located on tribal lands, no title transfer will occur.

Currently, the only site on tribal lands is the previous Western Nuclear, Inc., Sherwood uranium mill, located on the Spokane Indian tribe reservation in eastern Washington State. The Western Nuclear, Inc. Sherwood license was terminated in early 2001. Under long-term care, arrangements for the Sherwood site involve a site access agreement between the Indian tribe and DOE. DOE is allowed to conduct the required site surveillance and the site is accessible to NRC.

E4.2 Exclusive Jurisdiction

The Commission has determined that NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of 11e.(2) byproduct material (NRC 2002). Notwithstanding this determination, the NRC staff intends to work with the states on issues related to a licensee's completion of remedial actions and preparation for license termination. Although the NRC will, to the extent possible, accommodate a state's interest or perspective, it retains the right to terminate a specific license should a licensee have completed closure activities in accordance with NRC-approved closure plans.Where the issues involved are not those of direct NRC concern, NRC will address such issues with the states or other federal agencies on a case-by-case basis.

Currently, four sites (two NRC licensees: the United Nuclear Corporation/Church Rock site and the Homestake Mining Company/Grants site; and two Agreement State licensees: the Cotter Corp./Canon City and the UMETCO/Uravan sites, both in Colorado) are on the Superfund National Priorities List. For these sites, NRC will work with states and Superfund administering agencies to determine if it is appropriate to terminate the licenses.

E5.0 REFERENCES

NRC. "Termination of Uranium Milling Licenses in Agreement States." Draft Revision STP SA–900 Procedure. Washington, DC: NRC, Office of State and Tribal Programs. August 2001.

———. SECY–99–0277. "Concurrent Jurisdiction of Non-Radiological Hazards of Uranium Mill Tailings." Washington, DC: NRC. August 2000.

———. "Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills: Standard Format and Content Guide, and Standard Review Plan for Alternate Concentration Limit Applications." Washington, DC: NRC. February 1996.

———. SECY–90–282. "Rulemaking Issue (Affirmation): Amendments to 10 CFR Part 40 for General Licenses for the Custody and Long-Term Care of Uranium and Thorium Mill Tailings Disposal Sites." Washington, DC: NRC. August 1990.

———. NUREG–0706, "Final Generic Environmental Impact Statement on Uranium Milling." Washington, DC: NRC. 1980.

APPENDIX F

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF ON EFFLUENT DISPOSAL AT LICENSED URANIUM RECOVERY FACILITIES: CONVENTIONAL MILLS

F1.0 BACKGROUND

U.S. Nuclear Regulatory Commission (NRC)-licensed uranium mill recovery facilities produce liquid wastes (i.e., effluent) that require proper disposal. NRC Office of Nuclear Material Safety and Safeguards policy is presented below.

F1.1 Purpose and Applicability

This appendix presents guidance and discusses the technical and regulatory basis for review and evaluation of applications for the disposal of liquid waste. It is primarily intended to guide NRC staff reviews of site-specific applications for disposal of liquid waste.

F1.2 On-Site Evaporation

Applications for on-site evaporation systems must demonstrate that the proposed disposal facility is designed, operated, and closed in a manner that prevents migration of waste from the evaporation systems to subsurface soil, ground water, or surface water in accordance with 10 CFR Part 40, Appendix A. Applicants must also demonstrate that site-specific ground-water protection standards and monitoring requirements are adequately established to detect any migration of contaminants to the ground water and to implement corrective action to restore ground-water quality if, and when, necessary, as required by the regulations.

If surface impoundments are employed for evaporation, but they are not used for waste disposal, they must comply with the design provisions for surface impoundments [Criterion 5A(1) through Criterion 5A(5)]; measures for ground-water protection programs (Criterion 5E); and seepage control (Criterion 5F) of 10 CFR Part 40, Appendix A. However, if surface impoundments are employed for evaporation and waste disposal, they must comply with the regulatory requirements in 10 CFR Part 40, Appendix A. These include the design provisions for surface impoundments [Criterion 5A(1) through Criterion 5A(5)]; measures for ground-water protection programs (Criterion 5E); and seepage control (Criterion 5F). In addition, evaporation ponds must also meet other generally applicable regulatory provisions in Appendix A, in particular, the site-specific ground-water protection standards and leak detection requirements (Criterion 5B and Criterion 5C); corrective action programs (Criterion 5D); ground-water monitoring requirements (Criterion 7); and closure requirements (Criterion 6).

F1.3 Release in Surface Waters

The new source performance standards [40 CFR 440.34(b)] stipulate that, for new sources, there should be no discharge of process wastewater to navigable waters from mills using the acid leach, alkaline leach, or combined acid and alkaline leach process for the extraction of uranium.

F1.4 Land Applications

Proposals for disposing of liquid waste by land applications, including irrigation, must demonstrate that doses are maintained as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301. Proposed land application activities must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. This may require analysis to assess the chemical toxicity of radioactive and non-radioactive constituents. Specifically, licensees must submit (1) a description of the waste, including its physical and chemical properties that are important to risk evaluation; (2) the proposed manner and conditions of waste disposal; (3) projected concentrations of radioactive contaminants in the soil; and (4) projected impacts on ground-water and surface water quality and on land uses, including crops and vegetation. In addition, projected exposures and health risks that may be associated with radioactive constituents reaching the food chain should be analyzed to ensure that doses are as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301. Proposals should include provisions for periodic soil surveys to verify that contaminant levels in the soil do not exceed those projected and a remediation plan that can be implemented in the event that the projected levels are exceeded. Appropriate State and Federal agency permits must be obtained in accordance with 10 CFR 20.2007, and the applicant will be required to comply with NRC regulatory provisions for decommissioning.

F1.5 Deep Well Injection

Proposals for disposing of liquid waste by injecting the waste into deep wells must conform to the regulatory provisions in 10 CFR 20.2002 and demonstrate that doses are as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301. The injection facility must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. Specifically, proposals must describe the waste, including its physical and chemical properties important to risk evaluation, the proposed manner and conditions of waste disposal, an analysis and evaluation of pertinent information on the nature of the environment, information on the nature and location of other potentially affected facilities, and analyses and procedures to ensure that doses are as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301.

In addition, pursuant to the provisions of 10 CFR 20.2007, proposals for disposal by injection in deep wells must also comply with any other applicable Federal, State, and local government regulations pertaining to deep well injection, and licensees must obtain any necessary permits for this purpose. In particular, proposals must satisfy the U.S. Environmental Protection Agency (EPA) regulatory provisions in 40 CFR Part 146, “Underground Injection Control Program: Criteria and Standards,” and obtain necessary permits from the EPA and/or States authorized by the EPA to enforce these provisions. In general, NRC staff will approve applications that satisfy EPA regulations in accordance with the Underground Injection Control Program and the applicable provisions of 10 CFR Part 20.

Licensees and applicants disposing of effluent by injecting it into deep wells are further required to comply with the NRC regulatory provisions for decommissioning. Wells should be abandoned in accordance with the requirements of the State engineer.

APPENDIX G

NATIONAL HISTORIC PRESERVATION ACT AND ENDANGERED SPECIES ACT CONSULTATIONS

G1.0 BACKGROUND

The National Historic Preservation Act requires federal agencies to consider the effects of actions licensed by Federal agencies on properties included in or eligible for the *National Register of Historic Places.* The reclamation of a mill could impact historic properties directly (e.g., destruction or alteration of the integrity of a property) or indirectly (e.g., prohibiting access or increasing the potential for vandalism). Similarly, the Endangered Species Act requires that federal agencies consult with the U.S. Fish and Wildlife Service on any Federal action that could impact endangered species or their habitats. This appendix presents guidance to the U.S. Nuclear Regulatory Commission (NRC) staff on how to fulfill the NRC obligations under the National Historic Preservation and Endangered Species Acts.

G2.0 NATIONAL HISTORIC PRESERVATION ACT

G2.1 Review Procedures

The reviewer should ensure that those historic and cultural resources that could be impacted by proposed mill reclamation have been identified, located, and described in sufficient detail to serve as the basis for subsequent analysis and assessment of these impacts. Historic and cultural resources include districts, sites, buildings, structures, or objects of historical, archaeological, architectural, or cultural significance. The staff should review the results of any surveys conducted by the applicant, the location and significance of any properties that are listed in or eligible for inclusion in the *National Register of Historic Places (National Register)* as a historic place, and any additional information pertaining to the identification and description of historic properties that could be impacted by reclamation of the proposed mill. The descriptions to be examined by this review should be of sufficient detail to permit staff assessment and evaluation of specific impacts to historic and cultural resources from reclamation of the mill.

Regulatory criteria for the review of the historic properties that could be impacted by proposed reclamation of mills are based on the relevant requirements of the following:

- 36 CFR Part 800 defines the process by which a Federal agency conforms to the requirements under Sections 106 and 110 of the National Historic Preservation Act to ensure that agency-licensed undertakings consider the effects of the undertaking on historic properties included in or eligible for the *National Register*. Under this regulation, the Federal agency is required to identify and evaluate all historic properties in the project areas and take measures to mitigate adverse affects.

- 36 CFR Part 63 contains guidance by which historic properties are evaluated and determined eligible for listing on the *National Register*.

The reviewer should take the following steps to obtain the necessary information:

(1) Contact the appropriate State historic preservation officer to determine if there are any historic or cultural properties near the proposed mill site. In areas of Indian tribal land, the Indian tribal agencies may act as the State historic preservation officer. State historic preservation officer and tribal historic preservation officer lists are found on the Advisory Council on Historic Preservation Internet Home Page (http://www.achp.gov).

  (a) NRC can authorize the applicant to initiate consultation with the State historic preservation officer or tribal historic preservation officer, but remains legally responsible for all findings. Notify the State historic preservation officer/tribal historic preservation officer when an applicant is so authorized.

  (b) Make initial contact by phone and invite the State historic preservation officer to participate in the site visit. Then request information from the State historic preservation officer by letter.

  (c) If the State historic preservation officer has comments or information that add to or amplify information given to the applicant, request that the State historic preservation officer forward, by letter to the staff, these additional comments.

(2) Contact the Archeology and Ethnography Program of the National Park Service, U.S. Department of Interior (http://www.cr.nps.gov/aad/). This office has expertise in the area of historic and cultural preservation and is staffed with professionals who can assist in the environmental review and in analyzing the results of applicant surveys and investigations.

(3) In consultation with the State historic preservation officer, apply the *National Register* criteria outlined by the U.S. Department of the Interior (National Park Service, 1990, 1991) to all identified historic properties that are on the facility site or that will be directly affected by facility construction. If a property appears to meet the criteria, or if it is questionable whether the criteria are met, the staff should request, in writing, an opinion from the U.S. Department of the Interior about the property eligibility for inclusion in the *National Register*. The request for determination of eligibility should be sent directly to the Keeper of the National Register of Historic Places, National Park Service, U.S. Department of the Interior, Washington, DC, 20013-7127.

(4) Have the National Park Service–Archeology and Ethnography Program staff assist in defining the requirements of additional surveys and investigations that the staff decides should be completed by the applicant and in reviewing the results of these surveys.

(5) Consult the *National Register* to verify the list of *National Register* properties presented by the licensee. Since a proposed facility can have a visual or audible effect on historic and cultural resources that are located some distance from the proposed facility site, all *National Register* properties within the area of potential effects of the proposed facility or off-site areas should be identified.

(6) Discuss with the State historic preservation officer and, where appropriate, the State archaeologist and State historian, the information presented to the aplicant by the State historic preservation officer. The State historic preservation officer can alert the staff to relevant State and local laws, orders, ordinances, or regulations aimed at the preservation of cultural resources within the licensee State. Discuss with the State historic preservation officer any organizations or individuals that might be able to assist in identifying and locating archaeological and historic resources (e.g., university, Indian tribal archaeological and historical staffs, and regional U.S. Bureau of Land Management archaeologists).

(7) To discourage property vandalism and scavenging, it is necessary to present information on location of artifacts to the State historic preservation officer in a confidential manner. Summary information, which does not include site-specific information, could be included in the licensee and NRC staff documentation.

(8) Contact the Advisory Council on Historic Preservation if guidance is needed, if there are substantial impacts on important properties, in the event of a disagreement, or if there are issues of concern to Indian tribes.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

G2.2 Acceptance Criteria

The kinds of data and information needed will be affected by site- and facility-specific factors and the degree of detail should be modified according to the anticipated magnitude of the potential impact. Guidance can be found on the National Park Service Internet Home Page at http://www.cr.nps.gov/nr/nrpubs.html and in NUREG–1748 (NRC, 2001). The licensee should present the following data or information:

(1) A detailed description of any archaeological or historical surveys of the proposed site, including the following:

- (a) The physical extent of the survey: If the entire site was not surveyed, the basis for selecting the area to be surveyed.

- (b) A brief description of the survey techniques used and the reason for the selection of the survey techniques used.

- (c) The qualifications of the surveyors.

- (d) The findings of the survey in sufficient detail to permit a subsequent independent assessment of the impact of the proposed project on archaeological and historic resources.

(2) The results of consultation with Federal, State, local, and affected Indian tribal agencies.

(3) The comments of any organizations contacted by the licensee to locate and assess archaeological and historic resources located on or near the proposed mill site.

(4) A description of any historic property within the area of potential effects of the mill that are in or have been determined eligible for inclusion in the *National Register* or that are included in state or local registers or inventories of historic and cultural resources.

(5) A map indicating the location of all identified historic landmarks and historic places with respect to the location of facilities such as buildings, new roads, well fields, pipelines, surface impoundments, and utilities (not to be made public).

(6) A license condition prohibiting work if cultural artifacts are found in locations other than those already identified.

(7) The likely impact of the presence of new roads, pipelines, or other utilities on historic and cultural resources.

(8) A rating of the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management Visual Resource Management System (U.S. Bureau of Land Management, 1984, 1986a,b).

(9) The following information should usually be briefly described in the environmental assessment:

    (a) Historic properties listed in or eligible for inclusion in the *National Register*. Any resource considered to be eligible for the *National Register* should have concurrence from the appropriate state historic preservation officer.

    (b) Historic properties included in state or local registers or inventories.

    (c) Any additional important historic or cultural properties.

    (d) The efforts to locate and identify previously recorded archaeological and historic sites.

    (e) The overall results and adequacy of any surveys (archival or field) that were conducted by the applicant.

    (f) A list of organizations and individuals contacted by the applicant or the NRC staff who provided significant information concerning the location of historic and cultural properties.

G2.3 Evaluation Findings

If the staff review results in the acceptance of the characterization of the historic and cultural resources, the following conclusions may be presented in the environmental assessment.

The staff has completed its review of the site characterization information concerned with historic and cultural resources near the _______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Sections 2.1 and 2.2 of Appendix G of NUREG–1620. The licensee has acceptably described the historic and cultural resources near the site. A listing of all nearby areas and properties included or eligible for inclusion in the *National Register of Historic Places* is provided. A map indicates where all historic and cultural resources are located with respect to facilities. A record of the investigation of places and properties with historic and cultural significance, which follows guidance equivalent to that of the National Park Service, is provided. Contact with local tribal authorities is acceptably documented. A letter from the State historic preservation officer addressing any issues related to the properties that might be affected by the reclamation is included. The licensee has acceptably demonstrated that the State historic preservation officer and tribal authorities agree with the planned protection from, or determination of lack of conflict with, facilities and activities and with any places of importance to the State, Federal, or tribal authorities. The licensee has acceptably rated the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management Visual Resource Inventory and Evaluation System.

On the basis of the information presented in the application, and the detailed review conducted of the characterization of historic and cultural resources near the ______________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

G2.4 References

10 CFR 51.45, “Environmental report.”

36 CFR Part 63, “Determination of Eligibility for Inclusion in the National Register of Historic Places.”

36 CFR Part 800, “Protection of Historic and Cultural Properties.”

National Historic Preservation Act, as amended. 16 USC 470 *et seq.*

National Park Service. “How to Apply the National Register Criteria for Evaluation.” *National Register*. Bulletin No. 15. Washington, DC: U.S. Department of the Interior. 1991.

———. “Guidelines for Evaluating and Documenting Traditional Cultural Properties.” *National Register*. Bulletin No. 38. Washington, DC: U.S. Department of the Interior. 1990.

———. "Guidelines for Local Surveys: A Basis for Preservation Planning." *National Register*. Bulletin No. 24. Washington, DC: U.S. Department of the Interior. 1985.

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Draft. Washington, DC: NRC. 2001.

U.S. Bureau of Land Management. "Visual Resource Inventory." BLM Report H–8410–1. 1986a.

———. "Visual Resource Contrast Rating." BLM Report H–8431–1. 1986b.

———. "Visual Resource Management." BLM Report 8500. 1984.

U.S. Department of the Interior. "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines." 48 FR 44716. pp. 44,716–44,742. 1983.

G3.0 ENDANGERED SPECIES ACT

G3.1 Review Procedures

Federal agencies must determine if any proposed actions could impact endangered species or their habitats. For uranium mills, the NRC staff should take into consideration impacts resulting from excavation of clay used in constructing radon barriers or procurement of rocks used in riprap. Other surface reclamation work, such as the cleanup of windblown tailings, has the potential to impact endangered animals or plants. Also, the staff should review the processing of any alternate concentration limit application if the proposed site is located on or near surface water that contains endangered animal or plant species.

Procedures for conducting consultations with the U.S. Fish and Wildlife Service are contained in the endangered species consultation handbook (U.S. Fish and Wildlife Service/National Marine Fisheries Service, 1998). The reviewer analysis should consist of the following steps:

(1) Contact the U.S. Fish and Wildlife Service regional office or field office to obtain the list of threatened or endangered plant and animal species that may be present near the site. The attached table indicates the States in each U.S. Fish and Wildlife Service regional office and provides contact information.

(2) The licensee may request the species list; however, the NRC must formally designate the licensee in writing (U.S. Fish and Wildlife Service/National Marine Fisheries Service, 1998, pp. 2–13).

(3) If there may be endangered or threatened animal or plant species on or near the site, the reviewer should discuss the proposed action with the U.S. Fish and Wildlife Service and may need to ask the licensee to perform a survey and a biological assessment

(50 CFR 402.12) to evaluate the potential effects of the action on threatened and endangered species. Either the NRC or the licensee can prepare the biological assessment (U.S. Fish and Wildlife Service/National Marine Fisheries Service, 1998, pp. 3–11).

(4) Each State should be consulted about its own procedures for considering impacts to state-listed species.

G3.2 Acceptance Criteria

Consultations on identifying threatened and endangered species under the Endangered Species Act of 1973, as amended, are acceptable if the following criteria are met:

(1) The environmental impact assessment provides sufficient information to ensure that the licensing action is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the habitat of such species. The demonstration of compliance with this objective requires consultation with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service. The U.S. Fish and Wildlife Service will coordinate with the National Marine Fisheries Service.

(2) The licensee provides adequate discussion of the status of compliance with applicable permits, licenses and other environmental requirements that have been imposed by Federal agencies.

(3) There is adequate information on interagency cooperation and consultations with Federal, State, and local agencies with regard to the Endangered Species Act.

G3.3 Evaluation Findings

If staff review results in acceptance of compliance with the Endangered Species Act, the following conclusions may be presented in the environmental assessment:

The staff has completed its review of the site characterization information concerned with the threatened and endangered species near the ______________ uranium mill facility. This review included an evaluation using review procedures and acceptance criteria outlined in Sections 3.1 and 3.2 of Appendix G of NUREG–1620. The licensee has acceptably described the presence of threatened and endangered species near the site. Consultations with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service on threatened and endangered species were conducted and are documented in an acceptable manner. Any impacts on these species and their habitats have been identified, and mitigation measures necessary to avoid adverse impacts have been described.

On the basis of the information presented in the application, and the detailed review conducted of the characterization of threatened and endangered species near the ______________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

G3.4 References

10 CFR 51.45, “Environmental Report.”

40 CFR 1502.25, “Environmental Review and Consultation Requirements.”

50 CFR Part 402, “Interagency Cooperation-Endangered Species Act of 1973, as Amended.”

Endangered Species Act of 1973, as amended, 16 USC 1531 *et seq*.

U.S. Fish and Wildlife Service/National Marine Fisheries Service. "Endangered Species Consultation Handbook, Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act." Washington, DC: U.S. Fish and Wildlife Service/National Marine Fisheries Service. 1998.

U.S. Fish and Wildlife Service
Endangered Species Program Contacts

Washington, DC Office

U.S. Fish and Wildlife Service
Division of Endangered Species
Mail Stop 420ARLSQ
1849 C St., N.W., Washington, DC 20240
http://www.fws.gov

Region One (CA, HI, ID, NV, OR, WA)

Chief, Division of Endangered Species
Eastside Federal Complex, 911 NE 11th Ave, Portland, OR 97232
http://pacific.fws.gov
Contact: Call field office

Region Two (AZ, NM, OK, TX)

Chief, Division of Endangered Species
P.O. Box 1306, Albuquerque, NM 87103
http://southwest.fws.gov
Contact:: Species list on Internet for each county
Call field supervisor if there are questions

Region Three (IA, IL, IN, MI, MN, MO, OH, WI)

Chief, Ecological Services Operations
Federal Building, Ft. Snelling, Twin Cities, MN 55111
http://midwest.fws.gov
Contact: Species list on Internet by county, (except Missouri)
Call field supervisor if there are questions or if the site is in Missouri

Region Four (AL, AR, FL, GA, KY, LA, MS, NC, PR, SC, TN, U.S. VI)

Programmatic Assistant
Regional Director for Ecological Services
1875 Century Blvd., Suite 200, Atlanta, GA 30345
http://southeast.fws.gov
Contact: Letter to Programmatic Assistant

Region Five (CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV)

Chief, Division of Endangered Species
300 Westgate Center Drive, Hadley, MA 01035
http://northeast.fws.gov
Contact: Call field office

Region Six (CO, KS, MT, NE, ND, SD, UT, WY)

Division of Endangered Species
P.O. Box 25486, Denver Federal Center, Denver, CO 80225
http://mountain-prairie.fws.gov
Contact: Call field office

Region Seven (AK)

Division of Endangered Species
1011 E. Tudor Rd., Anchorage, AK 99503
http://alaska.fws.gov
Contact: Letter to Division of Endangered Species

APPENDIX H

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF ON THE RADIUM BENCHMARK DOSE APPROACH

H1.0 BACKGROUND

In 10 CFR 40.4, byproduct material is defined as the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Uranium milling is defined as any activity resulting in byproduct material. Therefore, 10 CFR Part 40, Appendix A, applies to *in situ* leach, heap leach, and ion-exchange facilities that produce byproduct material, as well as to conventional uranium and thorium mills. This guidance only addresses uranium recovery facilities because there are no currently licensed or planned thorium mills.

The final rule, “Radiological Criteria for License Termination of Uranium Recovery Facilities,” became effective on June 11, 1999, and added the following paragraph after the “radium in soil” criteria in Appendix A, Criterion 6(6):

> Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more that one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit, will not exceed 1 (unity). A calculation of the peak potential annual TEDE within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site, must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 100 mrem/yr, before application of as low as is reasonably achievable, requires the approval of the Commission after consideration of the recommendation of NRC staff. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before June 11, 1999.

H2.0 RADIUM BENCHMARK DOSE APPROACH

The general requirements for a decommissioning plan, including verification of soil contamination cleanup, are addressed in Chapter 5.0 of this standard review plan. This appendix discusses the NRC staff evaluation of the radium benchmark dose approach, specifically dose modeling and its application to site cleanup activities that should be addressed in the decommissioning plan for those uranium recovery facilities licensed by the NRC and subject to the new requirements for cleanup of contaminated soil and buildings under 10 CFR Part 40, Appendix A, Criterion 6(6), as amended in 1999. The facilities that did not have an approved decommissioning plan at the time the rule became final are required to reduce residual radioactivity, that is, byproduct material, as defined by 10 CFR Part 40, to levels based on the potential dose, excluding radon, resulting from the application of the radium (Ra-226) standard at the site. This is referred to as the radium benchmark dose approach.

This guidance also applies to any revised decommissioning plan submitted for NRC review and approval, after the final rule was effective. However, if a subject licensee can demonstrate that no contaminated buildings will remain, and that soil thorium-230 (Th-230) does not exceed 5 pCi/g (above background) in the surface and 15 pCi/g in subsurface soil in any 100-square-meter area that meets the radium standard, and the natural uranium (U-nat, that is, U-238, U-234, and U-235) level is less than 5 pCi/g above background, radium benchmark dose modeling is not required. If future modeling with site-specific parameters for uranium recovery sites indicates that this is not a protective approach, the guidance will be revised. Therefore, it would be prudent for a uranium recovery licensee to consider the potential dose from any residual thorium and uranium.

The unity “rule” mentioned in the new paragraph of Criterion 6(6) applies to all licensed residual radionuclides. Therefore, if the ore (processed by the facility), tailings, or process fluid analyses indicate that elevated levels of Th-232 could exist in certain areas after cleanup for Ra-226, some verification samples in those areas should be analyzed for Th-232 or Ra-228. The thorium (Th-232) chain radionuclides (above local background levels) in milling waste would have soil cleanup criteria similar to the uranium chain radionuclides. The staff considers the EPA memorandum of February 12, 1998, (Directive No. 9200.4–25) concerning use of 40 CFR Part 192 soil criteria for Comprehensive Environmental Response, Compensation and Liability Act sites, an acceptable approach. This means that the Th-230 and Th-232 should be limited to the same concentration as their radium progeny with the 5 pCi/g (0.19 Bq/g) criterion applying to the sum of the radium constituents (Ra-226 plus Ra-228) as well as the sum of the thorium constituents (Th-230 plus Th-232) above background.

H2.1 Radium Benchmark Dose Modeling

H2.1.1 Areas of Review

The radium benchmark dose approach involves calculation of the peak potential dose for the site resulting from the 5 pCi/g [0.19 Bq/g] concentration of radium in the surface 15 cm [6 in.] of soil. The dose from the 15 pCi/g [0.56 Bq/g] subsurface radium would also be calculated for any area where the criterion is applied. The dose modeling review involves examining the computer code or other calculations employed for the dose estimates, the code or calculation input values and assumptions, and the modeling results (data presentation).

Evaluation of the radium benchmark dose modeling as proposed in the decommissioning plan, requires an understanding of the site conditions and site operations. The relevant site information presented in the plan or portions of previously submitted documents (e.g., environmental reports, license renewal applications, reclamation plan, and characterization survey report) should be reviewed.

H2.1.2 Review Procedures

The radium benchmark dose modeling review consists of ascertaining that an acceptable dose modeling computer code or other type of calculation has been used, that input parameter values appropriate (reasonable considering long-term conditions and representative of the application) for the site have been used in the modeling, that a realistic (overly conservative is not acceptable as it would result in higher allowable levels of uranium or thorium which would not be as low as is reasonably achievable) dose estimate is provided, and that the data presentation is clear and complete.

H2.1.3 Acceptance Criteria

The radium benchmark dose modeling results will be acceptable if the dose assessment (modeling) meets the following criteria:

(1) Dose Modeling Codes and Calculations

The assumptions are considered reasonable for the site analysis, and the calculations employed are adequate. Reference to documentation concerning the code or calculations is provided [e.g., the RESRAD Handbook and Manual (Argonne National Laboratory, 1993a,b)].

The RESRAD code developed by the U.S. Department of Energy (Version 6.1, 2001) may be acceptable for dose calculations because, although the RESRAD ground-water calculations have limitations, this does not affect the uranium recovery sites that have deep aquifers (ground-water exposure pathway is insignificant). The DandD code developed for the NRC provides conservative default values, but does not, at this time, allow for modeling subsurface soil contamination and does not allow calculation of source removal due to soil erosion. The DandD code would not be adequate to model the dose from off-site contamination, but codes such as GENII are acceptable. See Appendix C of NUREG–1727 (NRC, 2000) for additional information.

If the code or calculations assumptions are not compatible with site conditions, adjustments have been made in the input to adequately reflect site conditions. For example, the RESRAD code assumes a circular contaminated zone. The shape factor (external gamma, code screen R017) is adjusted for an area that is not circular.

The code and/or calculation provides an estimated annual dose as total effective dose equivalent in mrem/yr. The DandD code provides the annual dose, but RESRAD calculates the highest instantaneous dose. However, RESRAD results are acceptable for long-lived radionuclides that do not move rapidly out of surface soils.

(2) Input Parameter Values

The code/calculation input data are appropriate for the site and represent current or long-term conditions, whichever is more applicable to the time of maximum dose. When code default values are used, they are justified as appropriate (representative) for the site. Excessive conservatism (i.e., upper bound value) is not used, as this would result in a higher dose and thus higher levels of uranium and thorium could be allowed to remain on site.

Previously approved MILDOS code input parameter values may not be appropriate, because derived operational doses in the restricted area may be an order of magnitude higher than acceptable doses for areas to be released for unrestricted use.

Site-specific input values are demonstrated to be average values of an adequate sample size. Confidence limits are provided for important parameters so that the level of uncertainty can be estimated for that input value. Alteration of input values considers that some values are interrelated [see draft NUREG–1549, Appendix C (NRC, 1998)], and relevant parameters are modified accordingly. The preponderance of important parameter values are based on site measurements and not on conservative estimates. One or more models consider the annual average range of parameter values likely to occur within the next 200 years, for important parameters that can reasonably be estimated. Some other considerations for the input parameter values follow:

(a) Scenarios for the Critical Group and Exposure Pathways

The scenario(s) chosen to model the potential dose to the average member of the critical group[1] from residual radionuclides at the site reflect reasonable probable future land use. The licensee has considered ranching, mining, home-based business, light industry, and residential farmer scenarios, and has justified the scenarios modeled.

On the basis of one or more of these projected (within 200 years is reasonably foreseeable) land uses to define the critical group(s), the licensee has determined and justified what exposure pathways are probable for potential exposure of the critical group to residual radionuclides at the site. Dairies are not likely to be established in the area of former uranium recovery facilities because the climate and soil restrict feed production. Even if some dairy cows were to graze in contaminated areas, the milk would probably be sent for processing (thus diluted), and not be consumed directly at the site. Therefore, milk consumption is not a likely ingestion exposure pathway. Also, a pond in the contaminated area providing a significant quantity of fish for the resident's diet is not likely, so the aquatic exposure pathway may not have to be modeled. However, the external gamma, plant ingestion, and inhalation pathways are likely to be important.

The radon pathway is excluded from the benchmark dose calculation as defined in Criterion 6(6) of Appendix A to 10 CFR Part 40. This also reflects the approach in the decommissioning rule (radiological criteria for license termination, 10 CFR Part 20, Subpart E).

[1]As defined in 10 CFR Part 20, "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

(b) Source Term

If the RESRAD code is used, the input includes lead-210 (Pb-210) at the same concentration input value as for Ra-226. The other radium progeny are automatically included in the code calculations. The chemical form of the contamination in the environment is considered in determining input values related to transport, or inhalation class (retention in the lung) for dose conversion factors.

(c) Time Periods

The time periods for calculation of the dose from soil Ra-226 include the 1,000-year time frame. The calculated maximum annual dose and the year of occurrence are presented in the results.

(d) Cover and Contaminated Zone

A cover depth of zero is used in the surface contamination model, and a depth of at least 15 cm [6 in.] is used for the subsurface model. The values for area and depth of contamination are derived from site characterization data. The erosion rate value for the contaminated zone is less than the RESRAD default value because in regions drier than normal, the erosion rate is less, as discussed in the RESRAD Data Collection Handbook (Argonne National Laboratory, 1993a), and the proposed value is justified. The soil properties are based on site data (sandy loam or sandy silty loam are typical for uranium recovery sites), and other input parameters are based on this demonstration of site soil type [see RESRAD handbook, pp., 23, 29, 77, and 105 (Argonne National Laboratory, 1993a)].

The evapotranspiration coefficient for the semi-arid uranium recovery sites is between 0.6 and 0.99. The precipitation value is based on annual values averaged over at least 20 years, obtained from the site or from a nearby meteorological station.

The irrigation rate value may be zero, or less than a code's default value, if supported by data on county or regional irrigation practices (e.g., zero is acceptable if irrigation water is obtained from a river not a well). The runoff coefficient value is based on the site's soil type, expected land use, and regional morphology.

(e) Saturated Zone

The dry bulk density, porosity, "b" parameter, and hydraulic conductivity values are based on local soil properties. The hydraulic gradient for an unconfined aquifer is approximately the slope of the water table. For a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.

If the RESRAD code is used, the non-dispersion model parameter is chosen for areas greater than 1,000 square meters (code screen R014), and the well pump rate is based on irrigation, stock, or drinking water well pump rates in the area.

(f) Uncontaminated and Unsaturated Strata

The thickness value represents the typical distance from the soil contamination to the saturated zone. Since the upper aquifer at uranium recovery sites is often of poor quality and quantity, the depth of the most shallow well used for irrigation or stock water in the region is chosen for the unsaturated zone thickness. A value of 18 m [60 ft] is typical for most sites {15 m [50 ft] for the Nebraska site}, but regional data are provided for justification. The density, porosity, and "b" parameter values are similar to those for the saturated zone, or any changes are justified.

(g) Distribution Coefficients and Leach Rates

The distribution coefficient (Kd) is based on the physical and chemical characteristics of the soil at the site. The leach rate value of zero in the RESRAD code is acceptable as it allows calculation of the value. If a value greater than zero is given, the value is justified.

(h) Inhalation

An average inhalation rate value of approximately 8,395 m^3/yr is used for the activity assumed for the rancher or farmer scenario based on a draft letter report (Sandia National Laboratories, 1998a). The mass loading for inhalation (air dust loading factor) value is justified based on the average level of airborne dust in the local region for similar activities as assumed in the model.

(i) External Gamma

The shielding factor for gamma is in the range of 0.3 to 0.6 (70 to 40 percent shielding) (the DandD code screening default value is 0.55 and EPA has recommended 0.4). The factor is influenced by the type (foundation, materials) of structures likely to be built on the site and the gamma energy of the radionuclides under consideration.

The time fractions for indoor and outdoor occupancy are similar to default values in RESRAD and draft guidance developed for the decommissioning rule [NUREG/CR–5512, Volume 3 (NRC, 1999b)]. For example, the staff would consider fraction values approximating 0.7 indoors and 0.15 outdoors for a resident working at home, and 0.5 outdoors and 0.25 indoors for the farmer scenario (the remaining fraction allocated to time spent offsite).

The site-specific windspeed value is based on adequate site data. The average annual windspeed for the uranium recovery sites varies from 3.1 to

5.5 meters/sec [7 to 13 mph]. The maximum and annual average windspeed are also considered when evaluating proposed erosion rates.

(j) Ingestion

Average consumption values (g/yr) for the various types of foods are based on average values as discussed in NUREG/CR–5512, Volume 3 (NRC, 1999), or the Sandia Draft Letter Reports (Sandia National Laboratories,1998a,b), or are otherwise justified. Livestock ingestion parameters are default values, or are otherwise justified.

For sites with more than 100 acres of contamination, the fraction of diet from the contaminated area is assumed to be 0.25 for the farmer scenario (Sandia National Laboratories, 1998a), or is otherwise justified based on current or anticipated regional consumption practices for home-grown food. Because of the low level of precipitation in the areas in which uranium recovery facilities are located, extensive gardens or dense animal grazing is not likely, so the percentage of the diet obtained from contaminated areas would be lower than the code default value.

Note that the default plant mass loading factor in the DandD code can reasonably be reduced to 1 percent (Sandia National Laboratories, 1998c). The depth of roots is an important input parameter for uranium recovery licensees using the RESRAD code. The value is justified based on the type of crops likely to be grown on the site in the future. For vegetable gardens, a value of 0.3 is more appropriate than the RESRAD default value of 0.9 meters that is reasonable for alfalfa or for a similar deep-rooted plant.

(3) Presentation of Modeling Results

The radium benchmark dose modeling section of the decommissioning plan includes the code or calculation results as the maximum annual dose (total effective dose equivalent) in mrem/yr, the year that this dose would occur, and the major exposure pathways by percentage of total dose. The modeling section also includes discussion of the likelihood of the various land-use scenarios modeled (reflecting the probable critical groups), and provides the variations in dose (dose distribution) created by changing key parameter values to reflect the range of dose values that are likely to occur on the site in the future. The section also contains the results of a sensitivity analysis (RESRAD can provide a sensitivity analysis via the graphics function) to identify the important parameters for each scenario.

H2.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radium benchmark dose modeling, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the site benchmark dose modeling for the ______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section H2.1 of Appendix H of this standard review plan.

The licensee has provided an acceptable radium benchmark dose model, and the staff evaluation has determined that (1) the computer code or set of calculations used to model the benchmark dose is appropriate for the site, (2) input parameter values used in each dose assessment model are site-specific or reasonable estimates, and (3) the dose modeling results include adequate estimates of dose uncertainty.

On the basis of the information presented in the application, and the detailed review conducted of radium benchmark dose modeling for the ______________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which provides requirements for soil and structure cleanup.

H2.2 Implementation of the Benchmark Dose

H2.2.1 Areas of Review

The results of the radium benchmark dose calculations are used to establish a surface and subsurface soil dose limit for residual radionuclides other than radium, as well as a limit for surface activity on structures that will remain after decommissioning. The staff should review the licensee’s conversion of the benchmark dose limit to soil concentration (pCi/g) or surface activity levels (dpm/100 cm^2) as a first step to determine cleanup levels. Alternatively, the licensee can derive the estimated dose from the uranium or thorium contamination (as discussed in Section 2.1.3) and compare this to the radium benchmark dose.

The reviewer should also evaluate the proposed cleanup guideline levels (derived concentration limit) in relation to the “as low as is reasonably achievable” requirement and the unity rule.

H2.2.2 Review Procedures

The decommissioning plan section on cleanup criteria will be evaluated for appropriate conversion of the radium standard benchmark dose to cleanup limits for soil uranium and thorium and/or surface activity. The plan will also be examined to ensure reasonable application of “as low as is reasonably achievable” to the cleanup guideline values and application of the unity rule where appropriate.

H2.2.3 Acceptance Criteria

(1) The soil concentration limit is derived from the site radium dose estimate. The modeling performed to estimate mrem/year per pCi/g of Th-230 and/or U-nat follows the criteria listed in Section 2.1.3. In addition, the U-nat source term input is represented as percent activity by 48.9 percent U-238, 48.9 percent U-234, and 2.2 percent U-235, or is based on analyses of the ore processed at the site. For a soil uranium criterion (derived

concentration limit), the chemical toxicity is considered in deriving a soil concentration limit if soluble forms of uranium are present.

(2) Detailed justification for the inhalation pathway parameters is provided, such as the determination of the chemical form in the environment, to support the inhalation class.

(3) The derived Th-230 soil limit will not cause any 100 square meter (m^2) area to exceed the Ra-226 limit at 1,000 years (i.e., current concentrations of Th-230 are less than 14 pCi/g surface and 43 pCi/g subsurface, if Ra-226 is at approximately background levels).

(4) In conjunction with the activity limit, the “as low as is reasonably achievable” principle is considered in setting cleanup levels (derived concentration guideline levels). The as low as is reasonably achievable guidance in NUREG–1727, Appendix D (NRC, 2000) is considered. The proposed levels allow the licensee to demonstrate that the 10 CFR 40.42 (k) requirements (the premises are suitable for release, and reasonable effort has been made to eliminate residual radioactive contamination) can be met.

(5) In recent practice at mill sites, the as low as is reasonably achievable principle is implemented by removing about 2 more inches [5 cm] of soil than is estimated to achieve the radium standard (reduce any possible excess or borderline contamination). At mills, it is generally cheaper to remove more soil than to do sampling and testing that may indicate failure and require additional soil removal with additional testing.

(6) The unity rule is applied to the cleanup if more than one residual radionuclide is present in a soil verification grid (100 m^2). This means that the sum of the ratios for each radionuclide of the concentration present/concentration limit may not exceed 1 (i.e., unity).

(7) The subsurface soil standard, if it is to be used, is applied to small areas of deep excavation where at least 15 cm [6 in.] of compacted clean fill is to be placed on the surface and where that depth of cover is expected to remain in place for the foreseeable future. The long-term cover depth used in the model is justified.

(8) The surface activity limit for remaining structures is appropriately derived using an approved code or calculation. Because recent conservative dose modeling by NRC staff has indicated that more than 2,000 dpm/100 cm^2 alpha (U-nat or uranium chain radionuclides) in habitable buildings [2,000 hr/yr] could exceed an effective dose equivalent of 25 mrem/yr, the licensee proposes a total (fixed plus removable) average surface activity limit for such buildings that is lower than 2,000 dpm/100 cm^2, or a higher value is suitably justified.

(9) If the DandD code is used, data are provided to support that 10 percent or less of the surface activity is removable; otherwise the resuspension factor is scaled to reflect the site-specific removable fraction. Note that this code assumes that the contamination is only on the floor, which can be overly conservative. If the RESRAD-Build code is used, the modeled distribution of contamination on walls and floor is justified.

H2.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the application of the radium benchmark dose modeling to the site cleanup criteria, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the proposed implementation of the benchmark dose modeling results for the _______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section H2.2 of Appendix H of this standard review plan.

The licensee has provided an acceptable implementation plan of the benchmark dose modeling results to the proposed site cleanup activities, and the staff evaluation has determined that (1) the cleanup criteria will allow the licensee to meet 10 CFR Part 40.42(k) and 10 CFR Part 40, Appendix A, Criterion 6(6) requirements; (2) the soil and structures of the decommissioned site will permit termination of the license because public health and the environment will not be adversely affected by any residual radionuclides.

H3.0 REFERENCES

Argonne National Laboratory. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." ANL/EAIS–8. Washington, DC: U.S. Department of Energy. April 1993a.

———. "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0." ANL/EAD/LD–2. Washington, DC: U.S. Department of Energy. September 1993b.

NRC. NUREG/CR–5512, "Residual Radioactive Contamination from Decommissioning—User's Manual." Vol. 2. Washington, DC: NRC. April 2001.

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Sandia National Laboratories. "Review of Parameter Data for the NUREG/CR–5512 Residential Farmer Scenario and Probability Distributions for the DandD Parameter Analysis." Draft Letter Report. January 30, 1998a.

———. "Review of Parameter Data for the NUREG/CR-5512 Building Occupancy Scenario and Probability Distributions for the DandD Parameter Analysis." Draft Letter Report. January 30, 1998b.

———. “Comparison of the Models and Assumptions Used in the DandD 1.0, RESRAD 5.61, and RESRAD-Build Computer Codes with Respect to the Residential Farmer and Industrial Occupant Scenarios Provided in NUREG/CR–5512.” Draft Report. October 15, 1998c.

APPENDIX I

REGULATORY ISSUE SUMMARY 2000–23

In Regulatory Issue Summary 2000–23 (NRC,2000), the Commission promulgated staff requirements to revise previously published guidance on matters related to regulation of uranium recovery facilities. This appendix presents that revised guidance as it relates to uranium mills and is included to assist the staff and operators when considering related actions. The issues and policies addressed are:

(1) Part 41 Rulemaking (SECY–99–011)

(2) Disposal of Non-11e.(2) Byproduct Material in Tailings Impoundments (SECY–99–012)

(3) Processing of Material Other Than Natural Uranium Ores (SECY–99–012)

(4) Concurrent Jurisdiction of Non-Radiological Hazards of Uranium Mill Tailings (SECY–99–277)

Reference:

NRC. Regulatory Issue Summary 2000-23. “Recent Changes to Uranium Recovery Policy.” Washington, DC: NRC. November 2000.

Appendix I

Recent Changes to Uranium Recovery Policy

November 30, 2000

- ADDRESSEES
- INTENT
- BACKGROUND
- PART 41 RULEMAKING (SECY–99–011)
- DISPOSAL OF NON-11e.(2) BYPRODUCT MATERIAL IN TAILINGS IMPOUNDMENTS (SECY–99–012)
- PROCESSING OF MATERIAL OTHER THAN NATURAL URANIUM ORES (SECY–99–012)
- CLASSIFICATION OF LIQUID WASTES AT ISL FACILITIES (SECY–99–013)
- GROUND-WATER ISSUES AT ISL FACILITIES (SECY–99–013)
- CONCURRENT JURISDICTION OF NON-RADIOLOGICAL HAZARDS OF URANIUM MILL TAILINGS (SECY–99–277)
- SUMMARY OF ISSUES

ADDRESSEES

All holders of materials licenses for uranium and thorium recovery facilities.

INTENT

The U.S. Nuclear Regulatory Commission (NRC) is issuing this regulatory issue summary (RIS) to inform materials licensees of the Commission's decisions on four Commission Papers prepared by the Uranium Recovery staff and the Office of the General Counsel (OGC). All the policy decisions will be codified in the 10 CFR Part 41 rulemaking that has been initiated. No specific action nor written response is required.

BACKGROUND

NRC staff prepared four Commission Papers in 1999 to address various uranium recovery issues. One Commission Paper (SECY–99–011, “Draft Rulemaking Plan; Domestic Licensing of Uranium and Thorium Recovery facilities—Proposed New 10 CFR Part 41”) addressed the need to revise and update uranium recovery regulations, particularly with respect to *in situ* leach (ISL) facilities and recommended the initiation of rulemaking to create a new Part 41 specific to uranium recovery. The other three Commission Papers addressed issues raised by the National Mining Association (NMA) in its April 1998 paper, “Recommendations for a Coordinated Approach to Regulating the Uranium Recovery Industry.“ The first of those papers (SECY–99–012, “Use of Uranium Mill Tailings Impoundments for the Disposal of Other Than 11e(2) Byproduct Materials, and Reviews of Applications to Process Material Other Than Natural Ore”) discussed the disposal of radioactive waste, other than byproduct material, defined in section 11e.(2) of the Atomic Energy Act (AEA) of 1954, as amended, in mill tailings impoundments, and the processing of material, other than natural ore, for source material at licensed uranium mills. The second of those papers (SECY–99–013, “Recommendations on ways to Improve the Efficiency of NRC Regulation at *In Situ* Leach Uranium Recovery Facilities") discussed the regulation of ground water at ISL sites and the issue of which waste streams at ISL facilities come under NRC regulatory jurisdiction as 11e.(2) byproduct material. The last paper (SECY–99–277, "Concurrent Jurisdiction of Non-Radiological Hazards of Uranium Mill Tailings) addressed the issue of concurrent jurisdiction (with States that do not have Agreement State regulatory authority for 11e.(2) material under section 274 of the AEA) over the non-radiological hazards of uranium mill tailings.

On July 13, 2000, the Commission issued a Staff Requirements Memorandum (SRM) on SECY–99–011. On July 26, 2000, the Commission issued SRMs on SECY–99–012 and SECY–99–013, and on August 11, 2000, the SRM on SECY–99–277 was issued.

The decisions and directions in these SRMs and the staff actions in response are discussed in sections that follow.

PART 41 RULEMAKING (SECY–99–011)

SECY–99–011 approved the staff's recommendation to provide a draft Rulemaking Plan (RP) for comment to the Agreement States, with the preferred option being the creation of a new Part 41 dedicated to uranium recovery regulation. The Commission directed the staff to revise the draft RP to reflect the Commission's guidance in the other uranium recovery SRMs.

On September 11, 2000, the staff transmitted the draft RP to all States for comment. The staff sent the draft RP to all States rather than just Agreement States because the issue of concurrent jurisdiction regarding non-radiological hazards primarily affects non-Agreement States, and the staff wanted to give those States an opportunity to comment on the draft RP. Comments have been received from several States. In addition, the NMA and two licensees provided comments on the draft RP. The staff will consider all the comments received in preparing its final RP, which it expects to issue in early 2001.

DISPOSAL OF NON-11e.(2) BYPRODUCT MATERIAL IN TAILINGS IMPOUNDMENTS (SECY–99–012)

In 1995, the staff published guidance, in the Federal Register [exit icon] (60 FR 49296), for the disposal, in uranium mill tailings impoundments, of radioactive material that is not byproduct material, as defined in section 11e.(2) of the AEA. The guidance consisted of 10 criteria to determine whether to approve a proposed disposal of non-11e.(2) byproduct material in a uranium mill tailings impoundment. In its 1998 white paper, the NMA emphasized that the criteria were too restrictive, pointing out that no requests for such disposals have been made since the guidance was issued. The Commission, in the SRM for SECY–99–012, approved an option that would allow more flexibility in permitting non-11e.(2) material to be disposed of in tailings impoundments. The NRC intends to incorporate the criteria into the new Part 41. In the interim, the Commission directed the staff to implement the SRM.

To comply with the direction in the SRM, the staff is revising the 1995 guidance in the following manner:

- The staff will remove the prohibitions, found in items 2, 4, and 5, regarding non-AEA radioactive material and material subject to regulation under other legislative authorities, such as the Toxic Substance Control Act (TSCA) or the Resource Conservation and Recovery Act (RCRA).

- The staff will add a criterion regarding approval from the appropriate regulators of TSCA, RCRA, and non-AEA radioactive material for disposal of such material in the tailings impoundment.

- The staff will revise the criterion, in item 8, regarding approval by Low-Level Waste Compacts, to allow for the situation in which material proposed for disposal does not fall under the jurisdiction of Low-Level Waste Compacts (e.g., radioactive material not regulated under the AEA).

- The Commission directed the staff to pursue a generic exemption to NRC's disposal requirements for low-level radioactive waste in 10 CFR Part 61, rather than having to grant an exemption, under 10 CFR 61.6, as identified in item 10. A generic exemption to regulations must be issued through a rulemaking process. Therefore, the staff will pursue incorporating the generic exemption in the new Part 41. In the interim, the requirement for a specific exemption will remain in the guidance, with addition of a caveat for material not regulated under Part 61.

The staff therefore is revising its 1995 guidance. The complete revised guidance, is in Attachment 1.

PROCESSING OF MATERIAL OTHER THAN NATURAL URANIUM ORES (SECY-99-012)

In 1995, the staff published its position and guidance, in the Federal Register (60 FR 49296), on the use of uranium feed material other than natural ores (alternate feed material), in uranium mills. The guidance identified three determinations that the staff had to make in order to approve an alternate feed request. The third determination—whether the ore is being processed primarily for its source material content—generated considerable controversy. This determination was required to address the concern that wastes that would otherwise have to be disposed of as radioactive or mixed waste would be proposed for processing at a uranium mill primarily to be able to dispose of them in the tailings pile as 11e.(2) byproduct material. This determination was essentially a determination of the motives of the mill operator in requesting approval of a specific stream of alternate feed material. In many cases it involved questioning the financial aspects of acquiring and processing the alternate feed material, and selling the resultant uranium product.

In its 1998 white paper, the NMA emphasized that NRC should not be looking to a licensee's motives in processing alternate feed material. After careful consideration of stakeholder comments and the staff's analysis, the Commission, in the SRM for SECY–99–012, directed the staff to allow processing of alternate feed material without inquiry into a licencee's economic motives, and referred to a Commission decision (CLI–00–01 51 NRC 9) on a specific instance of proposed processing of alternate feed, that was brought before the Atomic Safety Licensing Board and then appealed to the Commission. The Commission also addressed the second determination in the 1995 guidance (i.e., whether the feed material contains hazardous waste). It directed the staff to allow more flexibility with regard to this issue consistent with its direction to the staff on the disposal of non-11e.(2) byproduct material in tailings piles.

The Commission directed the staff to revise, issue, and implement final guidance on the processing of alternate feed as soon as possible and to codify the guidance in the new Part 41.

To comply with the SRM, the staff is revising the 1995 position and guidance in the following manner:

The staff will modify the prohibition in item 2 on feed material containing hazardous waste, to allow such feed material provided that the licensee obtains approval of the U.S. Environmental Protection Agency (EPA) or the State, and a commitment from the long-term custodian to accept the tailings after site closure.

The staff will revise the manner in which it determines whether the ore is being processed primarily for its source material content, to focus on the product of the processing, and eliminate any inquiry into the licensee's economic motives for the processing.

The staff therefore is revising its 1995 guidance. The complete revised guidance, is in Attachment 2.

CLASSIFICATION OF LIQUID WASTES AT ISL FACILITIES (SECY–99–013)

Before 1995, the staff practice for addressing the disposal of evaporation pond sludges at ISL facilities relied on a broad reading of the definition of 11e.(2) byproduct material. This broad reading only addressed discrete surface wastes capable of controlled disposal and did not distinguish between wastes generated at various phases of an ISL operation. All waste materials generated during ISL operations and ground-water restoration activities were designated 11e.(2) byproduct material and disposed of at licensed uranium mill tailings impoundments, in accordance with 10 CFR Part 40, Appendix A, Criterion 2.

The staff issued two guidance documents in 1995 to address issues raised by the industry in the uranium recovery program. The first, "Staff Technical Position on Effluent Disposal at Licensed Uranium Recovery Facilities" (hereinafter, the effluent guidance), was intended to ensure protection of the environment and public, while providing uranium recovery licensees with flexibility regarding the disposal of various types of liquid effluents generated during the operation of their facilities. In issuing this guidance, the staff took a more narrow view of the definition of 11e.(2) byproduct material. It differentiated between the various waste waters generated during ISL operations on the basis of their origin and whether uranium was extracted for its source material content during that phase of the operation. Waste waters and the associated solids produced during the uranium extraction phase of site operations, called "production bleed," were classified as AEA Section 11e.(2) byproduct material and therefore subject to regulation by NRC. Conversely, waste waters and the resulting solids produced after uranium extraction (i.e., during ground-water restoration activities) were classified as “mine waste waters,” and therefore were subject to regulation by individual States under their applicable mining programs. These wastes were considered naturally occurring radioactive material (NORM). However, because licensees often dispose of waste waters from uranium extraction and post-extraction activities in the same evaporation ponds, the resulting solids are a commingled waste consisting of 11e.(2) byproduct material and sludges derived from mine waste water.

In the second guidance document, “Final Revised Guidance on Disposal of Non-Atomic Energy Act of 1954, Section 11e.(2) Byproduct Material in Tailings Impoundments” (hereinafter, the disposal guidance), the staff identified 10 criteria that licensees should meet before NRC could authorize the disposal of AEA material other than 11e.(2) byproduct material in tailings impoundments. One of these criteria prohibited the disposal of radioactive material not covered by the AEA, including NORM (see earlier discussion for policy revisions). This criterion was intended to avoid the possibility of dual regulation of the radioactive constituents in the impoundments, since individual States are responsible for radioactive materials not covered by the AEA.

The industry expressed concerns, in NMA's white paper, that, taken together, these two guidance documents leave no option for the disposal of radioactively contaminated sludges from ISL evaporation ponds. The reason for this concern is that the 11e.(2) byproduct material was commingled with a NORM waste, which the disposal guidance prohibits from disposal in a tailings impoundment. The industry emphasized that the staff’s waste classification, based on the origin of the waste water (i.e., from the extraction or restoration phase) at an ISL facility, makes the disposal of such sludges in a mill tailings impoundment, as required under Criterion 2 of 10 CFR Part 40, Appendix A, impossible—even though the sludges derived from waste waters produced throughout a facility's life cycle are physically, chemically, and radiologically identical.

The staff analyzed several options in SECY-99-013 for addressing the industry's concerns. In the SRM for SECY–99–013, the Commission determined that all liquid effluents at ISL uranium recovery facilities are 11e.(2) byproduct material. NRC takes the position that any waste water generated during or after the uranium extraction phase of site operations, and all evaporation pond sludges derived from such waste waters, are classified as 11e.(2) byproduct material. The staff will make no legal distinction among the waste waters produced at different stages in a facility’s life cycle.

This revised policy is effective immediately. The staff intends to codify this policy in the new rulemaking for Part 41 and associated regulatory guidance.

GROUND-WATER ISSUES AT ISL FACILITIES (SECY–99–013)

Over the past several years, the industry has expressed concern that NRC’s regulation of ground water at ISLs is duplicative of the ground-water protection programs required by the Safe Drinking Water Act (SDWA), as administered by EPA or EPA-authorized States. EPA and the States protect ground-water quality through the Underground Injection Control (UIC) program, under the SDWA. The States often require additional measures in the UIC program that are more stringent than the Federal program. As presented in NMA's white paper, the industry contended that NRC's review and licensing activities are a duplicative form of regulation covering the same issues. Additionally, NMA also expressed the view that NRC did not have authority to regulate ground water at ISLs.

Historically, NRC has imposed conditions on ISL operations to ensure that ground-water quality is maintained during licensed activities and that actions are taken to ensure the restoration of ground-water quality before the license is terminated. The specific conditions imposed in an ISL license have typically been the result of NRC's independent review, as documented in safety evaluation reports and appropriate environmental evaluations.

In addition to NRC's review, licensees must also obtain a UIC permit from EPA or the EPA-authorized State before uranium recovery operations can begin. EPA or the authorized State conducts many of the same types of reviews as NRC. This is evidenced by NRC incorporating ground-water protection limits from a State's permitting program into specific license requirements, after conducting its own review of the licensee's groundwater protection program, including the use of State-imposed standards—and staff routinely accepting specific methodologies and guidance developed by EPA or States for ground-water monitoring programs and well construction.

In the SRM for SECY–99–013, the Commission approved the staff continuing discussions with EPA and appropriate States to determine the extent to which NRC can rely on the EPA UIC program for ground-water protection issues, thereby potentially minimizing duplicative review of ground-water protection at ISL facilities. Part of the discussions with EPA and appropriate States should include appropriate methods to implement any agreements, including Memoranda of Understanding (if necessary) and potential requirements that could be incorporated in the new Part 41. In the interim, it is recognized that some NRC/EPA dual regulation of the ground-water at ISL facilities will continue until such time that NRC can defer to EPA's UIC program.

NRC has initiated a new round of discussions with the EPA since the Commission decision in July 2000, and discussions with the appropriate States should begin in early to mid 2001.

In February 1998, staff documented its review process for ISLs, including a detailed evaluation of ground-water activities, in a draft Standard Review Plan (draft SRP) for ISL facility license applications (NUREG–1569), that was published for public comment. Following the comment period, staff held a public workshop on the SRP to discuss the issues raised. The staff intends to use the draft SRP in licensing reviews until the rulemaking for new Part 41 (SECY–99–011) has been completed and NUREG–1569 is finalized.

CONCURRENT JURISDICTION OF NON-RADIOLOGICAL HAZARDS OF URANIUM MILL TAILINGS (SECY–99–277)

In 1980, the staff considered the issue of whether the Uranium Mill Tailings Radiation Control Act (UMTRCA) preempts a non-Agreement State's authority to regulate the non-radiological hazards associated with 11e.(2) byproduct material and concluded that it did not. The NRC concluded that NRC and the State both exercised this authority. As a result, the staff has followed the practice of sharing jurisdiction of the non-radiological hazards with States. In its 1998 white paper, the NMA questioned the 1980 staff interpretation of UMTRCA. The Commission, in the SRM for SECY–99–0277 determined that NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of 11e.(2) byproduct material.

As a result of this decision, the staff will implement its exclusive authority over the non-radiological hazards of 11e.(2) byproduct material and not recognize State authority in this area.

SUMMARY OF ISSUES

The Commission has evaluated a range of uranium recovery issues and the staff evaluation and has directed, through SRMs, the staff to take various actions that will ultimately be incorporated into the new Part 41 rulemaking and existing uranium recovery SRPs.

In the interim, this RIS informs the licensees of the Commission's decisions. These are: (1) to allow more flexibility in the disposal of non-11e.(2) material in tailings impoundments, subject to certain considerations; (2) to allow alternate feed material to be processed for uranium (or thorium) without any inquiry into a licensee's economic motives; (3) to classify all waste water and sludges generated during or after the uranium (or thorium) extraction phase of *in situ* leach operations as 11e.(2) byproduct material; (4) to continue discussions with EPA and appropriate States to determine the extent that NRC can rely on the EPA UIC program for ground-water protection at ISL facilities; and (5) to note that NRC has exclusive jurisdiction over both the radiological and non-radiological hazards of 11e.(2) byproduct material.

This regulatory issue summary requires no specific action nor written response. If you have any questions about this summary, please contact the technical contact listed below.

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Attachments:

1. Interim Guidance Non-11e.(2)
2. Interim Position Alternate Feed
3. List of Recently Issued NRC Regulatory Issue Summaries

(ADAMS Accession Number ML003773008)

ATTACHMENT 1

Interim Guidance on Disposal of Non-Atomic Energy Act of 1954, Section 11e.(2) Byproduct Material in Tailings Impoundments

1. In reviewing licensee requests for the disposal of wastes that have radiological characteristics comparable to those of Atomic Energy Act of 1954, Section 11e.(2) byproduct material [hereafter designated as “11e.(2) byproduct material”] in tailings impoundments, the Nuclear Regulatory Commission staff will follow the guidance set forth below. Since mill tailings impoundments are already regulated under 10 CFR Part 40, licensing of the receipt and disposal of such material [hereafter designated as “non-11e.(2) byproduct material”] should also be done under 10 CFR Part 40.

2. Special nuclear material and Section 11e.(1) byproduct material waste should not be considered as candidates for disposal in a tailings impoundment, without compelling reasons to the contrary. If staff believes that such material should be disposed of in a tailings impoundment in a specific instance, a request for Commission approval should be prepared.

3. The 11e.(2) licensee must provide documentation showing necessary approvals of other affected regulators (e.g., the U.S. Environmental Protection Agency or State) for material containing listed hazardous wastes or any other material regulated by another Federal agency or State because of environmental or safety considerations.

4. The 11e.(2) licensee must demonstrate that there will be no significant environmental impact from disposing of this material.

5. The 11e.(2) licensee must demonstrate that the proposed disposal will not compromise the reclamation of the tailings impoundment by demonstrating compliance with the reclamation and closure criteria of Appendix A of 10 CFR Part 40.

6. The 11e.(2) licensee must provide documentation showing approval by the Regional Low-Level Waste Compact in whose jurisdiction the waste originates as well as approval by the Compact in whose jurisdiction the disposal site is located, for material which otherwise would fall under Compact jurisdiction.

7. The U.S. Department of Energy (DOE) and the State in which the tailings impoundment is located, should be informed of the U.S. Nuclear Regulatory Commission findings and proposed action, with a request to concur within 120 days. A concurrence and commitment from either DOE or the State to take title to the tailings impoundment after closure must be received before granting the license amendment to the 11e.(2) licensee.

8. The mechanism to authorize the disposal of non-11e.(2) byproduct material in a tailings impoundment is an amendment to the mill license under 10 CFR Part 40, authorizing the receipt of the material and its disposal. Additionally, an exemption to the

requirements of 10 CFR Part 61, under the authority of 10 CFR 61.6, must be granted, if the material would otherwise be regulated under Part 61. (If the tailings impoundment is located in an Agreement State with low-level waste licensing authority, the State must take appropriate action to exempt the non-11e.(2) byproduct material from regulation as low-level waste.) The license amendment and the 10 CFR 61.6 exemption should be supported with a staff analysis addressing the issues discussed in this guidance.

ATTACHMENT 2

Interim Position and Guidance on the Use of Uranium Mill Feed Material Other Than Natural Ores

In reviewing licensee requests to process alternate feed material (material other than natural ore) in uranium mills, the Nuclear Reguatory Commission staff will follow the guidance presented below. Besides reviewing to determine compliance with appropriate aspects of Appendix A of 10 CFR Part 40, the staff should also address the following issues:

1. Determination of whether the feed material is ore.

For the tailings and wastes from the proposed processing to qualify as 11e.(2) byproduct material, the feed material must qualify as "ore." In determining whether the feed material is ore, the following definition of ore will be used:

Ore is a natural or native matter that may be mined and treated for the extraction of any of its constituents or any other matter from which source material is extracted in a licensed uranium or thorium mill.

2. Determination of whether the feed material contains hazardous waste.

If the proposed feed material contains hazardous waste, listed under subpart D Sections 261.30-33 of 40 CFR (or comparable Resource Conservation and Recovery Act (RCRA) authorized State regulations), it would be subject to the U.S. Environmental Protection Agency (EPA) or State regulation under RCRA. If the licensee can show that the proposed feed material does not contain a listed hazardous waste, this issue is resolved.

Feed material exhibiting only a characteristic of hazardous waste (ignitable, corrosive, reactive, toxic) would not be regulated as hazardous waste and could therefore be approved for recycling and extraction of source material. However, this does not apply to residues from water treatment, so determination that such residues are not subject to regulation under RCRA will depend on their not containing any characteristic hazardous waste. Staff may consult with EPA (or the State) before making a determination of whether the feed material contains hazardous waste.

If the feed material contains hazardous waste, the licensee can process it only if it obtains EPA (or State) approval and provides the necessary documentation to that effect. Additionally, for feed material containing hazardous waste, the staff will review documentation from the licensee that provides a commitment from the U.S. Department of Energy or the State to take title to the tailings impoundment after closure.

3. Determination of whether the ore is being processed primarily for its source-material content.

For the tailings and waste from the proposed processing to qualify as 11e.(2) byproduct material, the ore must be processed primarily for its source-material content. If the only product produced in the processing of the alternate feed is uranium product, this determination is satisfied. If, in addition to uranium product, another material is also produced in the processing of the ore, the licensee must provide documentation showing that the uranium product is the primary product produced.

If it can be determined, using the aforementioned guidance, that the proposed feed material meets the definition of ore, that it will not introduce a hazardous waste not otherwise exempted, or if it has been approved by the EPA (or State) and the long-term custodian, and that the primary purpose of its processing is for its source-material content, the request can be approved.

APPENDIX J

TECHNICAL EVALUATION OF APPENDIX A CRITERIA

During the review process, U.S. Nuclear Regulatory Commission (NRC) staff will verify that specific criteria of 10 CFR Part 40, Appendix A have been met. It is suggested that the technical reviewer prepare a list of the specific technical criteria and the method or design used to meet these criteria to be included in the technical evaluation report. The example offered shows one method of documentation.

J1.0 EXAMPLE OF TECHNICAL EVALUATION OF APPENDIX A CRITERIA

The following text is from an NRC technical evaluation report for a uranium mill facility, and represents the type of conclusions related to meeting specific technical criteria in 10 CFR Part 40, Appendix A.

CONCLUSIONS RELATED TO MEETING APPENDIX A CRITERIA

The staff further concludes that the specific criteria of 10 CFR Part 40 Appendix A are met as follows.

J1.1 Criterion 1

Demonstrate that erosion, disturbance, and dispersion by natural forces over the long term are minimized.

The contaminated tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff (NRC, 1990). The staff considers that erosion protection that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. As discussed in technical evaluation report Sections 4.3 and 4.5, adequate protection is provided by (1) selection of proper rainfall and flooding events, (2) selection of appropriate parameters for determining flood discharges, (3) computation of flood discharges using appropriate and/or conservative methods, (4) computation of appropriate flood levels and flood forces associated with the design discharge, (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge, (6) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time, and (7) placement of a riprap layer in accordance with accepted engineering practice and in accordance with appropriate testing and quality assurance controls.

Demonstrate that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions at the site.

As discussed in technical evaluation report Sections 4.3 and 4.5, the staff considers that the riprap layers proposed will not require active maintenance over the 1,000-year design life, for the following reasons: (1) the riprap has been designed to protect the tailings from rainfall and flooding events which have very low probabilities of occurrence over a 1,000-year period, resulting in no damage to the layers from those rare events; (2) the rock proposed for the riprap layers is designed to be durable and is not expected to deteriorate significantly over the 1,000-year design life; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

J1.2 Criterion 4

Demonstrate that the upstream rainfall catchment areas are minimized to decrease erosion potential and the size of the floods that could erode or wash out sections of the tailings disposal area.

The site is located in an area that is flooded by off-site floods from Moab Wash and the Colorado River. However, as discussed in the technical evaluation report, the site is protected from direct on-site precipitation and flooding by engineered riprap layers for the top and side slopes; the tailings disposal cell will need this protection regardless of where it is located. The riprap for the side slopes and drainage ditches is large enough to resist flooding from the minimal flow velocities of floods occurring from a probable maximum flood on the Colorado River. A large rock apron has been provided to provide protection against the potential migration of Moab Wash and the Colorado River. The staff therefore concludes that the erosion potential at the site has been acceptably minimized, since any flooding at the site is mitigated by the erosion protection, and the forces associated with off-site floods are minimal.

Demonstrate that topographic features provide good wind protection.

The staff considers that the site is adequately protected from wind erosion by the placement of an engineered riprap layer that protects the tailings from surface water erosion. Studies performed for the NRC staff have shown that an engineered riprap layer designed to protect against water erosion will be capable of providing adequate protection against wind erosion.

Demonstrate that embankments and cover slopes are relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability.

The relatively flat top and side slopes of the covers will be protected from erosion by an engineered riprap layer which is designed to provide long-term stability (technical evaluation report Section 4.3). The erosion potential of the covers is minimized by the designing the rock to be sufficiently large to resist flooding and erosion, based on the slope selected. Thus, the staff concludes that the slopes, with their corresponding rock designs, are sufficiently flat to meet this criterion.

Demonstrate that the rock cover reduces wind and water erosion to negligible levels, including consideration of such factors as the shape, size, composition, and gradation of the rock particles; rock cover thickness and zoning of particle size; and steepness of underlying slopes. Demonstrate that rock fragments are dense, sound, and resistant to abrasion, and free from cracks, seams, and other defects.

The contaminated tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff (NRC, 1990). As discussed in Sections 4.3 and 4.5 of the technical evaluation report, the staff considers that erosion protection which meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. Adequate protection is provided by (1) selection of proper rainfall and flooding events, (2) selection of appropriate parameters for determining flood discharges, (3) computation of flood discharges using appropriate and/or conservative methods, (4) computation of appropriate flood levels and flood forces associated with the design discharge, (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge, (6) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time, and (7) placement of a riprap layer in accordance with accepted engineering practice and in accordance with appropriate testing and quality assurance controls.

J1.3 Criterion 12

Demonstrate that active on-going maintenance is not necessary to preserve isolation.

As discussed in Sections 4.3 and 4.5 of the technical evaluation report, the staff considers that the erosion protection will not require active maintenance over the 1,000-year design life, for the following reasons: (1) the riprap has been designed to protect the tailings from rainfall and flooding events which have low probabilities of occurrence over a 1,000-year period, resulting in no damage to the layers from those rare events; (2) the rock proposed for the riprap layers is designed to be durable and is not expected to deteriorate significantly over the 1,000-year design life; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

APPENDIX K

CONTENT AND FORMAT FOR ALTERNATE CONCENTRATION LIMIT APPLICATIONS

Application Content

The application should contain sufficient information to show that a hazardous constituent will not pose a substantial present or potential harm to human health or the environment, as long as the proposed Alternate Concentration Limit is not exceeded; and the proposed Alternate Concentration Limit is as low as reasonably achievable, considering practicable corrective actions. This demonstration should assess the hazards of the constituent in question and evaluate the consequences presented by potential exposures to the constituent. The application must consider the 19 factors listed in 10 CFR Part 40, Appendix A, Criterion 5B(6).

For ease of review, the application should address these factors through the following assessments. The Hazard Assessment should evaluate the radiological dose and toxicity of the constituents in question and the risk to human health and the environment posed by the constituents. The Exposure Assessment should examine the existing distribution of hazardous constituents, as well as the potential source(s) for future constituent releases. This should include the fate and transport of the hazardous constituents in ground water and hydraulically-connected surface water; and the potential consequences associated with human and environmental exposure to the hazardous constituents. The Corrective Action Assessment should (1) identify all realistic corrective action scenarios available; (2) assess their technical feasibility; (3) determine the costs and benefits associated with each scenario; and (4) select a practicable corrective action to achieve the hazardous constituent concentration that is protective of human health and the environment. The outcome of this assessment is a determination that the selected corrective action is as low as reasonably achievable.

There should be enough detailed information in the application to allow the NRC reviewer to independently verify that the proposed Alternate Concentration Limit will not pose a significant present or future hazard to human health or the environment, and that the limit is as low as reasonably achievable, considering practicable corrective actions. Site characteristics, milling processes, disposal operations, and ore composition should be discussed in the application. Information related to each of the 19 factors listed in 10 CFR Part 40, Appendix A, Criterion 5B(6) should be addressed; however, all of these factors may not be applicable to every site. If this is the case, the applicant must explain why a particular factor is not appropriate. For example, ground-water discharging into surface waters may not occur near a mill tailings site. Therefore, stream flow characteristics and transport assessments within the surface water may not be necessary. In any regard, the burden of proof resides with the applicant to demonstrate that selected factors do not need to be considered.

Much of this detailed information may already be available in existing licensing documents, such as environmental reports, license applications, or annual compliance monitoring reports. This information can be readily incorporated into the Alternate Concentration Limit application to produce a stand-alone document. The applicant may simply reference this existing information; however, additional time and NRC resources will be needed to collect the information from the licensee's docket file in order to proceed with the detailed review.

Appendix K

Application Format

A standard application format helps to assure the application contains information that addresses all applicable regulatory requirements, and helps to guide both the reviewer and interested stakeholders to pertinent and crucial information. A standard format also greatly contributes to the time efficiency and effectiveness of the review process. The applicant is not required to follow this standard format. Any application, regardless of format, that adequately addresses the suitability of a proposed Alternate Concentration Limit is acceptable for NRC review; however, reviewing an application with a significantly different format will likely require considerably more NRC staff time and resources to conduct the review. An applicant is strongly encouraged to provide a cross-reference table comparing the standard format to the format used in the application, if that format significantly differs from the standard format.

The applicant should present the technical information as clearly as possible and assure it supports compliance with the requirements in 10 CFR Part 40, Appendix A, Criterion 5B(6). Applicants are encouraged to follow the numbering system and headings of the standard format and use appendices for including supporting data not specifically included in a particular section. Conventional abbreviations should be used consistently throughout the application. Any abbreviations, symbols, or special terms should be defined where they first appear in the text. Where appropriate, calculated error bands or estimated uncertainties should be included along with numerical values. Some types of information are better presented clearly and concisely in a graphical manner by using maps, graphs, drawings, or tables and appropriate citations in the text descriptions. Applicants should ensure that graphical materials are legible and that the physical scales are adequate to clearly show details and notations. Symbols should be clearly defined and referenced.

Table 1 shows the standardized outline for an Alternate Concentration Limit application. It includes chapters for supporting information on the site and its setting, a hazard assessment, an exposure assessment, a review of realistic corrective action alternatives, and the proposed concentration limits.

The application should also be structured to allow ready substitution of pages in response to reviewer comments and information requests. Pages should be punched for a standard loose-leaf binder. Revisions should be provided on pages that will replace the original pages, with the changes indicated by a “line change” demarcation in the margin. The date and revision number should be indicated in the bottom outside margin of each revised page, and the package of submitted revisions should include a list of all page replacements for the application. The font style and text size should be plain and large enough to allow the document to be scanned electronically for easy inclusion in the Agencywide Documents Access and Management System (ADAMS). All figures and diagrams should also be clearly presented to assist in electronic scanning.

A legible base map is essential for all applications. The base map should include the tailings disposal area, the location of the reclaimed slopes, the Point of Compliance locations, the Point of Exposure locations, monitoring wells locations, and the proposed long-term control boundary. Pertinent site data, such as potentiometric surfaces, isoconcentration contours, and forecasted concentrations should use the base map as the common reference.

Table K–1. Standard Format of an Alternate Concentration Limit Application

EXECUTIVE SUMMARY

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1. General Information

    1.1 Introduction
    1.2 Facility Description
    1.3 Extent of Ground-Water Contamination
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2. Hazard Assessment

    2.1 Source and Contamination Characterization
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    3.2 Human Exposure Potential
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4. Corrective Action Assessment

    4.1 Previous and Current Corrective Action Programs
    4.1 Potential Corrective Action Alternatives
    4.2 Feasibility of Corrective Action Alternatives
    4.3 Costs and Benefits of Corrective Action Alternatives
    4.4 As Low As Reasonably Achievable Demonstration

5. Alternate Concentration Limit(s)

    5.1 Proposed Alternate Concentration Limit(s)
    5.2 Proposed Implementation and Ground-Water Monitoring Measures

6. References

7. Appendixes and Supporting Information