DOE/EH-0575

DOE Occupational Radiation Exposure

1997 Report

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NEUTRON • AEDE • ELECTRON • TEDE • INTERNAL • CEDE • GAMMA • BETA • SHIELD • ALARA • NEUTRON • AEDE • ELECTRON • TEDE • INTERNAL • CEDE • GAMMA • BETA • SHIELD • ALARA

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

The U.S. Department of Energy
Assistant Secretary for Environment, Safety and Health
Office of Worker Health and Safety

Foreword

The goal of the U.S. Department of Energy (DOE) is to conduct its radiological operations to ensure the health and safety of all DOE employees including contractors and subcontractors. The DOE strives to maintain radiation exposures to its workers below administrative control levels and DOE limits and to further reduce these exposures and releases to levels that are "As Low As Reasonably Achievable" (ALARA).

The *1997 DOE Occupational Radiation Exposure Report* provides summary and analysis of the occupational radiation exposure received by individuals associated with DOE activities. The DOE mission includes stewardship of the nuclear weapons stockpile and the associated facilities, environmental restoration of DOE, and energy research.

Collective exposure at DOE has declined by 80% over the past decade due to a cessation in opportunities for exposure during the transition in DOE mission from weapons production to cleanup, deactivation and decommissioning, and changes in reporting requirements and dose calculation methodology. In 1997, the collective dose decreased by 18% from the 1996 value due to decreased doses at five of the seven highest-dose DOE sites. These five sites attributed the decrease in collective dose to reductions in such activities as materials stabilization, maintenance, and the completion of several key projects.

This report is intended to be a valuable tool for managers in their management of radiological safety programs and commitment of resources. The process of data collection, analysis, and report generation is streamlined to give managers a current assessment of the performance of the Department with respect to radiological operations. The cooperation of the sites in promptly and correctly reporting employee radiation exposure information is key to the timeliness of this report.

Your feedback and comments are important to us to make this report meet your needs. A user survey form is included in Appendix F to collect your suggestions to improve this report.

Peter Brush
Acting Assistant Secretary
Environment, Safety and Health

Joseph Fitzgerald, Jr.
Deputy Assistant Secretary
Office of Worker Health and Safety

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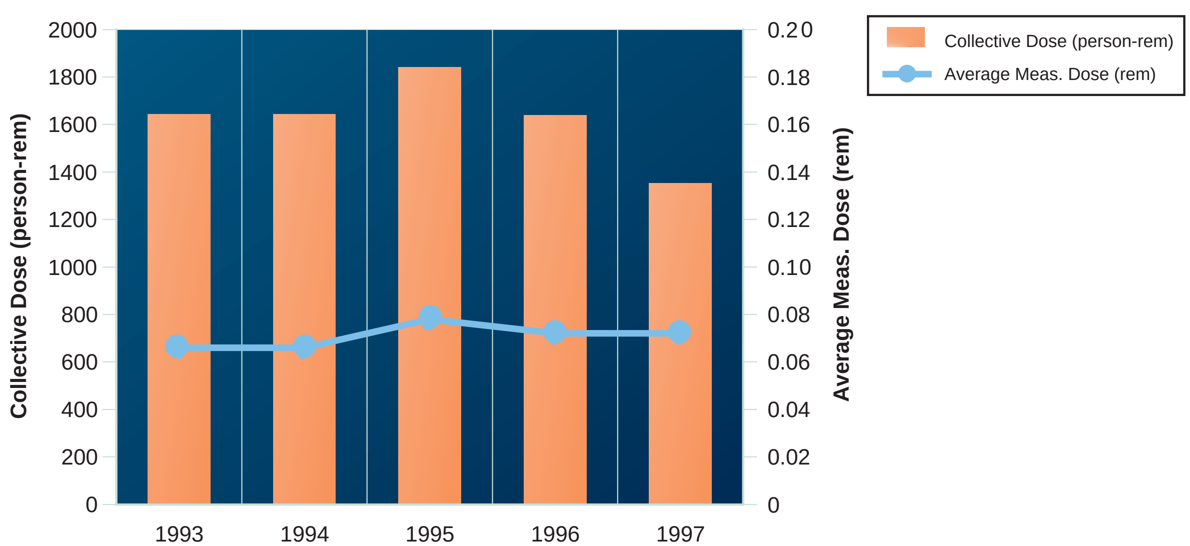
Executive Summary

The U.S. Department of Energy (DOE) Office of Environment, Safety and Health publishes the DOE Occupational Radiation Exposure Report. This report is intended to be a valuable tool for DOE/DOE contractor managers in managing radiological safety programs and to assist them in prioritizing resources. We appreciate the efforts and contributions from the various stakeholders within and outside DOE and hope we have succeeded in making the report more useful.

This report includes occupational radiation exposure information for all monitored DOE employees, contractors, subcontractors, and visitors. The exposure information is analyzed in terms of aggregate data, dose to individuals, and dose by site. For the purposes of examining trends, data for the past 5 years are included in the analysis.

Eighty-seven percent of the collective Total Effective Dose Equivalent (TEDE) for the DOE complex was accrued at seven DOE sites in 1997. These seven sites are (in descending order of collective dose) Rocky Flats, Hanford, Los Alamos, Savannah River, Idaho, Oak Ridge, and Brookhaven. Sites reporting under the category of weapons fabrication and testing account for the highest collective dose. Even though these sites are now primarily involved in nuclear materials stabilization and waste management, they still report under this facility type. For the past 4 years, technicians received the highest collective dose of any specified labor category.

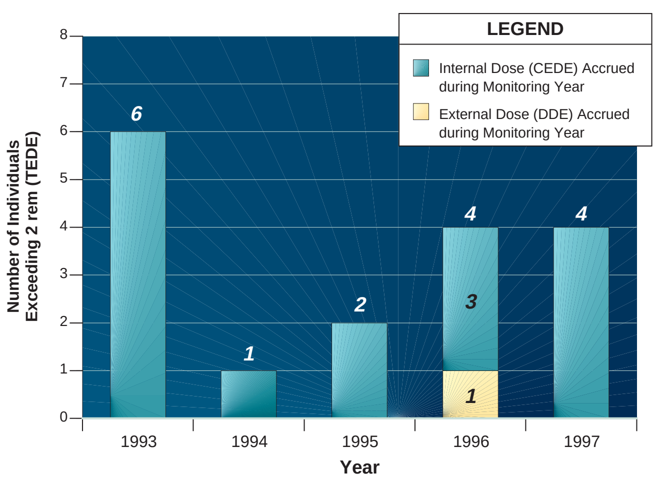
As shown in the figure below, between 1996 and 1997, the DOE collective TEDE decreased by 18% due to decreased doses at five of the seven sites with the highest radiation dose. In addition, the average dose to workers with measurable dose remained unchanged, the number of individuals receiving measurable dose dropped by 18%, and there was one exposure over the DOE 5 rem (50 mSv) TEDE limit.

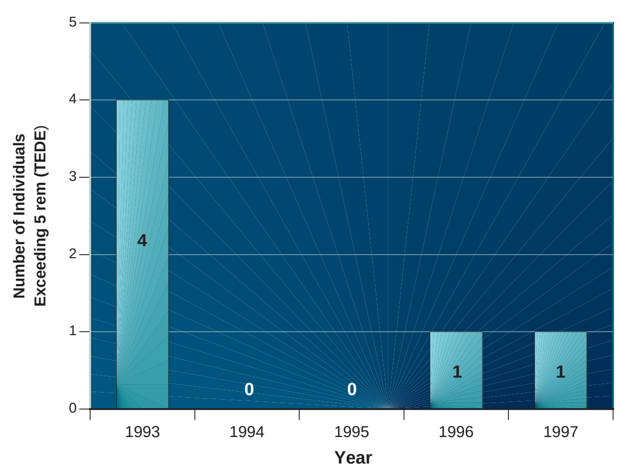


The change in operational status of DOE facilities has had the largest impact on radiation exposure over the past 5 years due to the shift in mission from production to cleanup activities and the shutdown of certain facilities. Reports submitted by four of the five sites with the highest collective dose that experienced decreases in the collective dose (Savannah River, Idaho, BNL, and Oak Ridge) indicate that decreases in the collective dose were due to reductions in such activities as materials stabilization, maintenance, and the completion of several key projects.

Statistical analysis reveals that, although the collective dose has decreased by 18%, the logarithmic mean dose has increased slightly from 1996 to 1997. This finding confirms that the collective dose has decreased primarily due to a reduction in overall work involving radiation exposure rather than reductions in dose to individuals. Statistical analysis has also revealed a decreasing trend in the neutron collective dose, and a statistically significant increase in extremity doses over the past 5 years. The decreasing trend in the mean neutron dose is primarily due to a decrease in neutron dose at LANL since 1993. The neutron dose at LANL is primarily from the production of heat sources for deep-space missions, which was completed in 1997. The increasing trend in extremity dose is due to increases at Rocky Flats, LANL, and Savannah River, which corresponds with increased plutonium recovery activities, cleanup and repackaging. While no site has reported an extremity dose in excess of the limit in the past 5 years, the increasing trend requires continued observation and may indicate the need for a review of extremity monitoring and protection practices at DOE sites in the future.

Over the past 5 years, few occupational doses at DOE facilities in excess of the 2 rem (20 mSv) Administrative Control Level (ACL) and 5 rem (50 mSv) TEDE regulatory limit have occurred, as shown in the figures on the facing page. All of the doses in excess of 2 rem (20 mSv) were due to internal dose. One individual received a dose in excess of the 5 rem (50 mSv) TEDE limit in 1997. This individual received an estimated internal Committed Effective Dose Equivalent (CEDE) of 15 to 30 rem (150 to 300 mSv) due to an unanticipated intake of curium-244 at the Lawrence Livermore National Laboratory (LLNL). Because the dose is an estimate, it has not been included in the figures presented in this report. Upon a final dose determination, subsequent annual reports will include this dose.





Section One

Introduction

1

Introduction

The *DOE Occupational Radiation Exposure Report, 1997* reports occupational radiation exposures incurred by individuals at U.S. Department of Energy (DOE) facilities during the calendar year 1997. This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and visitors. This information is analyzed and trended over time to provide a measure of DOE's performance in protecting its workers from radiation.

1.1 Report Organization

This report is organized into the five sections listed below. Supporting technical information, tables of data, and additional items that were identified by users as useful are provided in the appendices.

1.2 Report Availability

Requests for additional copies of this report or access to the data files used to compile this report should be directed to Ms. Nirmala Rao, Radiation Exposure Monitoring System (REMS) Project Manager, U.S. Department of Energy, Office of Worker Protection Programs and Hazards Management (EH-52), Germantown, MD 20874 or by calling the Environmental Safety & Health (ES&H) InfoCenter at 1-800-473-4375. A discussion of the various methods of accessing DOE occupational radiation exposure information is presented in Appendix E. Visit the DOE Radiation Exposure web site for information concerning occupational radiation exposure at the DOE complex at http://rems.eh.doe.gov.

Section One	Provides a description of the content and organization of this report.
Section Two	Provides a discussion of the radiation protection and dose reporting requirements and their impacts on data interpretation. Additional information on dose calculation methodologies, personnel monitoring methods and reporting thresholds, regulatory dose limits, and as low as reasonably achievable (ALARA) is included.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 1997. The data are analyzed to show trends over the 5 five years.
Section Four	Includes examples of successful ALARA projects within the DOE complex.
Section Five	Presents conclusions based on the analysis contained in this report.

Standards and Requirements

One of DOE's primary objectives is to provide a safe and healthy workplace for all employees and contractors. To meet this objective, DOE's Office of Worker Protection Programs and Hazards Management establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and members of the public. In addition to the requirement that radiation doses not exceed the limits, it is DOE's policy that doses also be maintained ALARA.

This section discusses the radiation protection standards and requirements that were in effect for the year 1997. The requirements leading up to this time period are also included to facilitate a better understanding of changes that have occurred in the recording and reporting of occupational dose.

2.1 Radiation Protection Requirements

DOE radiation protection standards are based on federal guidance for protection against occupational radiation exposure promulgated by the U.S. Environmental Protection Agency (EPA) in 1987 [1]. These standards are provided to ensure that DOE workers are adequately protected from exposure to ionizing radiation. This guidance, initially implemented by DOE in 1989, is based on the 1977 recommendations of the International Commission on Radiological Protection (ICRP) [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements (NCRP) [3]. This guidance recommended that internal organ dose (resulting from the intake of radionuclides) be added to the external whole-body dose to determine the Total Effective Dose Equivalent (TEDE). Prior to this, the whole-body dose and internal organ dose were each limited separately. The new DOE dose limits based on the TEDE were established from this guidance.

DOE became the first federal agency to implement the EPA guidance when it promulgated DOE Order 5480.11, "Radiation Protection for Occupational Workers," in December 1988 [4]. DOE Order 5480.11 was in effect from 1989 to 1995.

In June 1992, the "DOE Radiological Control (RadCon) Manual" [5] was issued and became effective in 1993. The "RadCon Manual" was the result of a Secretarial initiative to improve and standardize radiological protection practices throughout DOE and to achieve the goal of making DOE the pacesetter for radiological health and safety. The "RadCon Manual" is a comprehensive guidance document written for workers, line managers, and senior management. The "RadCon Manual" states DOE's views on the best practices currently available in the area of radiological control. The "RadCon Manual" was revised in 1994 in response to comments from the field and to enhance consistency with the requirements in 10 CFR 835 [6].

10 CFR 835 became effective on January 13, 1994, and required full compliance by January 1, 1996. In general, 10 CFR 835 codified existing radiation protection requirements in DOE Order 5480.11. The rule provides nuclear safety requirements that, if violated, will provide a basis for the assessment of civil and criminal penalties under the Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988 [7] as implemented by 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993. [8]

One and one-half years after the promulgation of 10 CFR 835, DOE Order 5480.11 was canceled and the "RadCon Manual" was made non-mandatory guidance with issuance of DOE Notice 441.1, "Radiological Protection for DOE Activities," [9] (applicable to defense nuclear facilities). This notice was issued to establish radiological protection program requirements that, combined with 10 CFR 835 and its associated non-mandatory implementation guidance, formed the basis for a comprehensive radiological protection program. DOE N 441.1 will continue in effect until a planned amendment to 10 CFR 835 is completed.

During 1994 and 1995, DOE undertook an initiative to reduce the burden of unnecessary, repetitive, or conflicting requirements on DOE contractors. As a result, DOE Order 5484.1 [10] requirements for reporting radiation dose records are now located in the associated manual, DOE M 231.1-1, "Environment, Safety and Health Reporting" [11], which became effective September 30, 1995.

The requirements of DOE M 231.1-1 are basically the same as Order 5484.1; however, the dose terminology was revised to reflect the changes made in radiation protection standards and requirements. For 1995, DOE Order 5484.1 remained in effect. Most sites reported under the new DOE M 231.1-1 for 1996. Because each site implements the new requirements as operating contracts are issued or renegotiated, complete implementation will take several years.

2.1.1 Monitoring Requirements

10 CFR 835.402 requires that, for external monitoring, personnel dosimetry be provided to general employees likely to receive an effective dose equivalent to the whole-body greater than 0.1 rem (1 mSv) in a year or an effective dose equivalent to the skin or extremities, lens of the eye, or any organ or tissue greater than 10% of the corresponding annual limits. Monitoring for internal radiation exposure is also required when the general employee is likely to receive 0.1 rem (1 mSv) or more Committed Effective Dose Equivalent (CEDE), and/or 5 rems (50 mSv) or more Committed Dose Equivalent (CDE) to any organ or tissue in a year. Monitoring for minors and members of the public is required if the dose (internal or external) is likely to exceed 50% of the annual limit of 0.1 rem (1 mSv) TEDE. Monitoring of declared pregnant workers is required if the dose (internal or external) to the embryo/fetus is likely to exceed 10% of the limit of 0.5 rem (5 mSv) TEDE.

Monitoring for external exposures is also required for any individual entering a high or very high radiation area.

2.1.1.1 External Monitoring

External or personnel dosimeters are used to measure ionizing radiation from sources external to the individual. The choice of dosimeter is based on the type and energy of radiation that the individual is likely to encounter in the workplace. An algorithm is then used to convert the exposure readings into dose. External monitoring devices include photographic film (film badges), thermoluminescent dosimeters, pocket ionization chambers, electronic dosimeters, personnel nuclear accident dosimeters, bubble dosimeters, plastic dosimeters, and combinations of the above.

Beginning in 1990, the DOE Laboratory Accreditation Program (DOELAP) formalized accuracy and precision performance standards for external dosimeters and quality assurance/ quality control requirements on the overall external dosimetry programs for facilities within the DOE complex. All DOE facilities were DOELAP-accredited by the fall of 1995.

External dosimeters have a lower limit of detection of approximately 0.010 - 0.030 rem (0.10 - 0.30 mSv) per monitoring period. The differences are attributable to the particular type of dosimeter used and the types of radiation monitored. Monitoring periods are usually quarterly for individuals receiving less than 0.300 rem/year (3 mSv/year) and monthly for individuals who routinely receive higher doses or who enter higher radiation areas.

2.1.1.2 Internal Monitoring

Bioassay monitoring includes in-vitro (outside the body) and in-vivo (inside the body) sampling. In-vitro assays include urine and fecal samples, nose swipes, saliva samples, and hair samples. In-vivo assays include whole-body counting, thyroid counting, lung counting, and wound counting.

Monitoring intervals for internal dosimetry depend on the radionuclides being monitored and their concentrations in the work environment. Routine monitoring intervals may be monthly, quarterly, or annually, whereas special monitoring intervals following an incident may be daily or weekly. Detection thresholds for internal dosimetry are highly dependent on the monitoring methods, the radionuclides in question, and their chemical form. Follow-up measurements and analysis may take many months to confirm preliminary findings. With the publication of American National Standards Institute (ANSI) N13.30-1996, "Performance Criteria for Radiobioassay," DOE has developed a Radiobioassay Accreditation Program with scheduled implementation starting in 1998.

2.2 Radiation Dose Limits

Radiation dose limits are now codified in 10 CFR 835.202, 204, 206, 207, 208 and are summarized in *Exhibit 2-1*.

Under 835.204, Planned Special Exposures (PSEs) may be authorized in certain conditions allowing an individual to receive exposures in excess of the dose limits shown in *Exhibit 2-1*. With the appropriate prior authorization, the annual dose limit for an individual may be increased to an additional 5 rems (50 mSv) TEDE above the routine dose limit as long as the individual does not exceed a cumulative lifetime TEDE of 25 rems (250 mSv) from other PSEs and doses above the limits. PSE doses are required to be recorded separately and are only intended to be used in exceptional situations where dose reduction alternatives are unavailable or impractical. Restrictions on the use of PSEs are extensive; for this reason, they are expected to be rarely used at DOE.

Exhibit 2-1:
DOE Dose Limits from 10 CFR 835

Personnel Category	Section of 10 CFR 835	Type of Exposure	Acronym	Annual Limit
General Employees	§835.202	Total Effective Dose Equivalent	TEDE	5 rems
		Deep Dose Equivalent + Committed Dose Equivalent to any organ or tissue (except lens of the eye). This is often referred to as the Total Organ Dose Equivalent	DDE+CDE (TODE)	50 rems
		Lens of the Eye Dose Equivalent	LDE	15 rems
		Shallow Dose Equivalent to the skin of the Whole-body or to any Extremity	SDE-WB and SDE-ME	50 rems
Declared Pregnant Worker	§835.206	Total Effective Dose Equivalent	TEDE	0.5 rem per gestation period
Minors	§835.207	Total Effective Dose Equivalent	TEDE	0.1 rem
Members of the Public	§835.208	Total Effective Dose Equivalent	TEDE	0.1 rem

2.2.1 Administrative Control Levels

Administrative Control Levels (ACLs) were included in the "RadCon Manual". ACLs are established below the regulatory dose limits to administratively control and help reduce individual and collective radiation dose. ACLs are multi-tiered, with increasing levels of authority required to approve a higher level of exposure.

The "RadCon Manual" recommends a DOE ACL of 2 rem (20 mSv) per year per person for all DOE activities. Prior to allowing an individual to exceed this level, approval from the appropriate Secretarial Officer or designee should be received. In addition, contractors are encouraged to establish an annual facility ACL. This control level is established by the contractor senior site executive and is based upon an evaluation of historical and projected radiation exposures, workload, and mission. The "RadCon Manual" suggests an annual facility ACL of 0.5 rem (5 mSv) or less; however, the Manual also states that a control level greater than 1.5 rem (15 mSv) is, in most cases, not sufficiently challenging. Approval by the contractor senior site executive must be received prior to an individual exceeding the facility ACL.

ACLs are not specified in 10 CFR 835. However, they are specified under DOE N 441.1. Administrative controls are required to be implemented to keep doses below the dose limits and ALARA. DOE N 441.1 establishes the following administrative control limits: a 2 rem (20 mSv) annual TEDE, a 1 rem (10 mSv) cumulative TEDE per year of age, and requires that a facility-specific ACL be established for each site.

2.2.2 ALARA Principle

Until the 1970s, the fundamental radiation protection principle was to limit occupational radiation dose to quantities less than the regulatory limits and to be concerned mainly with high dose and high dose rate exposures. During the 1970s, there was a fundamental shift within the radiation protection community to be concerned with low dose and low dose rate exposures because it can be inferred from the linear no-threshold dose response hypothesis that there is an increased level of risk associated with any radiation exposure. The As Low As Practicable (ALAP) concept was initiated and became part of numerous guidance documents and radiation protection good practices. ALAP was eventually replaced by ALARA. DOE Order 5480.11, the "RadCon Manual", and 10 CFR 835 formalized the guidance and required that each DOE facility have an ALARA Program as part of its overall Radiation Protection Program.

The ALARA methodology considers both individual and group doses and generally involves a cost/benefit analysis. The analysis considers social, technical, economic, practical, and public policy aspects of the overall goal of dose reduction. Because it is not feasible to reduce all doses at DOE facilities to zero, ALARA cost/benefit analysis must be used to optimize levels of radiation dose reduction. According to the ALARA principle, resources spent to reduce dose need to be balanced against the risks avoided. Reducing doses below this point results in a misallocation of resources; the resources could be spent elsewhere and have a greater impact on health and safety.

To ensure that doses are maintained ALARA at DOE facilities, the DOE mandated in DOE Order 5480.11 and subsequently in the "RadCon Manual" that ALARA plans and procedures be implemented and documented. To help facilities meet this requirement, DOE developed a manual of good practices for reducing exposures to ALARA levels [12]. This document includes guidelines for administration of ALARA programs, techniques for performing ALARA calculations based on cost/benefit principles, guidelines for setting and evaluating ALARA goals, and methods for incorporating ALARA criteria into both radiological design and operations. The establishment of ALARA as a required practice at DOE facilities demonstrates DOE's commitment to ensure minimum risk to workers from the operation of its facilities.

2.3 Reporting Requirements

In 1987, DOE promulgated revised reporting requirements in DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements." Previously, contractors were required to report only the number of individuals who received an occupational whole-body exposure in one of 16 dose equivalent ranges. The revised Order requires the reporting of exposure records for each employee and visitor. Required dose data reporting includes the TEDE, internal dose equivalent, Shallow Dose Equivalent (SDE) to the skin and extremities, and Deep Dose Equivalent (DDE). Other reported data include the individual's age, sex, employment status, and occupation, as well as the relevant organization and facility type.

Occupational radiation exposure reporting requirements are now included in DOE M 231.1-1, which became effective September 30, 1995. The reporting requirements under DOE M 231.1-1 are very similar to those under Order 5484.1.

2.4 Change in Internal Dose Methodology

Prior to 1989, intakes of radionuclides into the body were not reported as dose, but as body burden in units of activity of systemic burden. The implementation of DOE Order 5480.11 in 1989 specified that the intakes of radionuclides be converted to internal dose and reported using the Annual Effective Dose Equivalent (AEDE) methodology.

With the implementation of the "RadCon Manual" in 1993, the required methodology used to calculate and report internal dose was changed from the AEDE to the 50-year CEDE. The change was made to provide consistency with scientific recommendations, facilitate the transfer of workers between DOE and NRC regulated facilities, and simplify record keeping by recording all dose in the year of intake. The CEDE methodology is now codified in 10 CFR 835.

Readers should note that the method of calculating internal dose changed from AEDE to CEDE between 1992 and 1993 when analyzing TEDE data prior to 1993.

This report primarily analyzes dose informaton for the past 5 years, from 1993 to 1997. During these years, the CEDE methodology was used to calculate internal dose; therefore, the change in methodology from AEDE to CEDE between 1992 and 1993 does not affect the analysis contained in this report. Readers should keep in mind the change in methodology if analyzing TEDE data prior to 1993.

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Occupational Radiation Dose at DOE

3.1 Analysis of the Data

The purpose of analyzing occupational radiation dose data is to reveal opportunities to improve safety and to demonstrate performance. This is accomplished through analysis and explanation of observed trends. Several indicators were identified from the data submitted to the central data repository that can be used to evaluate the occupational radiation exposures received at DOE facilities. Analysis of these indicators falls into three categories: aggregate, individual, and site. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

The key indicators for the analysis of aggregate data are: number of monitored individuals and individuals with measurable dose, collective dose, average measurable dose, and the dose distribution. Analysis of individual dose data includes an examination of doses exceeding DOE regulatory limits, and doses exceeding the 2 rem (20 mSv) DOE ACL. Analysis of site data includes comparisons by site, labor category, and facility type. Additional information is provided concerning activities at sites contributing to the collective dose. In order to determine the significance of trends, statistical analysis was performed on the data.

3.2 Analysis of Aggregate Data

3.2.1 Number of Monitored Individuals

The number of monitored individuals represents the size of the DOE worker population provided with dosimetry. This number represents the sum of all monitored individuals, including all DOE employees, contractors, subcontractors, and visitors. The number of monitored individuals is an indication of the size of a dosimetry program, but it is not necessarily an indicator of the size of the exposed workforce. This is because of the conservative practice at some DOE facilities of providing dosimetry to individuals for reasons other than the potential for exposure to radiation and/or radioactive materials exceeding the monitoring thresholds. Many individuals are monitored for reasons such as security, administrative convenience, and legal liability. Some sites offer monitoring for any individual who requests monitoring, independent of the potential for exposure. For this reason, workers receiving measurable dose represents the exposed workforce.

3.2.2 Number of Individuals with Measurable Dose

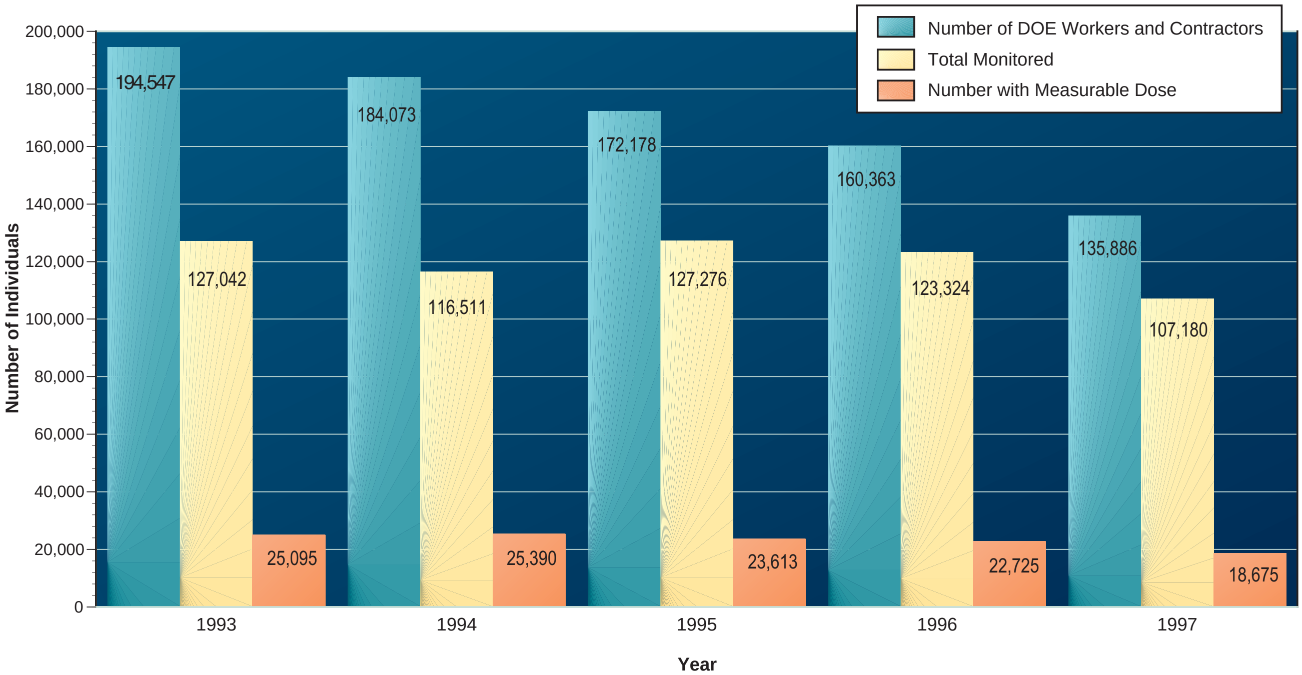
DOE uses the number of individuals receiving measurable dose to represent the exposed workforce size. The number of individuals with measurable dose includes any individuals with reported TEDE greater than zero.

Exhibit 3-1 shows the total number of workers at DOE, the total number monitored, and the number with measurable dose for the past 5 years. The percentage of the DOE workforce monitored for radiation exposure has increased by 14% from 1993 to 1997. However, most of the monitored individuals do not receive any measurable radiation dose. Only 19% of monitored individuals (14% of the DOE workforce) received a measurable dose during the past 5 years. The percentage of monitored workers receiving measurable dose has decreased from 20% in 1993 to 17% in 1997. In summary, a larger percentage of the DOE workforce was monitored for radiation in 1997, while a smaller percentage of the monitored individuals received a measurable dose.

Nineteen percent of monitored workers received a measurable dose over the past 5 years.

Twenty of the 29 reporting sites experienced decreases in the number of workers with measurable dose from 1996 to 1997, with the largest decreases occurring at the Savannah River and Hanford sites. The Portsmouth and Paducah

Exhibit 3-1:
Monitoring of the DOE Workforce



Gaseous Diffusion Plants had decreases in the number of workers since most activities at these facilities have been transferred to the United States Enrichment Corporation and are now under the regulatory authority of the U.S. Nuclear Regulatory Commission (NRC) and no longer report the majority of occupation exposure to DOE. The number of workers with measurable dose decreased from 22,725 in 1996 to 18,675 in 1997; and the percentage of monitored workers receiving measurable dose decreased by one percentage point from 18% in 1996 to 17% in 1997. A discussion of activities at various facilities is included in Section 3.5. Paducah and Portsmouth reported 591 individuals with measurable dose to the NRC in 1997. Therefore, the change in regulatory authority over these facilities contributed 2.6 percentage points of the decrease in number with measurable dose.

The number of workers with measurable dose decreased from 22,725 in 1996 to 18,675 in 1997.

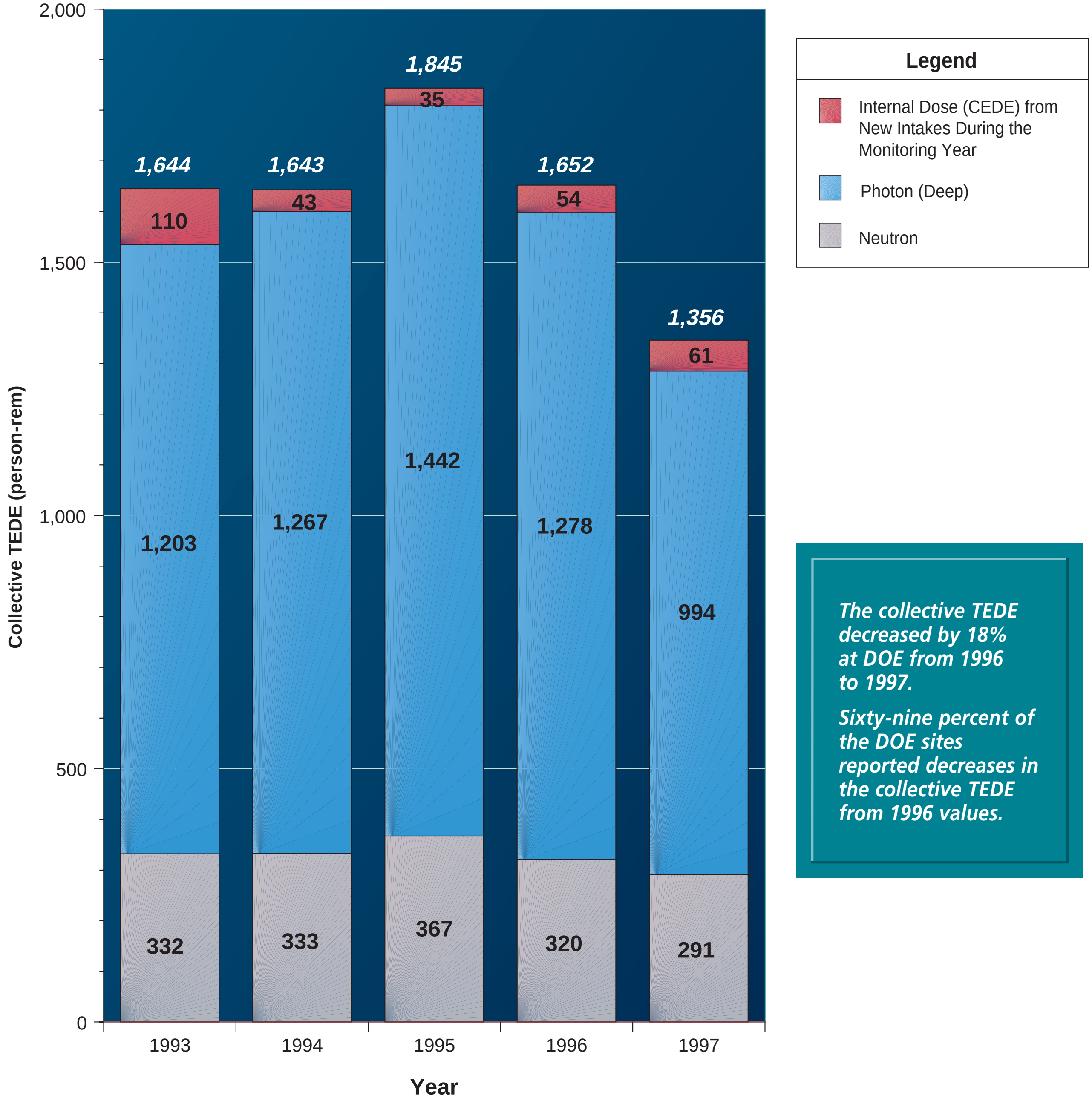
The percentage of monitored workers receiving measurable dose decreased by one percentage point from 18% in 1996 to 17% in 1997.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with measurable dose (*Exhibit 3-1*) and is measured in units of person-rem. The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and visitors. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

As shown in *Exhibit 3-2*, the collective TEDE decreased at DOE by 18% from 1996 to 1997. Sixty-nine percent of the DOE sites reported decreases in the collective TEDE from the 1996 values. Five out of seven of the highest dose sites reported decreases in the collective TEDE. The seven highest dose sites are (in descending order of collective dose) Rocky Flats, Hanford, Los Alamos, Savannah River, Idaho, Oak Ridge, and Brookhaven. A discussion of the activities leading to this decrease is included in Section 3.5. Paducah and

Exhibit 3-2:
Components of TEDE, 1993-1997



The collective TEDE decreased by 18% at DOE from 1996 to 1997.

Sixty-nine percent of the DOE sites reported decreases in the collective TEDE from 1996 values.

Photon dose - the component of external dose from gamma or x-ray electromagnetic radiation.

Neutron dose - the component of external dose from neutrons ejected from the nucleus of an atom during nuclear reactions.

Internal dose - radiation dose resulting from radioactive material taken into the body.

Portsmouth reported a collective TEDE of 30 person-rem (0.3 person-Sv) to the NRC in 1997. Therefore, the change in regulatory authority over these facilities contributed to 1.8 percentage points of the 18% decrease in the collective TEDE at DOE. Statistical analysis of the collective TEDE reveals a slight, but statistically significant increase in the mean TEDE from 1996 to 1997. This finding confirms that the collective dose has decreased primarily due to a reduction in overall work resulting in radiation exposure rather than reductions in dose to individuals. See Section 3.2.6 for more information on the statistical analysis, and Section 3.5 for more information on activities contributing to the collective dose.

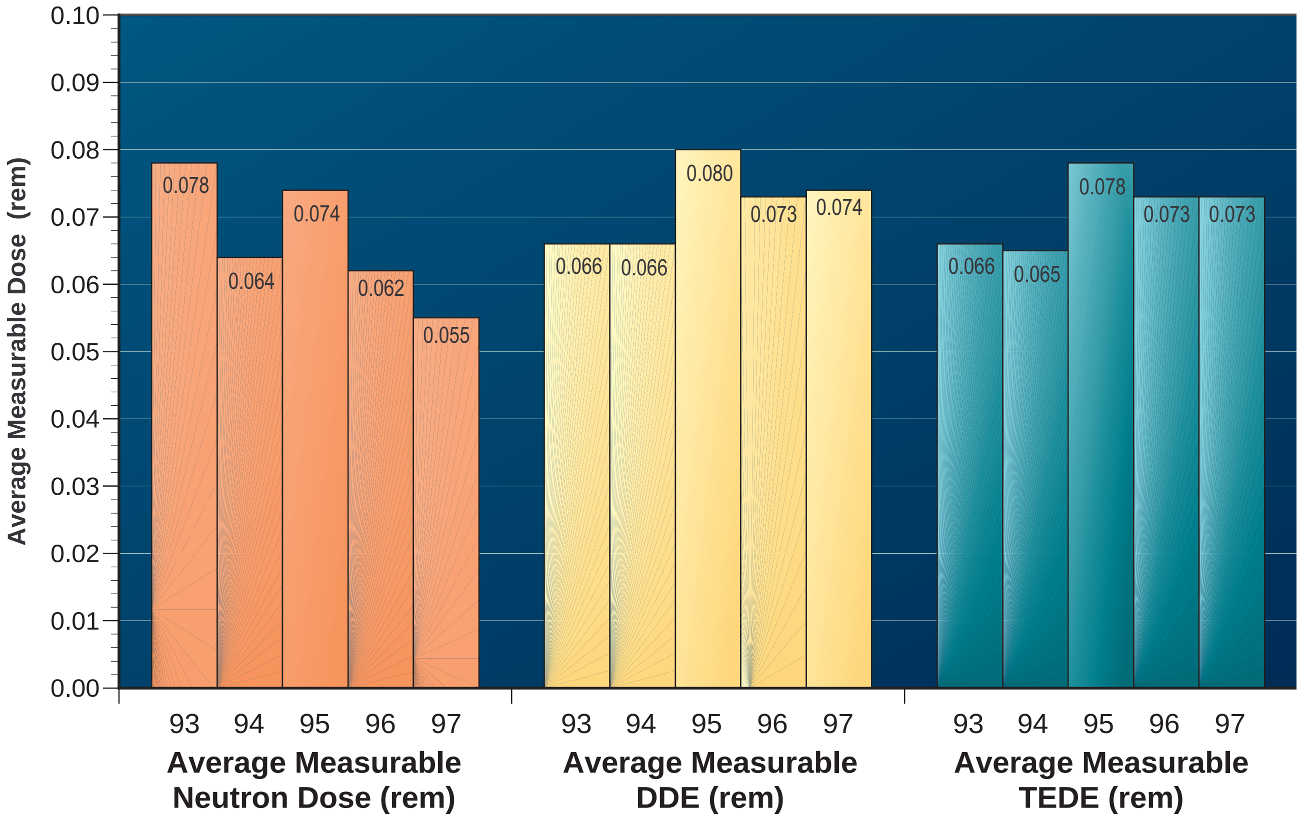
It is important to note that the collective TEDE includes the components of external dose and internal dose. *Exhibit 3-2* shows the types of radiation and their contribution to the collective TEDE. The photon, neutron, and internal dose components are shown.

It should be noted that the internal dose shown in *Exhibit 3-2* for 1993 through 1997 is based on the 50-year CEDE methodology. The internal dose component increased by 15% from 1996 to 1997. Nearly all of the increase in internal dose was due to the 28 person-rem (0.28 person-Sv) CEDE from radon reported by Grand Junction in 1997 (see Section 3.3.3). In addition, there is one internal dose that occurred in 1997 that is not yet included in the dose totals because the final dose has not yet been determined. This dose, in the range of 15 to 30 rem (150 to 300 mSv), would significantly change the collective internal dose for 1997. See Section 3.3.1 for more information on this internal dose event. The collective internal dose can vary from year to year due to the relatively small number of internal doses and the fact that they often involve long-lived radionuclides, which can result in relatively large committed doses. Due to the sporadic nature of these doses, care should be taken when attempting to identify trends from the internal dose records.

The external deep dose (comprised of photon and neutron dose) is shown in Exhibit 3-2 in order to see the contribution of external dose to the collective TEDE. The photon dose remained fairly stable at about 1,200 person-rem (12 person-Sv) during the years 1993 -1994, but increased by 14% to 1,442 person-rem (14.42 person-Sv) in 1995 due to increased activities at several of the highest dose sites. Activities responsible for increased dose at these sites included work on power sources for the National Aeronautics and Space Administration (NASA), increased research at an accelerator facility, nuclear materials stabilization activities, and decontamination and decommissioning (D&D) work. The photon dose decreased by 11% in 1996 and 22% in 1997. The collective photon dose for 1997 is below 1,000 person-rem (10 person-Sv) for the first time. Sites attributed the reduction in dose to the completion of several projects and operational changes. A discussion of the activities leading to this decrease is included in Section 3.5.

The neutron component of the TEDE decreased by 9% from 1996 to 1997. This is primarily due to decreases in the neutron dose at Los Alamos National Laboratory (LANL) and Savannah River. LANL contributed 41% of the neutron dose at the DOE over the past 3 years. This is because LANL is one of the few remaining sites to actively handle plutonium. Working with plutonium in gloveboxes results in neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium. Activities involving plutonium at LANL decreased in 1997, which resulted in decreased neutron dose by 16% from 121.6 person-rem (1.216 person-Sv) in 1996 to 102.3 person-rem (1.023 person-Sv) in 1997. The collective neutron dose at Rocky Flats experienced a 120% increase in 1997. This increase was due to product stabilization activities and D&D activities involving plutonium. The collective neutron dose by site is shown in Appendix B-3. External deep dose (DDE) and TEDE for prior years can be found in Appendix B-4.

Exhibit 3-3:
Average Measurable Neutron, DDE, and TEDE



3.2.4 Average Measurable Dose

The average measurable dose to DOE workers is determined by dividing the collective dose by the number of individuals with measurable dose. This is considered a key indicator of the overall level of radiation dose received by DOE workers.

The average measurable neutron, DDE, and TEDE is shown in *Exhibit 3-3*. The average measurable TEDE increased by 20% from 1994 to 1995. The average measurable TEDE decreased by 6% from 1995 to 1996. The average measurable TEDE remained unchanged from 1996 to 1997 due to the 18% decrease in the collective TEDE combined with the 18% decrease in the number of individuals with measurable TEDE. The average measurable DDE increased slightly from 1996 to 1997 and the average measurable neutron dose decreased by 11%. The 1% increase in average measurable DDE was primarily due to increases in the average measurable dose at Rocky Flats and Hanford. The decrease in the neutron dose appears to be part of a statistically significant 5-year decrease in neutron dose. The decreasing trend in the mean neutron dose is primarily due to a decrease in neutron dose at LANL since 1993.

The average measurable TEDE decreased by 6% from 1995 to 1996 but remained unchanged from 1996 to 1997.

The neutron dose at LANL is primarily from the production of heat sources for deep-space missions, which was completed in 1997. See Section 3.2.6 for more information on statistical analysis. The average measurable neutron, DDE, and TEDE values are provided for trending purposes, not for comparison between them.

Exhibit 3-4:
Dose Distributions, 1993-1997

	Dose Ranges (rem)	1993		1994		1995		1996		1997	
		TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE
Number of Individuals in Each Dose Range*	Less than Measurable	101,947	103,905	91,121	92,245	103,663	104,793	100,599	101,529	88,506	89,805
	Measurable < 0.1	21,210	19,356	21,511	20,469	19,272	18,191	18,759	17,903	15,262	14,098
	0.10 - 0.25	2,487	2,437	2,437	2,389	2,543	2,513	2,441	2,405	2,141	2,046
	0.25 - 0.5	1,017	985	934	920	1,134	1,124	1,003	983	856	830
	0.5 - 0.75	195	183	329	317	374	371	339	335	264	258
	0.75 - 1.0	93	89	99	94	131	131	99	94	101	99
	1 - 2	87	86	79	77	157	153	80	74	48	45
	2 - 3							2	1	1	
	3 - 4			1		1		1		1	
	4 - 5	2	1			1				1	
	5 - 6										
	6 - 7										
	7 - 8										
	8 - 9	1									
	9 - 10	1									
	10 - 11										
	11 - 12							1			
	> 12	2									
Total Monitored		127,042	127,042	116,511	116,511	127,276	127,276	123,324	123,324	107,181	107,181
Number with Meas. Dose		25,095	23,137	25,390	24,266	23,613	22,483	22,725	21,795	18,675	17,376
Number with Dose >0.1rem		3,885	3,781	3,879	3,797	4,341	4,292	3,966	3,892	3,413	3,278
% of Individuals with Meas. Dose		20%	18%	22%	21%	19%	18%	18%	18%	17%	16%
Collective Dose (person-rem)		1,644	1,534	1,643	1,600	1,845	1,809	1,652	1,598	1,356	1,285
Average Measurable Dose (rem)		0.066	0.066	0.065	0.066	0.078	0.080	0.073	0.073	0.073	0.074

* Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.

While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not indicate how each dose was distributed across the worker population.

3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the dose distribution among the worker population. *Exhibit 3-4* shows the number of individuals in each of 18 different dose ranges. The dose ranges are presented for the TEDE and DDE. The DDE is shown separately to allow for analysis of the dose independent of changes in internal dose. The number of individuals receiving doses above 0.1 rem (1 mSv) is also included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c).

Exhibit 3-4 shows that few individuals receive doses in the higher ranges and that the vast majority of doses are at low levels. This is one indication that ALARA principles are being applied to keep doses at low levels. A few examples of successful ALARA practices are included in Section 4. Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value compared to the total collective dose.

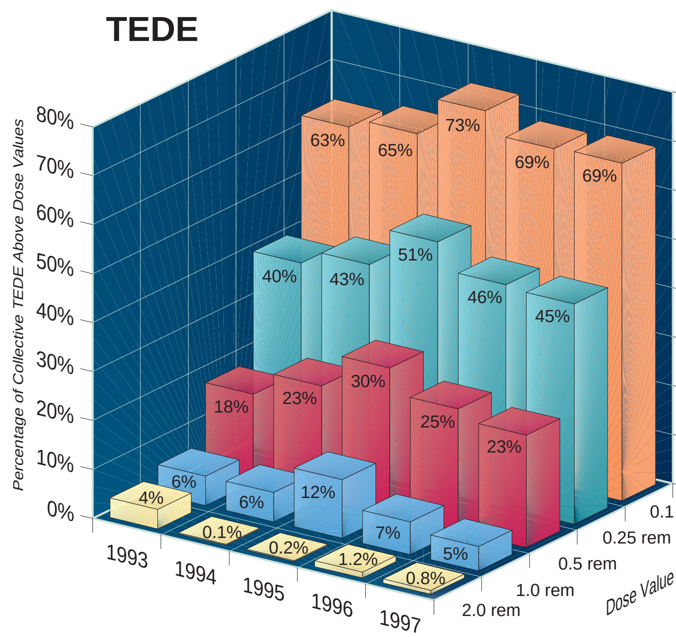
In 1982, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [13] defined distribution ratio "CR" as the fraction of the collective dose delivered above 1.5 rem (15 mSv). UNSCEAR identified this parameter as an indicator of the efforts to reduce high doses. DOE has adapted this approach to allow a quantification and analysis of the dose distribution at DOE.

Ideally, only a small percentage of the collective dose is delivered to individuals in the higher dose ranges. In addition, a trend in the percentage above a certain dose range decreasing over time may indicate the effectiveness of ALARA programs to reduce doses to individuals, or may indicate an overall reduction in activities involving radiation exposure.

Exhibit 3-5 shows the distribution ratio given by percentage of collective TEDE and DDE above each of five dose values, from 0.1 rem (1 mSv) to 2 rem (20 mSv). This graph shows the two properties described above as the goal of effective ALARA programs at DOE: (1) a relatively small percentage of the collective dose accrued in the high dose ranges, and (2) a decreasing trend over time of the percentage of the collective dose accrued in the higher dose ranges. Exhibit 3-5 shows that the percentages have decreased from 1996 to 1997 for all dose ranges at or above 0.25 rem.

The general trend has been an increase in the percentage of dose above each dose range from 1993 to 1995 and then a decrease from 1995 to 1997. This coincides with the increase in the collective dose reported in 1995 and the increase in activities resulting in radiation exposures at the highest dose sites during 1995. Most of these sites reported decreases in the collective dose and radiological activities in 1996 and 1997 (see Section 3.5), which coincides with the observed decreases in *Exhibit 3-5*.

Exhibit 3-5:
Distribution of Collective Dose vs Dose Values, 1993-1997



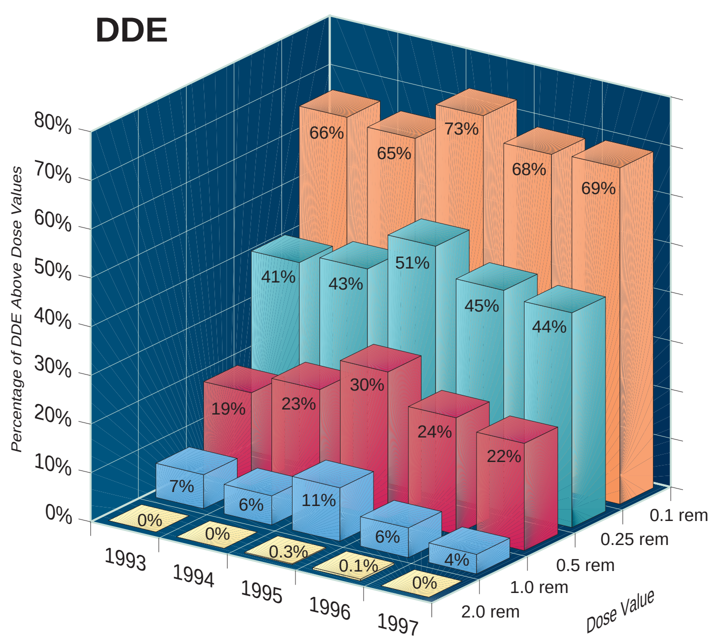


Exhibit 3-6:
Neutron Dose Distribution, 1993-1997

Year	No Meas. Dose	Meas. <0.100	0.10-0.25	0.25-0.50	0.5-0.75	0.75-1.0	1.0-2.0	>2.0	Total Monitored*	Number of Individuals with Meas. Dose	Collective Neutron DDE (person-rem)	Average Meas. Neutron DDE (rem)
1993	122,811	3,261	693	229	29	10	9	-	127,042	4,231	331.585	**0.078** ◂
1994	111,391	4,196	662	192	43	14	13	-	116,511	5,120	332.930	0.065
1995	122,333	3,944	667	240	46	25	21	-	**127,276** ◂	4,943	**367.446** ◂	0.074
1996	118,154	4,282	677	156	32	11	12	-	123,324	5,170	320.320	0.062
1997	101,865	4,495	630	149	29	6	4	-	107,178	**5,313** ◂	290.640	0.055

Note: Arrowed values indicate the greatest value in each column.
* Represents the total number of monitoring records. The number of individuals specifically monitored for neutron radiation cannot be determined.

In addition to the DDE and TEDE distribution, the neutron and extremity dose distributions are shown in *Exhibits 3-6* and *3-7*. The neutron dose is a component of the total DDE. Exposure to neutron radiation is much less common at DOE than photon dose. In 1997, 5,313 individuals received measurable neutron dose, which is only 5% of the monitored individuals, and 31% of the individuals with measurable DDE. The collective neutron dose represents 21% of the collective TEDE. All neutron doses were below 2 rem (20 mSv) for the past 5 years. While the number of individuals with measurable neutron dose has increased over the past 5 years, the collective neutron dose and average measurable neutron dose have decreased. Statistical analysis of the neutron dose (see Section 3.2.6) reveals that the dose has experienced a statistically significant decrease over the past 5 years, primarily due to decreases at LANL, which is responsible for nearly half the neutron dose at DOE. The neutron dose distribution by site is shown in Appendix B, *Exhibit B-3*.

Exhibit 3-7 shows the distribution of extremity dose over the past 5 years. "Extremities" are defined as the hands and arms below the elbow, and the feet and legs below the knee. 10 CFR 835.402(a)(1)(ii) requires monitoring for an SDE to the extremities of 5 rem (50 mSv) or more in a year. As shown in *Exhibit 3-7*, very few individuals have received doses above the 5 rem (50 mSv) monitoring threshold, and all of these exposures were for the upper extremities. The DOE annual limit for extremity dose is 50 rem (500 mSv). The higher dose limit is due to the lack of blood-forming organs in the extremities; therefore, extremity dose involves less health risk to the individual. No individual has received an extremity dose above the 50 rem (500 mSv) regulatory limit in the past 5 years. The number of individuals with a measurable extremity dose has decreased by 37% from 1994 to 1997. However, the number of individuals above 1 rem (10 mSv) has increased over the past 5 years as well as the average measurable extremity dose. Statistical analysis of

Exhibit 3-7:
Extremity Dose Distribution, 1993-1997

Year	No Meas. Dose	Meas. <0.1	0.1-1.0	1-5	5-10	10-20	20-30	30-40	>40	Total Monitored*	Number with Meas. Dose	No. Above Monitoring Threshold (5 rem)**	Collective Extremity Dose (person-rem)	Average Meas. Extremity Dose (rem)
1993	111,143	12,127	3,427	328	16	1	-	-	-	127,042	15,899	17	2,081.4	0.131
1994	96,545	15,903	3,619	418	22	2	2	-	-	116,511	**19,966** ◂	26	2,520.3	0.126
1995	113,089	10,187	3,298	621	57	22	1	1	-	**127,276** ◂	14,187	**81** ◂	**3,355.8** ◂	0.237
1996	108,458	10,576	3,583	646	50	9	1	1	-	123,324	14,866	61	3,272.8	0.220
1997	94,504	8,424	3,568	636	33	9	2	2	-	107,178	12,674	46	3,056.3	**0.241** ◂

Note: Arrowed values indicate the greatest value in each column.
* Represents the total number of monitoring records. The number of individuals provided extremity monitoring cannot be determined.
** DOE annual limit for extremities is 50 rem. 10 CFR835.402(a)(1)(ii) requires extremity monitoring for a shallow dose equivalent to the skin or extremity of 5 rem or more in one year.

the extremity dose (see Section 3.6) reveals a statistically significant increase since 1994. The extremity dose distribution by site for 1997 is shown in Appendix B, *Exhibit B-23*.

3.2.6 Five-Year Perspective

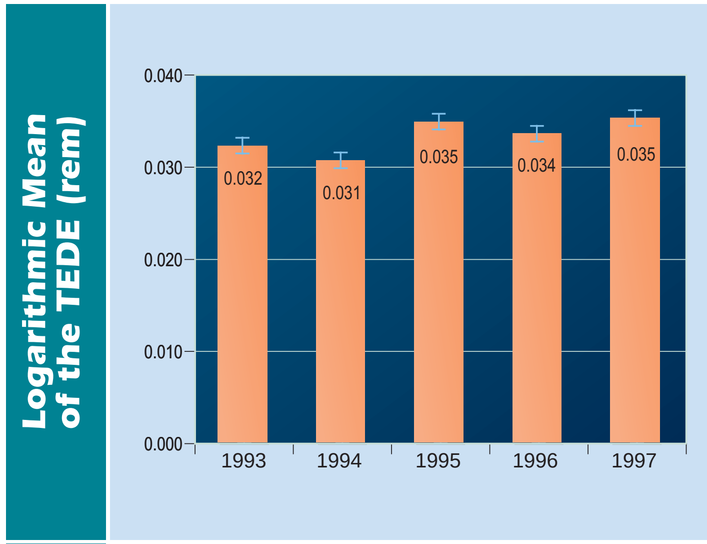
There are often differences in summary dose numbers from year to year, yet some of these differences may represent normal variations in a stable process, rather than significant changes. This section discusses the results of a statistical analysis to determine if there are statistically significant trends detectable over the last 5 years. The collective TEDE, neutron, and extremity doses were analyzed. Internal dose records have not been included as the number of records are too few and the dose distribution is not appropriate for the statistical model.

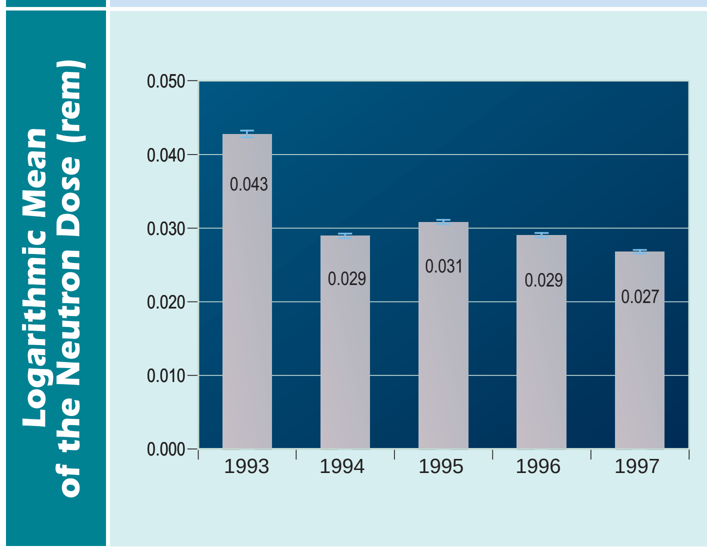
This analysis includes only measurable doses received in each year, and used two types of tests to measure different characteristics of the distributions. The first test used pairwise T-tests to identify significant differences between statistical means for the years analyzed. Because the dose values do not fit a statistically normal distribution, this test used log-transformed data, which were approximately normal. Note that the logarithmic means used here are different from the average measurable dose discussed elsewhere in this report. The T-tests uses a 95% confidence level to identify significant differences.

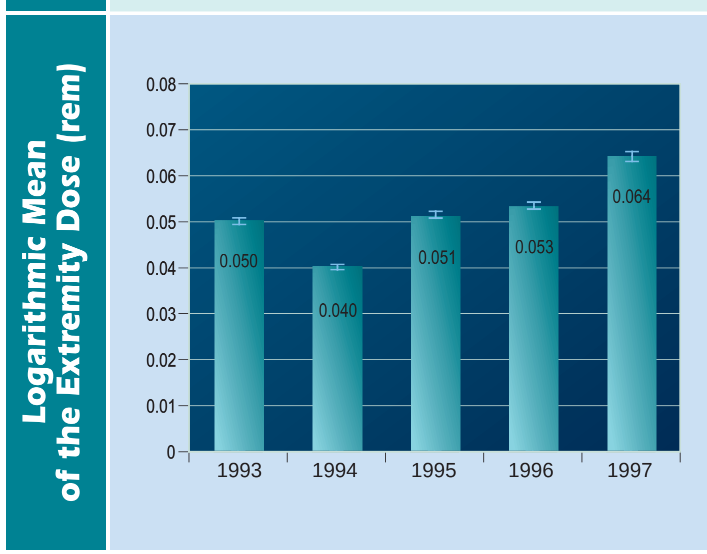
The second approach tested for differences in the distribution of dose (e.g. the shape of the distribution of dose among the worker population) from year to year. This is similar to testing whether the overall distribution of dose in *Exhibit 3-4* differed from year to year.

These statistical tests reveal trends that are not apparent when considering only the collective and average doses. In addition, the statistical analysis reveals that some of these trends are significant. *Exhibit 3-8* shows the results of the significance tests for the collective TEDE, neutron, and extremity dose DOE-wide. The error bars surrounding each data point represent the 95% confidence levels.

Exhibit 3-8:
DOE-Wide Summary Results for Statistical Tests







For the collective TEDE, there were small but significant differences in all years with no apparent trends across the 5-year period. The logarithmic mean TEDE per worker increased slightly by 0.001 rem (.01 mSv) from 1996 to 1997 in contrast to the 18% decrease in the collective TEDE. There is also a difference in the dose distribution from 1996 to 1997 resulting from a slight shift of workers from the lowest dose range into the 0.1-0.25 rem (1-2.5 mSv) range. These results indicate that, although the collective dose has decreased considerably, the mean dose delivered to workers has actually increased slightly. This substantiates the conclusion that the collective dose has decreased due to a reduction in overall work involving radiation exposure, rather than reductions in dose to individuals. *Exhibit 3-28* presents a summary of activities at the seven highest dose sites, and confirms that reductions at Savannah River, Idaho, Brookhaven National Laboratory (BNL), and Oak Ridge were due to reductions in such activities as materials stabilization, maintenance, and the completion of several key projects.

Analysis of the neutron dose shows that the measurable dose has significantly decreased over the past 5 years, primarily between the years 1993 and 1994. The largest decrease occurred at LANL, which is responsible for nearly half the neutron dose at DOE. Analysis of the extremity dose reveals a statistically significant increase in the mean of measurable doses each year since 1994. While no site has reported an extremity dose in excess of the limit in the past 5 years, the increasing trend requires continued observation and may indicate the need for a review of extremity monitoring and protection practices at DOE sites in the future.

3.3 Analysis of Individual Dose Data

The above analyses are all based on aggregate data for DOE. From an individual worker perspective as well as a regulatory perspective, it is important to closely examine the doses received by individuals in the high dose ranges to thoroughly understand the circumstances leading to high doses in the workplace and how these doses may be avoided in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rem TEDE) (50 mSv) and the DOE ACL (2 rem TEDE) (20 mSv).

3.3.1 Doses in Excess of DOE Limits

Exhibit 3-9 shows the number of doses in excess of the TEDE regulatory limit (5 rem)(50 mSv) from 1993 through 1997. Further information

Exhibit 3-9:
Number of Individuals Exceeding 5 rem (TEDE), 1993-1997

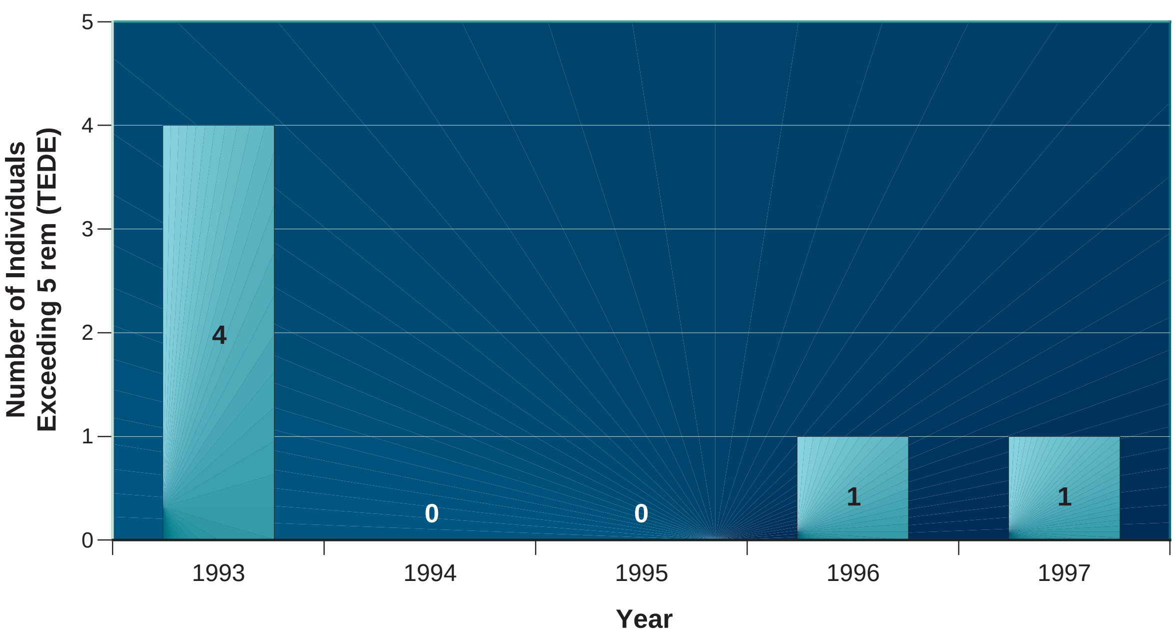


Exhibit 3-10:
Doses in Excess of DOE Limits, 1993-1997

Year	Year Uptake	TEDE (rem)	DDE (rem)	CEDE (rem)	Intake Nuclides	Facility Types	Site
1993	1993	17.220	0	17.220	Pu-239, Pu-240	Maint. & Support	Los Alamos Nat'l. Lab.
1993	1993	22.068	0.189	21.879	Pu-239, Pu-240	Research, General	Los Alamos Nat'l. Lab.
1993	1993	8.709	0.209	8.500	Pu-239, Pu-240	Research, General	Los Alamos Nat'l. Lab.
1993	1993	9.218	0.058	9.160	Pu-239, Pu-240, Am-241	Weapons Fabrication	Rocky Flats
1994					None Reported		
1995					None Reported		
1996	1996	11.623	0.123	11.500	Pu-238, Pu-239, Pu-241	Fuel Processing	Savannah River
1997	1997	–	–	15-30 rem*	Cm-244	–	Lawrence Livermore Nat'l. Lab.

* *Final dose assessment not yet available. See Section 3.3.1.*

concerning the individual doses, radionuclides involved, and site where the doses occurred is shown in *Exhibit 3-10*.

One individual received a dose in excess of the 5 rem (50 mSv) TEDE limit in July 1997. This individual received an estimated internal CEDE of 15 to 30 rem (150 to 300 mSv) due to an unanticipated intake of curium-244 (Cm-244) at the Lawrence Livermore National Laboratory. Technicians were shredding contaminated High Efficiency Particulate Air (HEPA) filters for disposal. The technicians were wearing hooded anti-contamination suits with full face respirators. While leaving the area, one technician set off the alarm of the hand and foot contamination monitor, initiating an investigation into the source of the contamination. The subsequent investigation revealed a failure of one of the technician's respirators, resulting in facial contamination and an inhalation of Cm-244. The direct cause was determined to be the breach of respiratory protection, although the exact cause of the failure could not be determined. Contributing causes cited were the inadequacy of the operational safety procedure, mischaracterization of the amount and type of radioactivity, the continuous air monitor not being turned on, and a failure to communicate the needed information concerning the wastes and hazards of the operation. The root cause was attributed to the failure of management and supervisors to adequately analyze, control, and manage the hazardous waste treatment operation. For more information on this occurrence, see the Occurrence Report SAN–LLNL-LLNL-1997-0038. Because the dose is an estimate, it has not been included in the figures presented in this report. Upon a final dose determination, subsequent annual reports will include this dose.

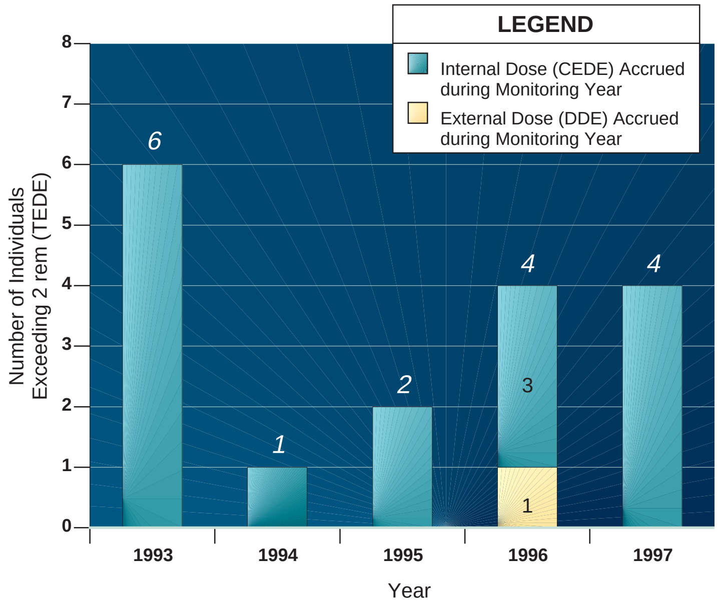
One individual received a dose in excess of the 5 rem (50 mSv) TEDE limit in 1997.

All of the events resulting in doses in excess of DOE limits from 1993 to 1997 were from internal dose.

3.3.2 Doses in Excess of Administrative Control Level

The "RadCon Manual" [5] recommends a 2 rem (20 mSv) ACL for TEDE, which is not to be exceeded without prior DOE approval. Each DOE site required to follow the RadCon manual is required to establish its own, more restrictive ACLs that require contractor management approval to be exceeded. The number of individuals receiving doses in excess of the 2 rem (20 mSv) ACL is a measure of the effectiveness of DOE's radiation protection program. It should be noted that doses above the 2 rem (20 mSv) ACL do not necessarily pose an undue health risk to the individual.

Exhibit 3-11:
Number of Doses in Excess of the DOE 2 rem ACL, 1993-1997



Four individuals received doses above the 2 rem (20 mSv) ACL in 1997, as shown in *Exhibit 3-11*. One of these doses also exceeded the 5 rem (50 mSv) DOE limit and is described in Section 3.3.1. All three of the remaining doses occurred at the TA-55 Plutonium Processing Facility at LANL and involved internal dose from intakes of plutonium. The first individual received an external dose of 1.071 rem (10.71 mSv) in addition to an internal dose of 1.2 rem (12 mSv) CEDE, resulting in a TEDE of 2.271 rem (22.71 mSv). The intake actually occurred in 1996, but was discovered during subsequent bioassay measurements and was reported in 1997. A routine review of air sample data was performed in July 1996, and it was discovered that readings were elevated in proximity to a certain glovebox. Subsequent investigation revealed a leaky window gasket on the glovebox. Bioassay measurements were taken for the individuals who had recently performed maintenance in that glovebox. The bioassay results indicated that one individual had received an uptake of Pu-239 resulting in a CEDE of 1.2 rem (12 mSv). The root cause of this intake was determined to be the failure of the window gasket on the glovebox. The gasket was replaced and operations resumed. For further information, see Occurrence Report ALO-LA-LANL-TA55-1997-0021.

The second individual received an external dose of 1.184 rem (11.84 mSv) in addition to an internal dose of 3.2 rem (32 mSv) CEDE, resulting in a TEDE of 4.384 rem (43.84 mSv). In February 1997, the individual was removing plutonium-contaminated rags from a storage can inside a glovebox. When the worker removed his hands and monitored them, alpha contamination was detected. The storage can was rusty and apparently cut through the glove of the glovebox, resulting in the contamination. Nasal smears indicated a low-level intake, but the diagnostic bioassay did not indicate an intake. Subsequent bioassay revealed the intake and resultant CEDE of 3.2 rem (32 mSv). The direct cause of the event was determined to be the failure of the glove in the glovebox. The damaged glove was immediately replaced. The root cause was attributed to personnel error and inattention to detail.

For further information, see Occurrence Report ALO-LA-LANL-TA55-1997-0013. The occurrence report does not include information on the final internal dose assessed for this event since the bioassay data were unavailable at the time the final occurrence report was submitted.

The third individual received an external dose of 0.139 rem (1.39 mSv) in addition to an internal dose of 3.4 rem CEDE, resulting in a TEDE of 3.539 rem (35.39 mSv). In June 1997, an individual was attempting to transfer components from a drop box to a glovebox using a spool piece. When the components were transferred, the spool piece was to be evacuated and back-filled with inert argon gas. During this procedure, the worker was unable to operate the valve on the vacuum line. After several attempts, the worker decided to replace the valve himself and did not follow appropriate procedures for this change in conditions. Unbeknownst to the worker, he had added positive pressure to the spool piece. Due to the positive pressure, plutonium contamination was released during the valve replacement, resulting in an intake by the individual. The direct cause was attributed to personnel error. The individual made errors in judgment on several levels and his employment was subsequently terminated. As a corrective action, additional training was given to employees in work controls and procedures. For further information, see Occurrence Report ALO-LA-LANL-TA55-1997-0027.

Five of the nine doses above the 2 rem (20 mSv) ACL in the past 3 years have occurred at the TA-55 Plutonium Processing Facility at LANL. This facililty conducts extensive handling of plutonium. Due to the long radiological and biological half-life of plutonium, even a small intake of plutonium will result in a significant 50-year CEDE.

An occurrence report submitted to the Occurrence Reporting & Processing System (ORPS) by Rocky Flats in December 1997 indicated that an individual received an intake in 1995 that may have exceeded 5 rem (50 mSv). The dose assessment has now been finalized at 4.5 rem (45 mSv) CEDE. The individual also received an external dose of 0.092 rem (0.92 mSv), resulting in a TEDE of 4.592 rem (45.92 mSv). This dose did not exceed the 5 rem (50 mSv) TEDE limit. However, the intake also resulted in a dose of 80 rem (800 mSv) CDE to the bone surface, which exceeds the 50 rem (500 mSv) organ limit. For further information, see Occurrence Report RFO-KHLL-371OPS-1997-0106. Dose totals from 1995 in this report have been updated to reflect this dose.

3.3.3 Internal Depositions of Radioactive Material

As discussed in Section 3.3.1, in the past, some of the most significant doses to individuals have been the result of intakes of radioactive material. For this reason, DOE emphasizes the need to avoid intakes and tracks the number of intakes as a performance measure.

The number of internal depositions of radioactive material (otherwise known as worker intakes) for 1995-1997 is shown in *Exhibit 3-12*. The internal depositions were categorized into nine radionuclide groups. Intakes involving multiple nuclides are listed as "mixed." Nuclides where fewer than 10 individuals had intakes over the 3-year period were grouped together as "other." Only those records with internal dose greater than zero are included in this analysis. It should be noted that the different nuclides have different radiological properties, resulting in varying minimum levels of detection and reporting.

The number of workers with measurable internal dose increased by 19% from 1996 to 1997, and the collective CEDE increased 15%. Most of this increase is due to the radon dose reported for the first year in 1997 by Grand Junction. It should be noted that relatively few workers receive significant internal dose and therefore fluctuations in the number of workers and collective CEDE can occur from year to year.

Exhibit 3-12 shows the intakes that occurred during the past 3 years that were reported using the CEDE internal dose calculation methodology.

Exhibit 3-12:
Number of Intakes, Collective Internal Dose, and Average Dose by Nuclides, 1995-1997

Nuclide	Number of Workers with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
Year	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**
Hydrogen-3 (Tritium)	810	**797** ◄	734	6.995	6.353	5.450	0.009	0.008	0.007
Technetium	-	2	8	-	0.006	0.009	-	0.003	0.001
Radon-222	-	-	270	-	-	**27.834** ◄	-	-	0.103
Thorium	31	148	14	1.192	9.633	0.153	0.038	0.065	0.011
Uranium	**880** ◄	539	**787** ◄	11.354	12.380	13.022	0.013	0.023	0.017
Plutonium	73	66	69	**14.230** ◄	**24.297** ◄	13.718	**0.195** ◄	**0.368** ◄	**0.199** ◄
Americium-241	20	16	9	0.457	0.572	0.564	0.023	0.036	0.063
Other	34	31	13	0.918	0.283	0.275	0.027	0.009	0.021
Mixed	4	-	5	0.166	-	0.341	0.042	-	0.068
Totals	**1,852**	**1,599**	**1,909**	**35.312**	**53.524**	**61.366**	**0.019**	**0.033**	**0.032**

Note: Arrowed values indicate the greatest value in each column.

*Individuals may have received intakes of more than one nuclide and therefore may be counted more than once.

Most intakes of radioactive material during the 3-year period were the result of exposure to tritium or uranium. The average CEDE doses from these intakes are quite low because of the radiological and biological characteristics of these radionuclides and the large number of monitored individuals with low CEDE dose from these radionuclides.

The highest average CEDE dose from 1995 to 1997 was from plutonium. Plutonium yields particularly high values for CEDE because of the long radiological half-life and the long-term deposition of the material in the bone. Americium intakes have a high average CEDE for similar reasons, but the number of intakes and collective dose are much smaller than for plutonium. Both the collective and average doses for plutonium decreased in 1997 primarily because of reductions at Savannah River and Hanford.

The collective CEDE from thorium decreased in 1997 because the site reporting most of these intakes, the Portsmouth Gaseous Diffusion Plant, has gone through several operational changes. This plant was licensed to operate by the NRC in March 1997; therefore, for monitoring year 1997, all radiation exposure from plant operations has been reported to the NRC. The legacy "tails" cylinders and some other environmental activities that are not involved in the plant operation are still DOE responsibility and are included in this report.

A new radionuclide, radon-222, was added for 1997. This is the first year that a site has reported radon as a source of occupational exposure. The Grand Junction Office is involved in environmental remediation of uranium mill tailings at a former uranium mill site at Monticello, Utah, as well as various Uranium Mill Tailings Remedial Action (UMTRA) sites. The primary radiological exposure pathway at the Monticello mill site is from radon progeny emanating as a gas from the uranium tailings piles. "Tailings" are the soil left over after the uranium ore extraction process. While radon is normally considered an environmental background source of radiation, in this case exposure to radon progeny is considered occupational exposure since the radiation source is above the normal background and it exposes workers during their remediation activities.

It should be noted that the radon doses listed here include the natural background dose from radon as well as the additional dose received from the elevated radon levels. Dose from radon was also received at the site in 1996 but has not yet been reported. The doses are currently being determined and will be included as 1996 exposure in subsequent reports.

The internal dose records indicate that the majority of the intakes reported are at very low doses. In 1997, 74% of the internal dose records were for doses below 0.020 rem (0.20 mSv). These records represent only 10% of the collective internal dose. The other 26% of the internal dose records had doses above 0.020 rem (0.20 mSv) and accounted for 90% of the collective internal dose. Over the 5-year period, internal doses from new intakes accounted for only 4% of the collective TEDE. Only 4% of the individuals who received internal dose were above the monitoring threshold specified in 10 CFR 835.402(c).

The internal dose records indicate that the majority of the intakes reported are at very low doses.

Over the 5-year period, internal doses from new intakes accounted for only 4% of the collective TEDE.

Exhibit 3-13:
Internal Dose Distribution from Intakes, 1993-1997

Number of Individuals* with internal dose in each dose range (rem).

Year	Meas. <0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0	Total No. of Indiv.*	Total Collective Internal Dose CEDE (person-rem)
1993	2,533	354	56	22	6	2	1			1	4	2,979	109.913
1994	1,712	224	29	18	7	2	2		1			1,995	45.600
1995	1,564	245	33	4	1		3	1		1		1,852	35.312
1996	1,324	202	42	13	9	4	3		1		1	1,599	53.524
1997	1,420	358	100	17	8	1	3		2			1,909	61.366

Note: Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.

* Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

Exhibit 3-13 shows the distribution of the internal dose from 1993 to 1997. The total number of individuals with doses in each dose range is for each record of intake. The internal dose does not include doses from prior intakes (legacy AEDE dose). Individuals with multiple intakes during the year may be counted more than once. Doses below 0.020 rem (0.20 mSv) are shown as a separate dose range to show the large number of doses in this low-dose range. All but two of the internal doses were below 2 rem (20 mSv) in 1997. The distribution of internal dose by site and nuclide for 1997 is presented in Appendix B-22.

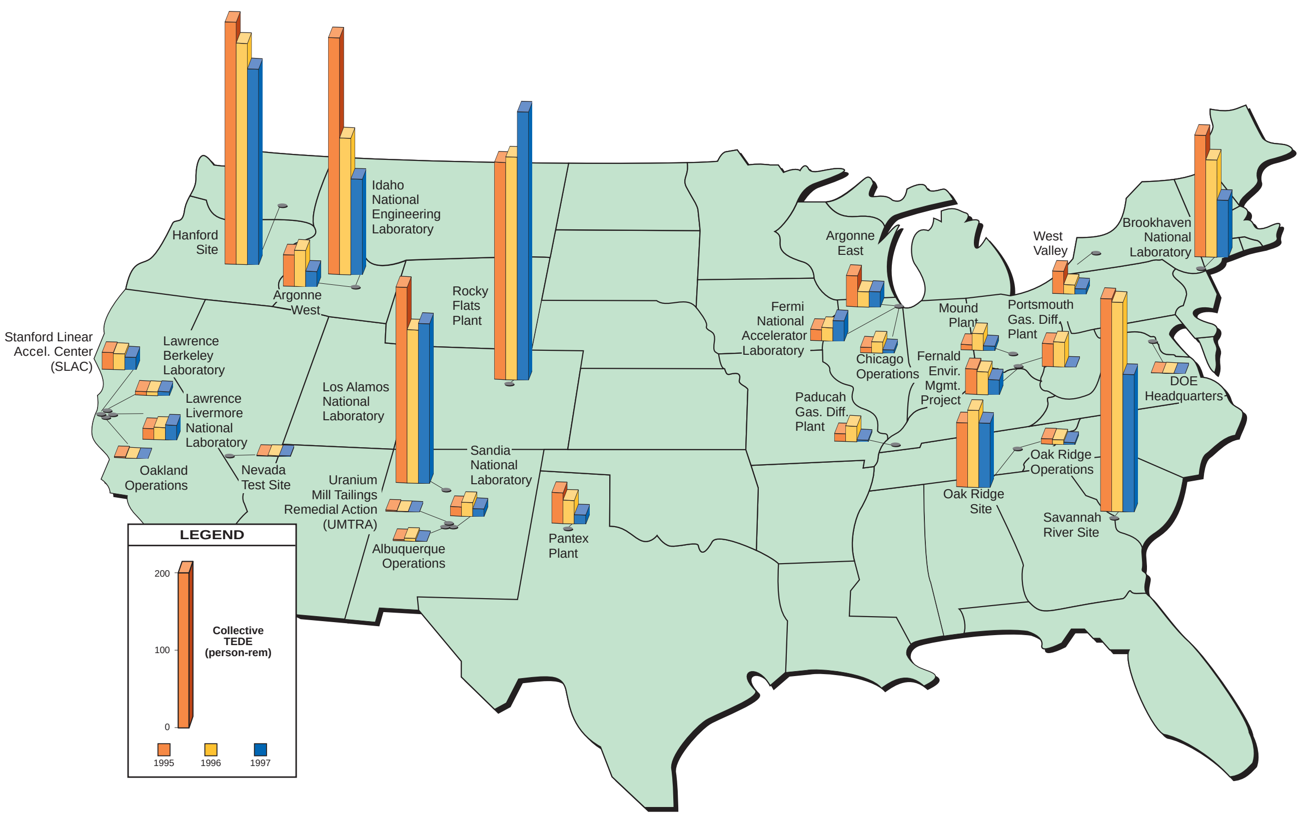
When examining trends involving internal dose, several factors should be considered. Some of the largest changes in the number of reported intakes over the years resulted from changes in internal dosimetry practices. Periodically, sites may change monitoring practices or procedures, which may involve increasing the sensitivity of the detection equipment, thereby increasing the number of individuals with measurable internal doses. Conversely, sites may determine that internal monitoring is no longer required due to historically low levels of internal dose or a decreased potential for intake. There are relatively few intakes each year, and the CEDE method of calculating internal dose can result in large internal doses from the intake of long-lived nuclides. This can result in significant statistical variability of the internal dose data from year to year.

3.4 Analysis of Site Data

3.4.1 Collective TEDE by Operations/Field Offices

The relative collective TEDE for 1995-1997 for the major DOE sites and Operations/Field Offices is shown in *Exhibit 3-14*. A list of the collective TEDE and number of individuals with measurable TEDE for the DOE Operations/Field Offices and sites is shown in *Exhibit 3-15*. The collective TEDE decreased by 18% between 1996 and 1997, with seven of the highest dose sites (BNL, Savannah River, Oak Ridge, LANL, Rocky Flats, Idaho, and Hanford) contributing 87% of the total DOE collective TEDE.

Exhibit 3-14:
Relative Collective TEDE by Site/Facility



Note: A complete list of the collective dose, number of individuals with measurable dose, and average measurable dose for each Operations/Field Office can be found in Appendix B.

Exhibit 3-15:
Collective TEDE and Number of Individuals with Measurable TEDE by Site/Facility, 1995-1997

Operations/ Field Office	**Site/Facility**	**1995** Collective TEDE (person-rem)	**1995** Number with Meas. TEDE	**1996** Collective TEDE (person-rem)	**1996** Number with Meas. TEDE	**1997** Collective TEDE (person-rem)	**1997** Number with Meas. TEDE
Albuquerque	Ops. and Other Facilities	1.6	40	3.6	37	0.5	25
	Los Alamos National Lab. (LANL)	234.9	2,583	184.1	1,984	192.2	2,333
	Pantex Plant (PP)	36.9	329	28.1	327	11.1	213
	Sandia National Lab. (SNL)	11.1	343	16.7	485	9.7	196
	Uranium Mill Tailings Remedial Action (UMTRA) Project	1.3	58	0.4	26	0.3	36
Chicago	Ops. and Other Facilities	6.5	135	13.5	182	4.5	134
	Argonne Nat'l. Lab. - East (ANL-E)	37.2	297	18.5	202	19.0	238
	Argonne Nat'l. Lab. - West (ANL-W)	37.6	335	43.6	331	18.9	249
	Brookhaven Nat'l. Lab.(BNL)	145.8	973	116.8	1,448	68.9	1,463
	Fermi Nat'l. Accelerator Lab.(FERMI)	13.4	473	16.2	538	25.0	859
DOE HQ	DOE Headquarters	0.1	8	0.3	6	0.2	5
	DOE North Korea Project			13.3	36	8.3	24
Idaho	Idaho Site	284.0	1,501	164.1	1,299	115.3	1,141
Nevada	Nevada Test Site (NTS)	0.5	9	1.0	19	1.3	25
Oakland	Ops. and Other Facilities	1.3	20	0.0	6	1.4	50
	Lawrence Berkeley Lab. (LBL)	4.5	76	4.6	100	5.2	128
	Lawrence Livermore Nat'l. Lab. (LLNL)	13.0	159	14.9	187	18.1	186
	Stanford Linear Accelerator Center (SLAC)	20.2	236	19.3	312	14.2	117
Oak Ridge	Ops. and Other Facilities	6.2	167	11.9	200	6.6	135
	Oak Ridge Site	76.9	1,804	88.6	1,582	77.7	1,614
	Paducah Gaseous Diff. Plant (PGDP)	9.0	225	18.6	290	2.5	36
	Portsmouth Gaseous Diff. Plant (PORTS)	27.5	1,623	29.9	758	0.2	3
Ohio	Ops. and Other Facilities	0.0	5	0.0	5	0.1	2
	Fernald Environmental Management Project	30.4	955	27.4	804	18.4	520
	Mound Plant	6.4	175	20.1	403	5.8	197
	West Valley	26.9	311	11.2	231	6.9	174
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	265.3	3,427	**267.6**	3,430	**323.2**	3,187
Richland	Hanford Site	**290.7**	2,500	265.7	2,761	235.4	2,058
Savannah River	Savannah River Site (SRS)	255.5	**4,846**	251.8	**4,736**	165.3	**3,327**
Totals		**1,844.7**	**23,613**	**1,651.9**	**22,725**	**1,356.1**	**18,675**

Note: Arrowed values indicate the greatest value in each column.

Exhibit 3-16:
Dose by Labor Category, 1995-1997

Labor Category	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Agriculture	9	8	8	0.5	0.4	1.1	0.058	0.047	0.134
Construction	2,300	2,588	1,695	164.2	176.8	125.7	0.071	0.068	0.074
Laborers	729	542	509	76.3	49.0	81.9	0.105	0.090	**0.161** ◀
Management	1,629	1,212	1,402	78.9	57.2	75.4	0.046	0.047	0.054
Misc.	3,496	**5,012** ◀	2,093	169.4	259.8	98.2	0.048	0.052	0.047
Production	2,779	2,434	1,794	282.0	267.4	144.3	0.101	0.110	0.080
Scientists	3,513	3,828	3,052	153.7	164.4	136.1	0.044	0.043	0.045
Service	962	569	634	37.0	31.7	35.0	0.038	0.056	0.055
Technicians	3,929	3,576	2,824	429.1	**416.6** ◀	**336.3** ◀	0.109	**0.117** ◀	0.119
Transport	313	401	177	18.0	18.8	8.4	0.057	0.047	0.047
Unknown	**3,954** ◀	2,555	**4,487** ◀	**435.4** ◀	209.9	313.7	**0.110** ◀	0.082	0.069
Totals	**23,613**	**22,725**	**18,675**	**1,844.7**	**1,651.9**	**1,356.1**	**0.078**	**0.073**	**0.073**

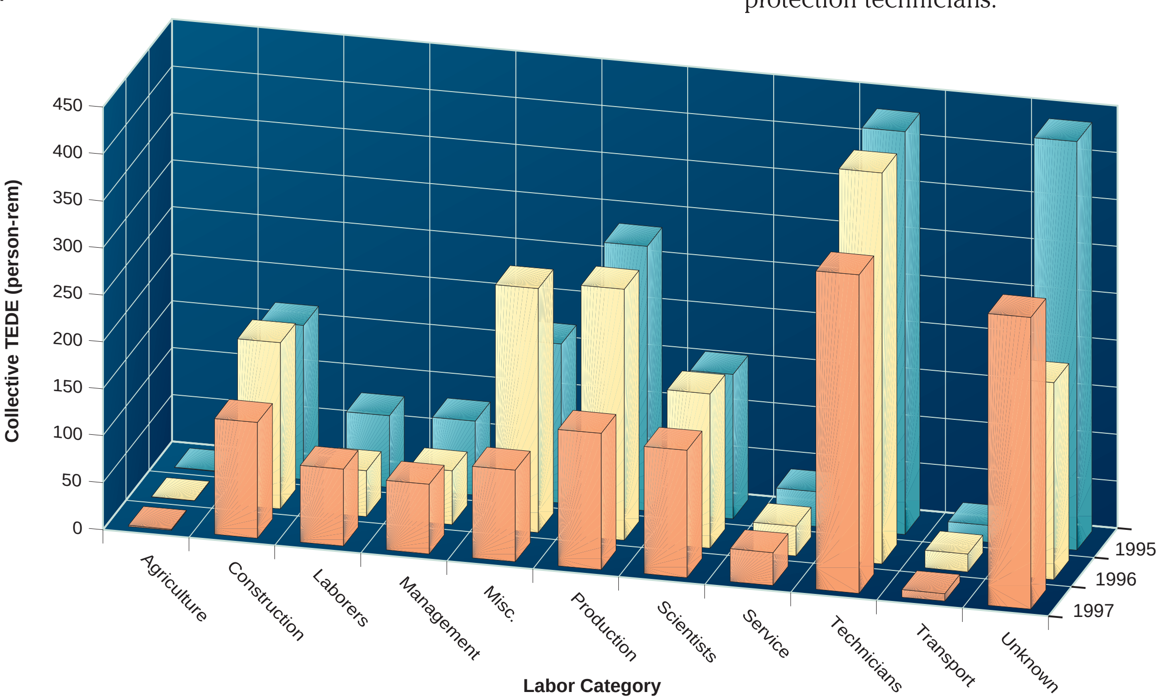
Note: Arrowed values indicate the greatest value in each column.

* *1995-1997 TEDE = CEDE + DDE*

3.4.2 Dose by Labor Category

DOE occupational exposures are tracked by labor category at each site to facilitate identification of exposure trends, which assist management in prioritizing ALARA activities. Worker occupation codes are reported in accordance with DOE M 231.1-1 and are grouped into major labor categories in this report. The collective TEDE for each labor category for 1995-1997 is shown in *Exhibits 3-16* and *3-17*. Technicians and production staff have the highest collective TEDE for 1997 because they generally handle more radioactive sources than individuals in the other labor categories. Forty-two percent of the technician dose is attributed to radiation protection technicians.

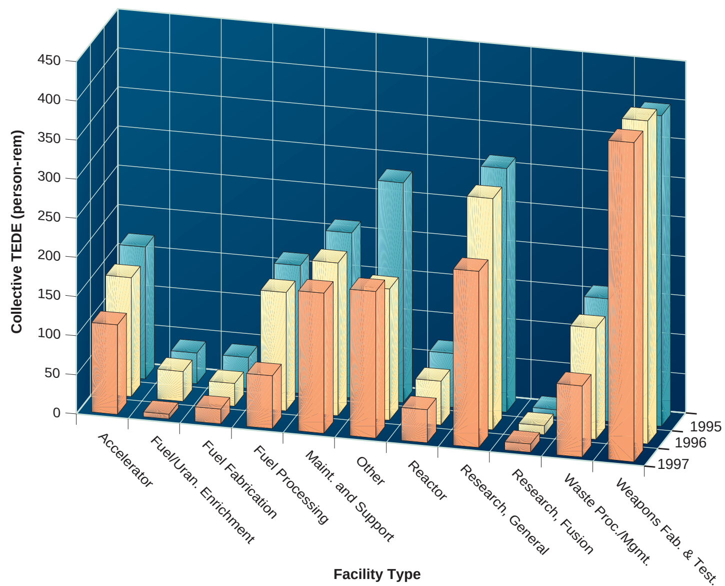
Exhibit 3-17:
Graph of Dose by Labor Category, 1995-1997



The collective TEDE is also high for the "unknown" and "miscellaneous" categories. Sixty-three percent of the dose in the "unknown" category is attributed to LANL. The LANL computer system does not currently maintain the data necessary to report occupation codes in accordance with DOE M 231.1-1. LANL is addressing this issue. Other sites also report large numbers of individuals with an occupation code of "unknown." Typically, these workers are subcontractors or temporary workers. Information concerning these workers tends to be limited.

An examination of internal dose from intake by labor category is presented in Appendix B-20. In addition, Appendix B-21 shows the TEDE distribution by labor category and occupation for 1997.

Exhibit 3-18:
Graph of Dose by Facility Type, 1995-1997



3.4.3 Dose by Facility Type

DOE occupational exposures are tracked by facility type at each site to better understand the nature of exposure trends and to assist management in prioritizing ALARA activities. Contribution of certain facility types to the DOE collective TEDE is shown in *Exhibits 3-18* and *3-19*. The collective dose for each facility type at each Operations/Field Office is shown in Appendix B-8. An examination of internal dose from intake by facility type and nuclide is presented in Appendix B-18.

Exhibit 3-19:
Dose by Facility Type, 1995-1997

Facility Type	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Accelerator	1,718	2,345	2,562	168.5	152.0	114.4	0.098	0.065	0.045
Fuel/Uranium Enrichment	1,915	908	149	39.2	38.3	6.2	0.020	0.042	0.041
Fuel Fabrication	1,055	864	545	39.5	29.0	18.8	0.037	0.034	0.035
Fuel Processing	1,505	1,498	1,261	163.0	151.2	67.4	0.108	**0.101**	0.053
Maintenance and Support	2,820	2,886	2,177	210.9	195.2	180.0	0.075	0.068	0.083
Other	2,510	2,514	2,419	280.9	168.1	187.3	**0.112**	0.067	0.077
Reactor	896	912	729	68.7	56.1	42.3	0.077	0.062	0.058
Research, General	3,269	3,095	2,681	311.1	295.7	226.0	0.095	0.096	0.084
Research, Fusion	134	163	132	9.0	11.4	10.5	0.067	0.070	0.080
Waste Processing/Mgmt.	2,458	2,422	1,609	156.9	142.1	94.5	0.064	0.059	0.059
Weapons Fab. and Testing	**5,333**	**5,118**	**4,411**	**397.0**	**412.8**	**408.7**	0.074	0.081	**0.093**
Totals	**23,613**	**22,725**	**18,675**	**1,844.7**	**1,651.9**	**1,356.1**	**0.078**	**0.073**	**0.073**

Note: Arrowed values indicate the greatest value in each column.
* *1995-1997 TEDE = CEDE + DDE*

The collective TEDE for 1995-1997 was highest at weapons fabrication and testing facilities. Seventy-nine percent of this dose was accrued at Rocky Flats, with 15% from Savannah River. It should be noted that, although weapons fabrication and testing facilities account for the highest collective dose, Rocky Flats and Savannah River account for the majority of this dose and these sites are now primarily involved in nuclear materials stabilization and waste management.

3.4.4 Radiation Protection Occurrence Reports

In addition to the records of individual radiation exposure monitoring required by DOE M 231.1-1 (previously DOE Order 5484.1), sites are required to report certain unusual or off-normal occurrences involving radiation under DOE Order 232.1A (previously DOE Order 5000.3B). These reports are submitted to ORPS in accordance with the reporting criteria of DOE M 232.1-1A. Two of the occurrence categories are directly related to occupational exposure and are required to be reported under Section 9.3 as "Group 4" occurrences. Group 4A reports are *radiation exposure* occurrences, and Group 4B are *personnel contamination* occurrence reports. The occurrence reporting requirements for DOE M 232.1-1A are summarized in *Exhibit 3-20*. These requirements became effective under DOE M 232.1-1 in September 1995, and remained essentially unchanged under DOE M 232.1-1A which became effective in July 1997.

In summary, *radiation exposure* occurrences are reported when individuals are exposed to radiation above anticipated levels. *Personnel contamination* occurrences are reported when personnel or clothing are contaminated above certain thresholds. The number of reports submitted to ORPS is usually indicative of breaches or lapses in radiation protection practices resulting in unanticipated radiation exposure or contamination of personnel or clothing. Increases or decreases in the number of these occurrences may reflect radiation exposures or the effectiveness of DOE radiation protection programs respectively.

It is important to note that reports are submitted to ORPS for an occurrence or event. In some cases, one event could result in the contamination or exposure of multiple individuals. In ORPS, this is counted as one occurrence, even though multiple individuals were exposed. In addition, one occurrence report may involve multiple similar occurrences. For the analysis included in this report, only the number of occurrences is considered.

Exhibit 3-20:
Criteria for Radiation Exposure and Personnel Contamination Occurrence Reporting

Occurrence	Category	DOE M 232.1-1A Criteria
Radiation Exposure	Unusual	Individuals receiving a dose in excess of the occupational exposure limits (See Exhibit 2-1) for on-site exposure or exceeding the limits in DOE 5400.5, Chapter II, Section 1 for off-site exposure to a member of the public.
	Off-Normal	◆ Any single occupational exposure that exceeds an expected exposure by 100 mrem. ◆ Any single unplanned exposure onsite to a minor, student, or member of the public that exceeds 50 mrem. ◆ Any dose that exceeds the limits specified in DOE 5400.5, Chapter II, Section 7 for off-site exposure to a member of the public.
Personnel Contamination	Unusual	◆ Any single occurrence resulting in the contamination of five or more personnel or clothing at a level exceeding the 10 CFR 835 Appendix D values for total contamination limits. ◆ Any occurrence requiring off-site medical assistance for contaminated personnel. ◆ Any measurement of personnel or clothing contamination offsite due to DOE operations.
	Off-Normal	Any measurement of personnel or clothing contamination at a level exceeding the 10 CFR 835 Appendix D total contamination limits.

Exhibit 3-21:
Radiation Exposure Occurrence, 1993-1997

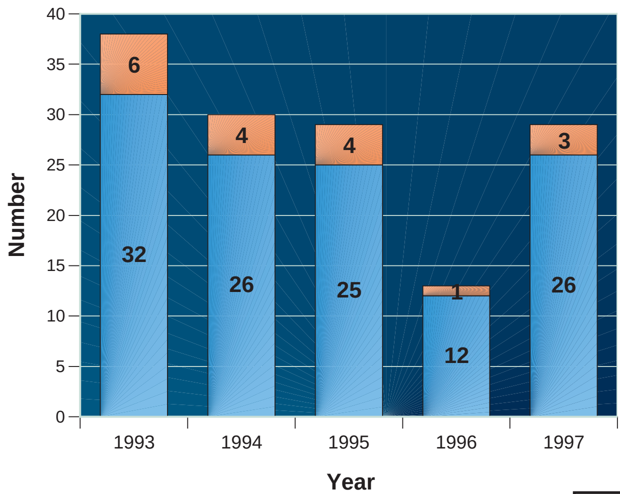
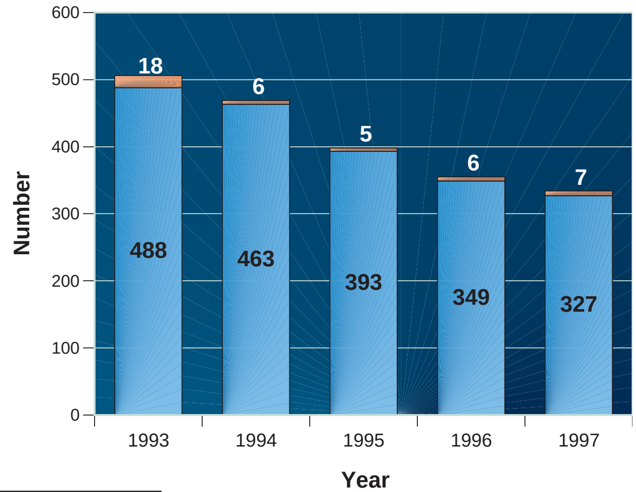
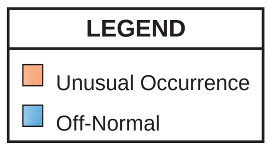


Exhibit 3-22:
Personnel Contamination Occurrence, 1993-1997





The number of occurrences for *radiation exposures* and *personnel contaminations* is presented in *Exhibits 3-21* and *3-22*. The number of *radiation exposure* occurrences has increased by 123% from 1996 to 1997 but is equal to the 1995 level, while the number of *personnel contaminations* has decreased by 6% from 1996 to 1997.

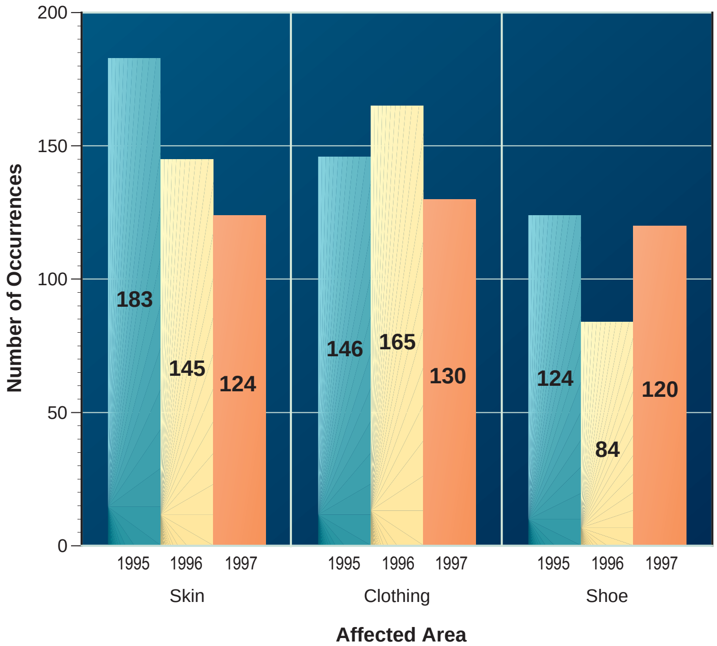
> ***The number of Radiation Exposure occurrences has increased by 123% from 1996 to 1997 but is equal to the 1995 level.***
>
> ***The number of Personnel Contamination occurrences has decreased by 6% from 1996 to 1997.***

Three *radiation exposure* occurrences were classified as unusual events. Only one of three occurred in 1997. The other two occurred in 1995 and 1996 but were discovered and reported in 1997. Several *personnel contamination* occurrences involved multiple persons.

The increase in the number of *radiation exposure* occurrences is primarily due to increases in the number of sites (11) having occurrences in 1997 rather than an increase in reports from any given site. A potential factor in the change in the number of *radiation exposure* occurrences is the change in reporting requirements in 1996. The reporting threshold is generally lower under the new requirements, but for some sites that have low ACLs, it may be higher. The impact of this change in requirements is difficult to determine since ACLs and the implementation date of the new requirements vary from site to site.

For 1997, 26 of the 29 occurrences (90%) shown in *Exhibit 3-21* involved "off-normal" occurrences. Twenty-two of the 26 off-normal occurrences (85%) involved internal dose or potential internal dose, while 4 of the 26 off-normal occurrences (15%) involved external dose. Of the 29 *radiation exposure* occurrences, three were categorized as "unusual" occurrences since the individuals exceeded the DOE occupational dose limit of 5 rem (50 mSv) TEDE. Two of the three exposures occurred in 1995 and 1996. The third occurred in 1997 and is described in Section 3.3.2. Nineteen of the 29 off-normal occurrences were for

Exhibit 3-23:
Personnel Contamination Occurrences by Affected Area, 1995-1997



unanticipated internal doses greater than 100 millirem (1 mSv). Two occurrences were for a contamination event that did not result in internal dose. The four occurrences involving external radiation exposure were for unanticipated doses of greater than 100 millirem (1 mSv) of the planned dose. One of these external exposures was from neutron radiation.

No *radiation exposure* occurrence reports submitted to ORPS from 1995 to 1997 have involved exposures to minors or members of the public.

Personnel contamination occurrences can involve contamination of the skin, clothing, or shoes. *Exhibit 3-23* shows the breakdown of occurrences by affected area from 1995 through 1997. The affected area is not recorded as part of the ORPS report and must be determined by reviewing the text of each report. Some occurrences may involve more than one affected area and therefore may be counted in more than one category. Between 1995 and 1997, contamination occurrences involving the skin continued to decrease. Clothing contaminations increased by 13% from 1995 to 1996, but decreased by 21% from 1996 to 1997. The number of shoe contaminations increased by 43% from 1996 to 1997.

Exhibits 3-24 and *3-25* show the breakdown of occurrences for *radiation exposure* and *personnel contamination* by site for the three-year period 1995 to 1997. Sixty-five percent of the *radiation exposure* occurrences were reported by four sites: Rocky Flats, Hanford, Savannah River, and Oak Ridge. *Personnel contamination* occurrence reports are distributed among the sites, with Hanford and the Oak Ridge sites submitting 42% of the reports.

Exhibit 3-24:
Radiation Exposure Occurrences by Site, 1995-1997

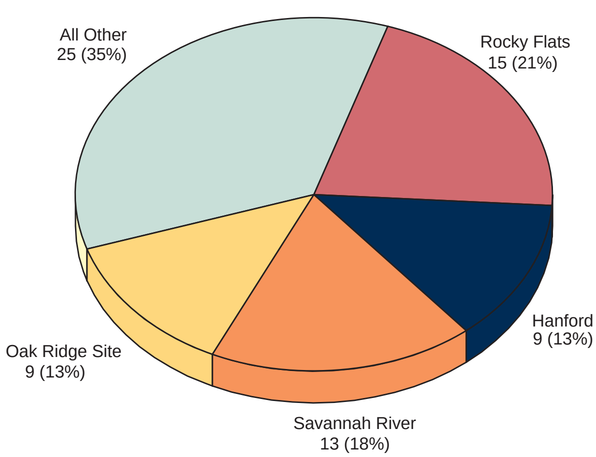
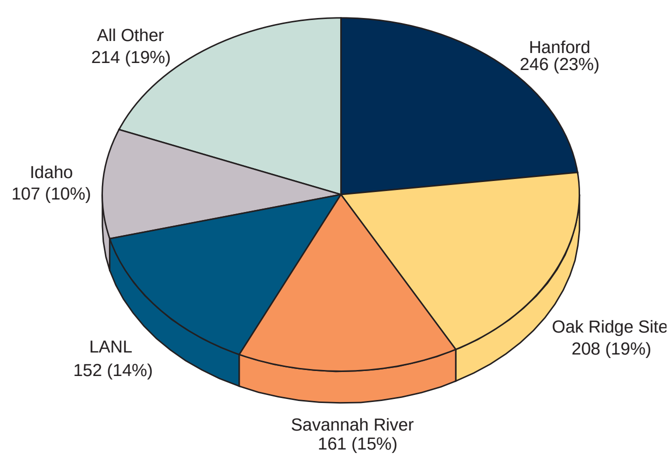


Exhibit 3-25:
Personnel Contamination Occurrences by Site, 1995-1997



Exhibits 3-26 and *3-27* show the breakdown of *radiation exposure* and *personnel contamination* occurrence reports by root cause. For ORPS, the "root cause" is defined as that which, if corrected, would prevent similar occurrences. Only the four significant main root cause categories are considered here. Over the past 3 years, management problems were the identified root cause for 36% of the *radiation exposure* and *personnel contamination* occurrences. The most often-cited management problem is inadequate administrative control. Other management problems in 1997 include inadequate policy definition and dissemination, and work organization/planning deficiencies.

The number of *radiation exposure* and *personnel contamination* occurrences attributed to unknown sources of radiation decreased by 11% from 1996 to 1997, but remains the second largest category contributing to these occurrences. Therefore, attention should be given to these occurrences and actions taken in the field to ensure that previously unidentified sources of exposure and contamination are identified and remediated.

Further information concerning ORPS can be obtained by contacting Eugenia Boyle, of EH-33, or the ORPS web page at:

http://tis.eh.doe.gov/web/oeaf/orps/

Exhibit 3-26:
Radiation Exposure Occurrences by Root Cause, 1995-1997

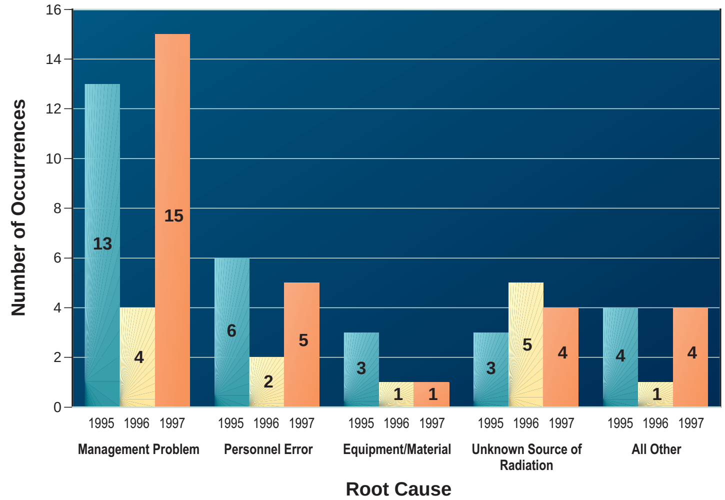
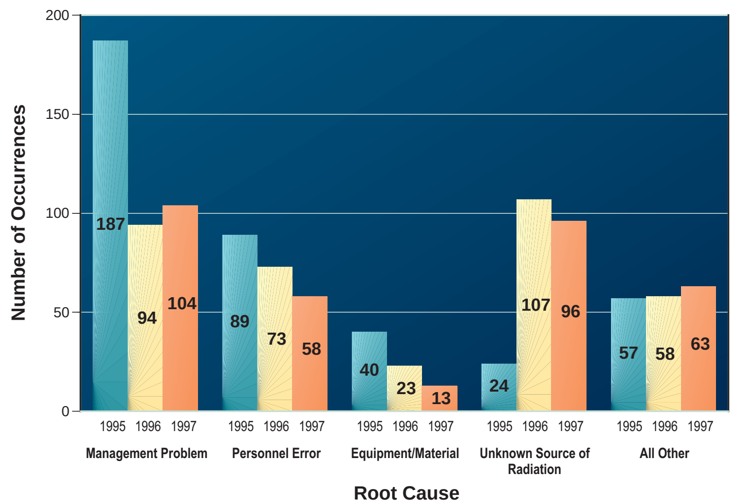


Exhibit 3-27:
Personnel Contamination Occurrences by Root Cause, 1995-1997



3.5 Activities Contributing to Collective Dose in 1997

In an effort to identify the reasons for changes in the collective dose at DOE, several of the larger sites were contacted to provide information on activities that contributed to the collective dose for 1997. These sites (BNL, Hanford, Idaho, LANL, Oak Ridge, Rocky Flats, and Savannah River) were the top seven sites in their contribution to the collective TEDE for 1997 and comprised 87% of the total DOE dose. Five of the seven sites reported decreases in the collective TEDE, which resulted in an 18% decrease in the DOE collective dose in 1997. The seven sites are shown in *Exhibit 3-28*, including a description of activities that contributed to the collective TEDE for 1997.

Exhibit 3-28:
Activities Contributing to Collective TEDE in 1997 for Seven Sites

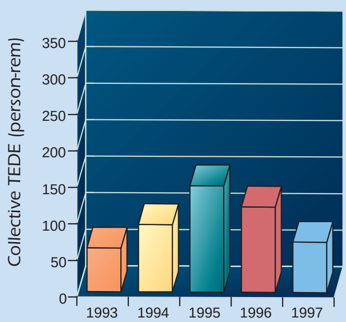
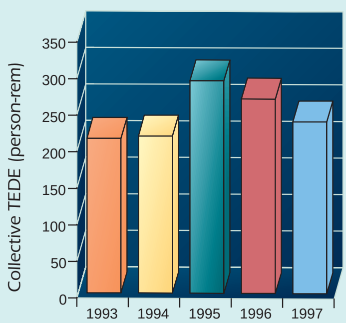
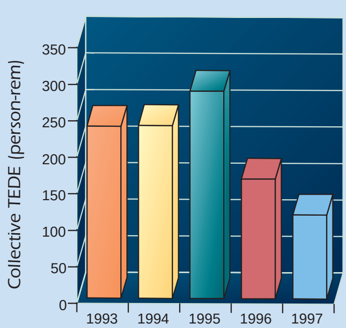
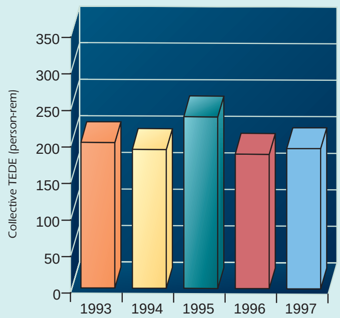
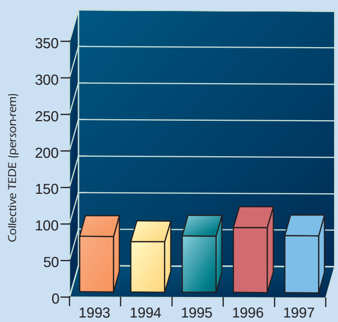
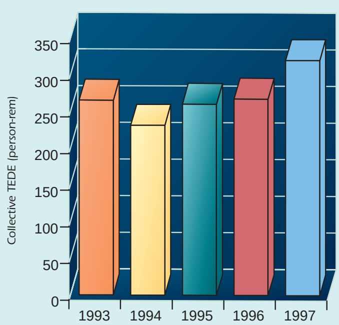
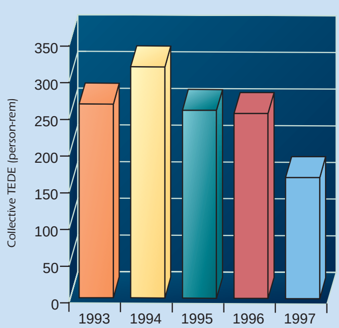
Site	Collective TEDE (person-rem)	% Change from 1996 to 1997	Description of Activities at the Site
Brookhaven National Lab.		-41%▼	During 1997, nearly 65% of the 69 person-rem for BNL was attributed to the Alternating Gradient Synchrotron (AGS). The AGS annual dose summary recorded 45 person-rem for 1997 as compared to the 1996 value of 82 person-rem. This reduction is due in part to fewer beamline component failures and increased operational periods. As a result, less maintenance activities were scheduled, which resulted in a reduction in the number of higher dose tasks. Approximately 10% of the Laboratory's dose was attributed to the Reactor Division. The Division reported a 1997 collective dose of 7.02 person-rem when compared to the 10.57 person-rem received during 1996. Since December 1996, the HFBR has been in long-term shut-down. Project reviews of activities supporting the shut-down (tritium remediation, pool de-watering and fuel shipments) indicated lower individual and collective doses than those tasks completed during 1996.
Hanford		-11%▼	The site collective TEDE decreased by 11% in 1997. No specific operational changes were identified by Hanford that resulted in a significant exposure reduction.
Idaho		-30%▼	The principal reason for the TEDE dose reduction at the INEEL between 1996 and 1997 was a change in overall work scope at the Idaho Nuclear Technology Engineering Center (INTEC) (previously the ICPP). The High Level Liquid Waste Evaporator work was completed in 1996 and two other significant 1996 projects at the INTEC Tank Farm and Calciner were completed during the late summer of 1997. In the latter part of 1997, INTEC moved from the overhaul phase to an operating phase resulting in a reduction in collective dose.

Exhibit 3-28:
Activities Contributing to Collective TEDE in 1997 for Seven Sites (continued)

Site	Collective TEDE (person-rem)	% Change from 1996 to 1997	Description of Activities at the Site
Los Alamos National Lab.		4%▲	The site collective TEDE increased by 4% for 1997. TA-55 continues to be the chief contributor to doses at Los Alamos. Production of Pu-238 heat sources decreased during 1997 because the campaign to supply power for deep-space missions was completed, resulting in lower neutron doses. Total dose increased because of the significant increase in "recovery" activities, that is, the purifying and repackaging of plutonium scrap. This older plutonium is high in americium content, which results in photon dose to workers handling the material.
Oak Ridge Site		-12%▼	The collective dose at the Oak Ridge Site, which includes Y-12, ORNL, and the East Tennessee Technology Park, decreased by 12% in 1997. The 1997 collective TEDE for the LMES Y-12 Plant did not significantly change from 1996 as similar work continued in 1997 in support of plant restart. The 10% decrease in the TEDE and 15% decrease in neutron exposure for ORNL can be attributed to (1) lack of major processing campaigns at the Radiochemical Engineering Development Center during 1997 and (2) work on the Melton Valley Line Item lasted only a few months in 1997. The 33% increase in the collective TEDE from 1.09 person-rem in 1996 to 1.45 person-rem at the East Tennessee Technology Park is due to the Deposit Removal Project in support of site reindustrialization.
Rocky Flats		21%▲	At Rocky Flats, the 1997 collective doses increased by 21% over the 1996 collective doses as follows: TEDE increased by 21%, deep neutron dose increased by 120%, and CEDE dose increased by 30%. These increases were due to product stabilization activities and decontamination and decommissioning (D&D) cleanup at the site. These activities included tank draining of plutonium solutions, plutonium liquid and residue stabilization, brushing operations, plutonium residue repackaging, and, D&D glovebox cleanup. These activities occurred primarily in the plutonium operations areas, which included Buildings 371, 707, 771, 776/777, and 779.
Savannah River		-34%▼	The site collective TEDE decreased by 34% in 1997. This was primarily due to decreases in deep dose by a factor of 2-3 for the two major contributors to dose–nuclear materials stabilization and high-level waste programs. Both experienced reduction in work activities in 1997. High-level waste made fewer waste transfers with subsequently less diversion box work. Nuclear material stabilization was between missions, which meant fewer critical maintenance activities and reduced process sampling. The site also continues to pursue an aggressive ALARA program.

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ALARA Activities at DOE

This section recognizes highly successful ALARA projects and encourages the use of similar innovative ideas at other locations in the DOE complex. In future years, ALARA success stories, such as those described below, will be included in the *DOE Occupational Radiation Exposure Report*. Sites are encouraged to submit material on successful ALARA activities for publication in future annual reports.

4.1 Successful ALARA Projects

The following are descriptions of several successful ALARA projects submitted by Idaho and Hanford concerning projects that reduced radiation exposure.

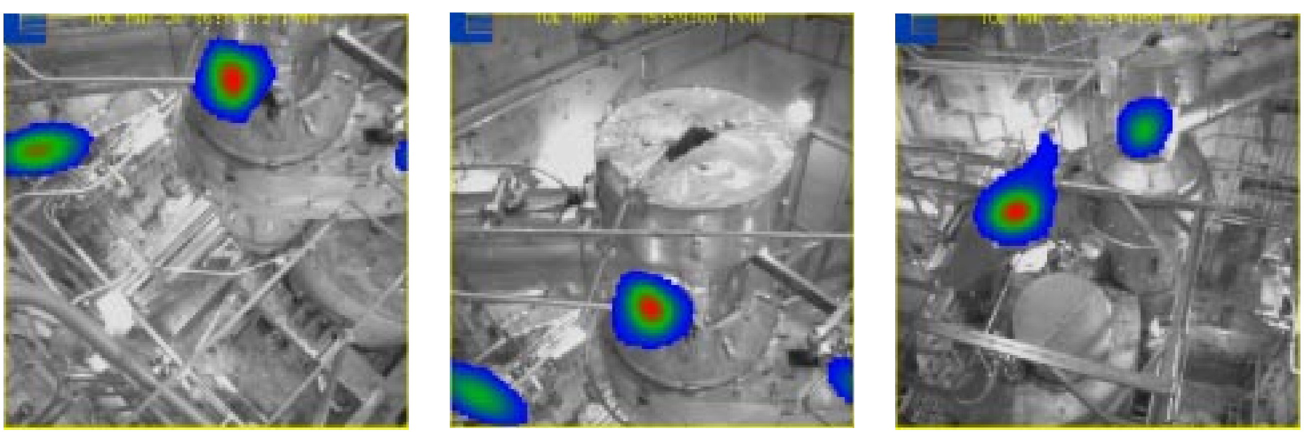
4.2 Rover Project at Idaho

Recently, the ROVER Deactivation Project at the ICPP ended. The ROVER Project required significant planning and employee participation at all levels to maintain radiological exposure ALARA. Since this was a first-time activity for LMITCO, the ICPP ALARA committee was involved at the beginning.

The facility was built to recover highly enriched uranium from an experimental nuclear-powered fuel tested at the Nevada Test Site. Residual uranium, primarily in ash or powder form, created high radiation dose rates (see Exhibit 4-1). Initially, an architectural engineering contractor estimated the job would require about 171 person-rem of exposure. At the request of the DOE, Idaho Operations Office, LMITCO Operations developed a deactivation plan that was much more ambitious. The worker exposure goal was approximately 52 person-rem. This resulted because people doing the work were involved in the planning process, and there was significant input from RadCon personnel and the ALARA committee. Collapsible containment tents were constructed to maintain contamination control and a unique, modified donning and doffing sequence for personnel protective equipment was developed to protect workers. Mock-ups were used, temporary shielding was installed, and dry runs were completed to keep worker dose ALARA. As work progressed, additional radiation dose saving methods were recognized, and even after more than 1,000 entries into high radiation areas, the final worker dose was 37.5 person-rem.

For more information concerning this ALARA project, contact Ken Whitham, Radiological Controls Manager, at (208) 526-4151.

Exhibit 4-1:
"Gammacam" Pictures Showing Areas of High Dose Rate.



Photos Courtesy of ICPP

4.3 Grout Fill Project at the Waste Calcine Facility at Idaho

The ICPP ALARA committee played an important role in another decommissioning project. In conjunction with the Waste Calcine Facility (WCF) Resource Conservations and Recovery Act (RCRA) Closure Plan and in agreement with the State of Idaho, vessels below grade at CPP 633 were to be filled with grout. Four of these vessels in the Off-Gas Cell were left with no grout fill paths due to line blockages, earlier grout placements, and leaking valves. After brainstorming options, the WCF project team concluded the only available course of action would be to cut holes in the vessels to permit grout placement.

Radiation levels were expected to be in excess of 10R/hr and manned entry would have resulted in about 10-15 person-rem exposure. After evaluating all options, remote cutting was determined to be the most viable. In accordance with ALARA procedure, a cost/benefit analysis was completed and it was concluded that using remote systems was cost effective. Remote systems personnel were enlisted to establish a mock-up to determine feasibility for using remote core drilling to create access to the vessels. The team identified the most effective location for a core drill hole to avoid structural members, piping, and other obstructions, yet permitting as much access to the four vessels as possible.

A 10-inch diameter hole was cut through the top of the cell and grout access holes were successfully cut into all four vessels, using remote tools aided by video cameras placed through observation holes. The cutting process took approximately 4 days, with radiation exposure totaling about 10 mrem at a cost of about $25,000 for the entire operation. This was a savings of about 11 person-rem. Additionally, the core-drilled hole provides access to the off-gas cell for disposition of other debris.

For more information concerning this ALARA project, contact Ken Whitham, Radiological Controls Project Manager, at (208) 526-4151.

4.4 Drum Removal at Idaho

Workers were tasked to remove ten 55-gallon drums from RCRA underground storage vaults at the Intermediate Level Transuranic Storage Facility (ILTSF). By removing the drums and placing them in shielded overpacks, the facility saved the expense of performing required inspections and moved the waste above ground. The job entailed grabbing the drum with a lift fixture, lifting it out of the vault, and placing the drum in a shielded overpack. A crane was used to perform the open-air transfers. The exposure rate on the drums varied from 1R/hr to 28R/hr. Because this was a unique, first-time job, dry runs and mock-ups were performed to identify steps in the process that were either major dose contributors or potentially dangerous.

Several different crafts were involved, including mechanics, heavy equipment operators, laborers, instrument technicians, and RCTs. Problems with the drum lift fixture were identified and fixed during the dry runs, and a 20-foot long drum-handling tool was made to steady the drum during the transfer. This tool also allowed the drum handler to work further back, reducing total exposure.

A facility ALARA committee meeting was scheduled where the job was discussed, suggestions offered, and worker dose limits set. The maximum worker dose level was set to 100 mrem and the collective dose set at 400 mrem. Key steps in the operation were discussed, including a lively discussion on the safe operation of the drum-lifting fixture. The ALARA committee approved the work with the recommendation that only those people who had participated in the dry runs could perform the actual drum transfer. The committee also recommended that the work be performed early in the morning to reduce dose to construction workers working on the Transuranic Storage Area - Retrieval Enclosure. As a result of the planning, mock-ups, and dry runs, no worker exceeded 25 mrem and the collective dose was less than half that set by the ALARA committee.

For more information concerning this ALARA project, contact Ken Whitham, Radiological Controls Program Manager, at (208) 526-4151.

4.5 Using Aerosol Generation to Apply a Fixative at Hanford

Work in several valve transfer pits at Hanford results in a spread in contamination downwind each time the pits are opened. These pits are highly contaminated and are located below ground level. Concrete cover blocks are removed to gain access to the work area and all work is accomplished using long handling tools. During work, about half the time was spent decontaminating surfaces to keep the contamination inside the work area. Prior to using temporary containment structures, surveys taken after the job would often reveal that contamination had spread several hundred feet in a downwind direction. In the past, decontamination of this area has taken several days. A review was made of possible contamination control techniques that would eliminate the spread of contamination. An aerosol generator owned by Encapsulation Technologies (see Exhibit 4-2) was tested and no spread of contamination occurred. The generator uses sound waves to shear molecules from a chemical solution forming a fog-like aerosol. This aerosol flows down a hose and enters the pit through a hole in the cover block, which is still in place. Any airborne radioactive particles in the pit are captured and fall to the surface. Surface contamination is covered with a fixative so that it does not spread. The passive aerosol works on all vertical surfaces as well as inside openings and the underside of equipment to completely coat the pit. After a few hours, the aerosol equipment is removed and the cover blocks are removed for work.

Exhibit 4-2:
Aerosol Generator Used to Reduce the Spread of Contamination at Hanford

Photo Courtesy of Hanford

Removable contamination levels prior to applying the aerosol were >1,000,000 dpm/ 100cm^2 and barely detectable after the aerosol was applied. Covering the high levels of loose contamination with the fixative has resulted in significant improvement in the conduct of the work. The time spent in the work area has been reduced by about 50% since work is halted less frequently to decontaminate the work area. As discussed above, work on these highly contaminated pits can now be accomplished without contamination spread. Since the job is completed faster, there is a corresponding savings in dose.

For more information on this project, contact C.E. Upchurch at (509) 373-0074. For more information concerning the encapsulation process, contact Bill Rigby of Encapsulation Technologies at (509) 375-4986.

4.6 Segmenting a Six-Ton Crane in Place Saves Dose at Hanford

The project entailed finding the best way to remotely cut up a 6-ton bridge crane located in a Hot Cell Airlock at Building 324. Removing the crane in segments would save dose compared to leaving it in the air lock and taking it out as one piece later. In addition, high airborne radioactivity levels were suspected to exceed the protection factors of respiratory equipment. Since the background radiation levels in the airlock were >100 mrem/hr, it was necessary to perform this operation using a manipulative arm.

Several techniques were evaluated and it was finally decided to cut the crane with a laser cutting device held by the manipulative arm. Work was started using the laser, but molten metal from the cut caught the plastic sleeving on fire. Work was stopped and it was decided to switch to a skill saw with a metal cutting blade. Work was completed and the sections of crane were placed in burial boxes for waste disposal. Estimated dose savings from segmenting the crane instead of storing it and taking it out in one piece later was about 10 person-rem.

For more information on this project, contact S. Landsman at (509) 372-1290.

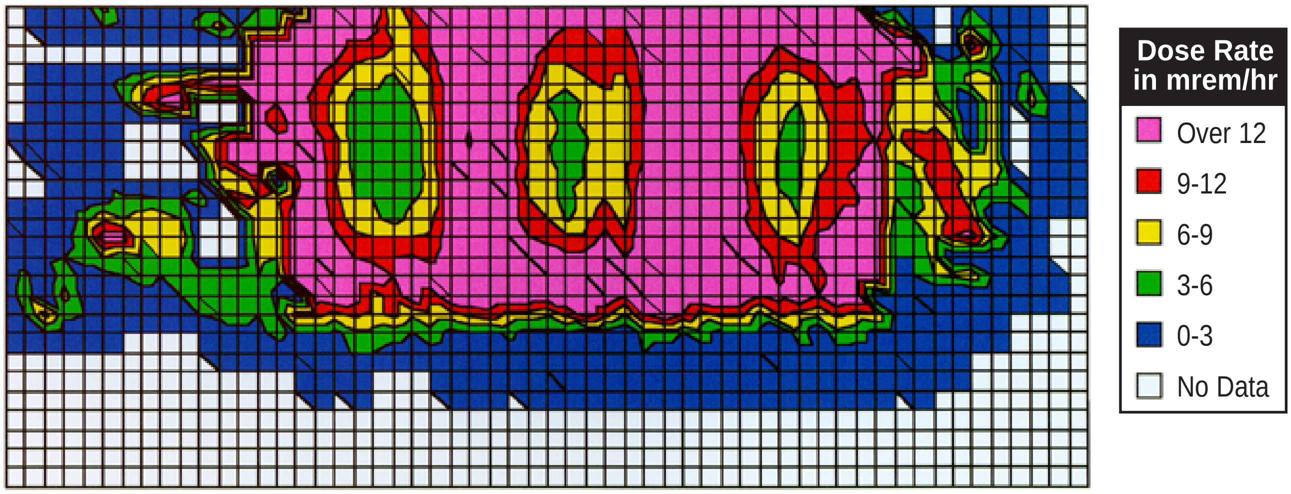
4.7 Area Dose Rate Reduction in Spent Nuclear Fuel Storage Basin at Hanford

ALARA protective measures were needed to reduce general area dose rates in the 105 KE Spent Nuclear Fuel (SNF) Storage Basin. Significant collective dose (800 person-rem) was calculated to be required to complete program work in the Basin due to high general area dose rates (see Exhibit 4-3). Existing general area dose rates clearly indicated that radiation dose was one of the limiting constraints on program execution. It was necessary to reduce general area dose rates to execute anticipated work within planned resource constraints and to maintain radiation dose ALARA.

The SNF project implemented a long-range plan to reduce general area dose rates. This included hydrolasing pipes in the basin, installing perimeter lead plate shielding, cleaning and coating the basin walls so that the water level could be raised to improve shielding, and pipe and valve removal. Since 1994, these actions have reduced average general area dose rates from 9.28 mrem/hr to 2.57 mrem/hr, with a projected savings of 650 person-rem. Future actions project dose rate reductions to 1.5 mrem/hr from general area sources.

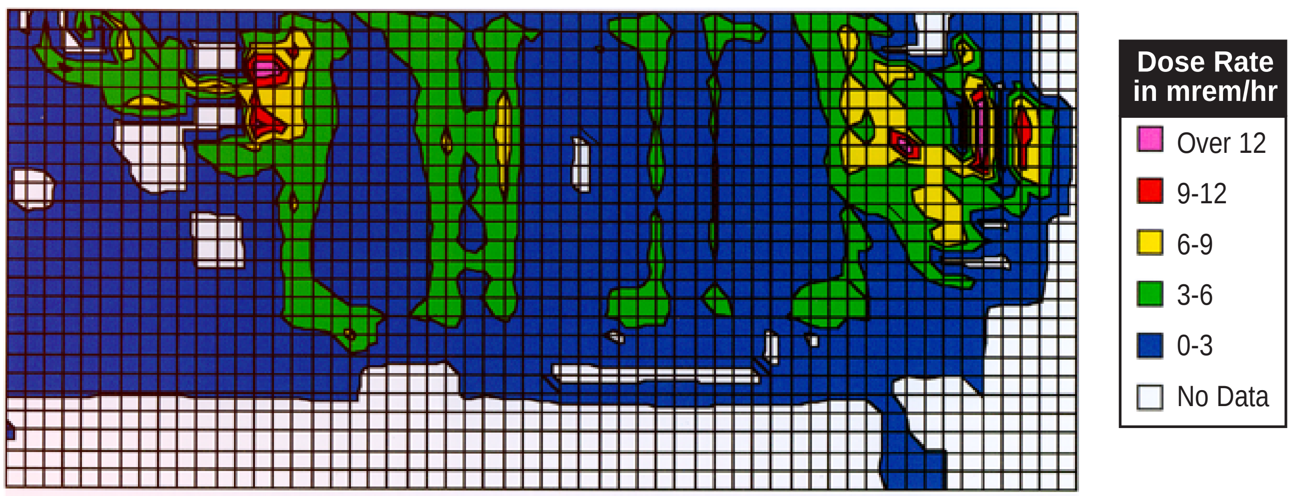
For more information on this project, contact F.W. Moore at (509) 373-4079.

Exhibit 4-3:
Dose Rates Before the Start of Dose Reduction Project.



Chest Average Over Entire Basin: 9.28 mrem/hr
Chest Average Over Basin Pool Only: 13.92 mrem/hr

Dose Rates After the Dose Reduction Project.



Chest Average Over Entire Basin: 2.57 mrem/hr
Chest Average Over Basin Pool Only: 2.86 mrem/hr

4.8 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Worker Protection Programs and Hazards Management. The submittal should describe the process in sufficient detail to provide a basic understanding of the project, the radiological concerns, and the activities initiated to reduce dose.

The submittal should address the following:

- mission statement,
- project description,
- radiological concerns,
- information on how the process implemented ALARA techniques in an innovative or unique manner,
- estimated dose avoided,
- project staff involved,
- approximate cost of the ALARA effort,
- impact on work processes, in person-hours if possible (may be negative or positive), and
- point-of-contact for follow-up by interested professionals.

4.9 Lessons Learned Process Improvement Team

In March 1994, the Deputy Assistant Secretary for Field Management established a DOE Lessons Learned Process Improvement Team (LLPIT). The purpose of the LLPIT is to develop a complex-wide program to standardize and facilitate identification, documentation, sharing, and use of lessons learned from actual operating experiences throughout the DOE complex. This information sharing and utilization is commonly termed "Lessons Learned" within the DOE community. The LLPIT has now transitioned into the DOE Society for Effective Lessons Learned Sharing.

The collected information is currently located on an Internet World Wide Web (Web) site as part of the Environmental Safety & Health (ES&H) Technical Information System (TIS). This system allows for shared access to lessons learned across the DOE complex. The information available on the system complements existing reporting systems presently used within DOE. DOE is taking this approach to enhance those existing systems by providing a method to quickly share information among the field elements. Also, this approach goes beyond the typical occurrence reporting to identify good lessons learned. DOE uses the Web site to openly disseminate such information so that not only DOE but other entities will have a source of information to improve the health and safety aspects of operations at and within their facilities. Additional benefits include enhancing the work place environment and reducing the number of accidents and injuries.

The Web site contains several items that are related to health physics. Items range from off-normal occurrences to procedural and training issues. Documentation of occurrences includes the description of events, root-cause analysis, and corrective measures. Several of the larger sites have systems that are connected through this system. DOE organizations are encouraged to participate in this valuable effort.

The Web site address for DOE Lessons Learned is:

http://www.tis.eh.doe.gov:80/others/ll/ll.html

The specific Web site address may be subject to change. This Web site can always be accessed through the main ES&H TIS Web site at:

http://www.tis.eh.doe.gov

Section Five
Conclusions

5

Conclusions

5.1 Conclusions

The detailed nature of the data available has made it possible to investigate distribution and trends in data and to identify and correlate parameters having an effect on occupational radiation exposure at DOE sites. This also revealed the limitations of available data, and identified additional data needed to correlate more definitively trends in occupational exposure to past and present activities at DOE sites.

The collective dose at DOE facilities has experienced a dramatic (80%) decrease over the past decade. The main reasons for this large decrease were the shutdown of facilities within the weapons complex and the end of the Cold War era, which shifted the DOE mission from weapons production to shutdown, stabilization, and D&D activities. The DOE weapons production sites have continued to contribute the majority of the collective dose over these years. As facilities are shut down and undergo transition from operation to stabilization or D&D, there are significant changes in the opportunities for individuals to be exposed. More modest reductions in collective dose have occurred during the past 5 years at some facilities that have continued to transition to shutdown and stabilization.

The collective TEDE decreased by 18% in 1997 due to decreases in the collective dose at five of the seven highest dose sites. These seven sites accounted for more than 87% of the collective dose at DOE. Reports submitted by four of the five sites that experienced decreases in the collective dose (Savannah River, Idaho, BNL, and Oak Ridge) indicate that these decreases were due to reductions in such activities as materials stabilization, maintenance, and the completion of several key projects.

Statistical analysis reveals that, although the collective dose has decreased by 18%, the mean dose has increased slightly from 1996 to 1997. This finding confirms that the collective dose has decreased primarily due to a reduction in overall work involving radiation exposure rather than reductions in dose to individuals. Statistical analysis has also revealed a decreasing trend in the neutron collective dose, and a statistically significant increase in extremity doses over the past 5 years. The decreasing trend in the mean neutron dose is primarily due to a decrease in neutron dose at LANL since 1993. The neutron dose at LANL is primarily from the production of heat sources for deep-space missions, which was completed in 1997. The increasing trend in extremity dose is due to increases at Rocky Flats, LANL, and Savannah River, which corresponds with increased plutonium recovery activities, cleanup, and repackaging.

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References

1. EPA (U.S. Environmental Protection Agency), 1987. "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," *Federal Register* 52, No. 17, 2822; with corrections published in the *Federal Registers* of Friday, January 30, and Wednesday, February 4, 1987.

2. ICRP (International Commission on Radiological Protection), 1977. "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, Annals of the ICRP, Vol. 1, No. 3 (Pergamon Press, New York).

3. NCRP (National Council on Radiation Protection and Measurements), 1987. "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP 91; superceded by NCRP Report No. 116.

4. DOE (U.S. Department of Energy), December 21, 1998, Order 5480.11, Radiation Protection for Occupational Workers, Change 3, June 17, 1992.

5. DOE 1994. *Radiological Control Manual.* Revision 1, DOE/EH-0256T, Assistant Secretary for Environment, Safety and Health, April.

6. 10CFR Part 835. "Occupational Radiation Protection." Final Rule; DOE *Federal Register*, December 14, 1993.

7. The Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988.

8. 10CFR 820. "Procedural Rules for DOE Nuclear Activities." August 17, 1993.

9. DOE Notice 441.1, "Radiological Protection for DOE Activities," September 29, 1995.

10. DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 24, 1981, Change 7, October 17, 1990.

11. DOE M231.1-1, "Environment, Safety and Health Reporting," September 10, 1995.

12. Munson, L.H. et al., 1988. *Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are As Low As Reasonably Achievable (ALARA)*, PNL-6577, Pacific Northwest Lab.

13. UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), 1982. "Ionizing Radiation Sources and Biological Effects," report to the General Assembly.

14. Rich, B.L. et al., 1988. *Health Physics Manual of Good Practices for Uranium Facilities,* EGG-2530, Idaho National Engineering Lab.

15. Faust, L.G. et al., 1988. *Health Physics Manual of Good Practices for Plutonium Facilities,* EGG-6534, Pacific Northwest Lab, 1988.

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Glossary

ACL

A dose level that is established below the DOE dose limit in order to administratively control exposures. ACLs are multi-tiered, with increasing levels of authority required to approve a higher level of exposure.

ALARA

Acronym for "As Low As Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the workforce and the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process with the objective of attaining doses as far below the applicable limits as is reasonably achievable.

Annual Effective Dose Equivalent (AEDE)

The summation for all tissues and organs of the products of the dose equivalent calculated to be received by each tissue or organ during the specified year from all internal depositions multiplied by the appropriate weighting factor. Annual effective dose equivalent is expressed in units of rem.

Average Measurable Dose

Dose obtained by dividing the collective dose by the number of individuals who received a measurable dose. This is the average most commonly used in this and other reports when examining trends and comparing doses received by workers because it reflects the exclusion of those individuals receiving a less than measurable dose. Average measurable dose is calculated for TEDE, DDE, neutron dose, extremity dose, and other types of doses.

Collective Dose

The sum of the total annual effective dose equivalent or total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person–rem.

Committed Dose Equivalent (CDE) (H_T,50)

The dose equivalent calculated to be received by a tissue or organ over a 50–year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem.

Committed Effective Dose Equivalent (CEDE) (H_E,50)

The sum of the committed dose equivalents to various tissues in the body (H_T,50), each multiplied by the appropriate weighting factor (w_T)—i.e., $H_E,50 = \Sigma w_T H_T,50$. Committed effective dose equivalent is expressed in units of rem.

CR

CR is defined by the United Nations Scientific Committee on the Effects of Atomic Radiation as the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem to the collective dose.

Deep Dose Equivalent (DDE)

The dose equivalent derived from external radiation at a depth of 1 cm in tissue.

Effective Dose Equivalent (H_E)

The summation of the products of the dose equivalent received by specified tissues of the body (H_T) and the appropriate weighting factor (w_T)—i.e., $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem.

Lens of the Eye Dose Equivalent (LDE)

The radiation exposure for the lens of the eye is taken as the external equivalent at a tissue depth of 0.3 cm.

Minimum Detectable Activity (MDA)

The smallest quantity of radioactive material or level of radiation that can be distinguished from background with a specified degree of confidence. Often used synonymously with minimum detection level (MDL) or lower limit of detection (LLD).

Number of individuals with measurable exposure

The subset of all monitored individuals who receive a measurable exposure (greater than limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable exposure. For this reason, the number of individuals with measurable exposure is presented in this report as a more accurate indicator of the exposed workforce.

Occupational exposure

An individual's exposure to ionizing radiation (external and internal) as a result of that individual's work assignment. Occupational exposure does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

Shallow Dose Equivalent (SDE)

The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

Total Effective Dose Equivalent (TEDE)

The sum of the effective dose equivalent for external exposures and the effective dose equivalent for internal exposures. Deep dose equivalent to the whole body is typically used as effective dose equivalent for external exposures. The internal dose component of TEDE changed from the Annual Effective Dose Equivalent (AEDE) to the Committed Effective Dose Equivalent (CEDE) in 1993.

Total monitored individuals

All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, and visitors.

DOE Reporting Sites and Reporting Codes

Appendix A

A.1 Labor Categories and Occupation Codes

The following is a list of the Occupation Codes that are reported with each individual's dose record to the DOE Radiation Exposure Monitoring System (REMS) in accordance with DOE Manual 231.1-1 [11]. Occupation Codes are grouped into Labor Categories for the purposes of analysis and summary in this report.

Exhibit A-1.
Labor Categories and Occupation Codes.

Labor Category	Occupation Code (5484.1)	Occupation Name
Agriculture	0562	Groundskeepers
	0570	Forest Workers
	0580	Misc. Agriculture
Construction	0610	Mechanics/Repairers
	0641	Masons
	0642	Carpenters
	0643	Electricians
	0644	Painters
	0645	Pipe Fitter
	0650	Miners/Drillers
	0660	Misc. Repair/Construction
Laborers	0850	Handlers/Laborers/Helpers
Management	0110	Manager - Administrator
	0400	Sales
	0450	Admin. Support and Clerical
Misc.	0910	Military
	0990	Miscellaneous
Production	0681	Machinists
	0682	Sheet Metal Workers
	0690	Operators, Plant/ System/Utility
	0710	Machine Setup/Operators
	0771	Welders and Solderers
	0780	Misc. Precision/Production
Scientists	0160	Engineer
	0170	Scientist
	0184	Health Physicist
	0200	Misc. Professional
	0260	Doctors and Nurses
Service	0512	Firefighters
	0513	Security Guards
	0521	Food Service Employees
	0524	Janitors
	0525	Misc. Service
Technicians	0350	Technicians
	0360	Health Technicians
	0370	Engineering Technicians
	0380	Science Technicians
	0383	Radiation Monitors/Techs.
	0390	Misc. Technicians
Transport	0820	Truck Drivers
	0821	Bus Drivers
	0825	Pilots
	0830	Equipment Operators
	0840	Misc. Transport
Unknown	0001	Unknown

A.2 Organizations Reporting to DOE REMS, 1993-1997

The following is a listing of all organizations reporting to the DOE REMS from 1993 to 1997. The Operations Office and Site groupings used in this report are shown in addition to the organization reporting code and name.

Exhibit A-2.
Organizations Reporting to DOE REMS, 1993-1997.

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'93	'94	'95	'96	'97
Albuquerque	Ops. and Other Facilities	0501001	Albuquerque Field Office	●	●	●	●	●
		0501006	Albuquerque Office Subs.			●	●	
		0502009	Albuquerque Transportation Division	●	●	●	●	●
		0530001	Kansas City Area Office	●		●	●	●
		0531002	Allied-Signal, Inc.	●	●	●	●	●
		0553002	Martin Marietta Specialty Components Inc.	●	●	●	●	●
		0590001	WIPP Project Integration Office	●	●	●	●	●
		0593001	Carlsbad Area Office					●
		0593004	Carlsbad Area Miscellaneous Contractors	●	●	●	●	●
		2806003	National Renewable Energy Lab (NREL)-GO		●	●	●	●
	Los Alamos National Lab. (LANL)	0540001	Los Alamos Area Office	●	●	●	●	●
		0544003	Los Alamos National Laboratory	●	●	●	●	●
		0544809	Protection Technologies Los Alamos	●	●	●	●	●
		0544904	Johnson Controls, Inc.	●	●	●	●	●
	Pantex Plant (PP)	0510001	Amarillo Area Office	●	●	●	●	●
		0514004	Battelle - Pantex	●	●	●	●	●
		0515002	Mason & Hanger - Amarillo	●	●	●	●	●
		0515006	M&H - Amarillo - Subcontractors	●	●			
		0515009	M&H - Amarillo - Security Forces	●	●	●		
	Sandia National Lab. (SNL)	0570001	Kirtland Area Office	●	●	●	●	●
		0575003	Inhalation Toxicology Research	●	●	●	●	
		0577004	Ross Aviation, Inc.	●	●	●		
		0578003	Sandia National Laboratory	●	●	●	●	●
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0580001	UMTRA Project Office	●				
		0582004	MK-Ferguson Subs - UMTRA	●	●	●	●	●
		0582005	MK-Ferguson Co. - UMTRA	●	●	●	●	●
		0583004	Jacobs-Weston Team	●				
Chicago	Ops. and Other Facilities	1000503	Ames Laboratory (Iowa State)	●	●	●	●	●
		1000903	Battelle Memorial Institute-Columbus (Old)	●	●	●	●	●
		1001501	Chicago Field Office	●	●	●	●	●
		1001606	Chicago Office Subs	●	●	●		
		1002001	Environmental Meas. Lab.	●	●	●	●	●
		1004031	New Brunswick Laboratory	●	●	●	●	●
		1005003	Princeton Plasma Physics Laboratory	●	●	●	●	●
		1006003	National Renewable Energy Lab (NREL)-CH	●				
	Argonne Nat'l Lab.-East (ANL-E)	1000703	Argonne National Laboratory - East	●	●	●	●	●
	Argonne Nat'l Lab.-West (ANL-W)	1000713	Argonne National Laboratory - West	●	●	●	●	●
	Brookhaven Nat'l Lab. (BNL)	1001003	Brookhaven National Laboratory	●	●	●	●	●
	Fermi Nat'l. Accelerator Lab.(FERMI)	1002503	Fermilab	●	●	●	●	●
DOE HQ	DOE Headquarters	1504001	DOE Headquarters	●	●	●	●	●
		1504506	DOE Office Subs	●	●			
	N. Korea Project	8009001	DOE North Korea Project				●	●
		8009104	CenTech 21 - North Korea				●	●
		8009204	Nuclear Assurance Corp. (NAC)				●	●
		8009304	Pacific Northwest Lab. - Korea				●	●
		8009401	U.S. Dept. of State - North Korea				●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1993-1997 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'93	'94	'95	'96	'97
Idaho	Idaho Site	3000209	Protection Technology - INEL	●	●			
		3000504	Chem-Nuclear Geotech	●	●	●	●	
		3003003	EG&G Idaho, Inc.	●	●			
		3003402	Babcock & Wilcox Idaho, Inc.	●	●		●	●
		3003502	Westinghouse Idaho Nuclear Co.	●	●			
		3004001	Idaho Field Office	●	●	●	●	●
		3004004	Idaho Office Subs	●	●	●	●	●
		3005004	Lockheed Martin Idaho Tech. Co.-Services			●	●	●
		3005005	Lockheed Martin Idaho Tech. Co.-Construction				●	●
		3005016	LMITCO Subcontractors - Construction					●
		3005024	LMITCO Subcontractor - Coleman					●
		3005034	LMITCO Subcontractor - Parsons					●
		3005505	MK-Ferguson Company - ID	●	●			●
		3005506	MK-Ferguson Subcontractors - ID	●	●			
Nevada	Nevada Test Site (NTS)	3500000	Nevada Operations					●
		3501405	Bechtel Nevada - NTS					●
		3501416	Bechtel Nevada - NTS Subcontractors					●
		3502004	Computer Sciences Corporation					●
		3502504	EG&G Kirtland		●			●
		3502804	EG&G Special Technologies Laboratories	●	●	●	●	●
		3502904	EG&G Washington D.C.	●	●	●		
		3503004	EG&G Las Vegas	●	●	●	●	
		3503504	EG&G Los Alamos	●	●	●		
		3504504	EG&G Santa Barbara	●	●	●	●	●
		3506004	Raytheon Services - Nevada	●	●	●	●	
		3506024	Raytheon Services Subcontractors	●	●	●	●	
		3507501	Nevada Field Office	●	●	●	●	●
		3507514	Nevada Miscellaneous Contractors	●	●	●	●	●
		3507531	Defense Nuclear Agency - Kirtland AFB	●	●	●	●	●
		3507551	Environmental Protection Agency (NERC)	●	●	●	●	●
		3508004	Nye County Sheriff					●
		3508504	Reynolds Elec. & Engr. Co. Services	●	●	●	●	●
		3508505	Reynolds Elec. & Engr. Co. - NTS	●	●	●	●	●
		3508703	Science Applications Int'l. Corp.-NV	●	●	●	●	●
		3509009	Wackenhut Services, Inc. - NV	●	●	●	●	●
		3509504	Westinghouse Electric Corp. - NV	●				
Oak Ridge	Ops. and Other Facilities	4001117	Jacobs Environmental Restoration Team			●	●	●
		4004203	Oak Ridge Inst. for Science & Educ. (ORISE)	●	●	●	●	●
		4004501	Oak Ridge Field Office			●	●	●
		4004704	Bechtel National, Inc. - (FUSRAP)	●	●	●	●	●
		4005002	RMI Company	●	●	●	●	●
		4009006	Morrison-Knudsen (WSSRAP)	●	●	●	●	●
		4009503	Thomas Jefferson National Accel. Facility		●	●	●	●
	Oak Ridge Site	4005105	Lockheed Martin/MK-Ferguson Co.	●	●	●	●	
		4005505	Rust Engineering Company					●
		4006002	Lockheed Martin Energy Systems (K-25)	●	●	●	●	●
		4006503	Lockheed Martin Energy Systems (ORNL)	●	●	●	●	●
		4008002	Lockheed Martin Energy Systems (Y-12)	●	●	●	●	●
	Paducah Gas. Diff. Plant (PGDP)	4007002	Martin Marietta (Paducah)	●	●	●	●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1993-1997 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported**** '93	'94	'95	'96	'97
Oak Ridge	Portsmouth Gaseous Diff. Plant (PORTS)	4002501	LMES Portsmouth					●
		4002502	Martin Marietta (Portsmouth)	●	●	●	●	
		4002504	M.M. Portsmouth Subcontractors	●	●	●		
		4002506	M.M. Portsmouth Subcontractors	●	●	●		
Oakland	Ops. and Other Facilities	8001003	Rockwell International, Rocketdyne - ETEC	●	●	●	●	●
		8006103	U. of Cal./Davis, Radiobiology Lab. - LEHR	●	●	●	●	●
		8006303	U. of Cal./SF - Lab of Radiobiology	●	●	●	●	
		8007001	Oakland Field Office	●				
	Lawrence Berkeley Lab. (LBL)	8003003	Lawrence Berkeley Laboratory	●	●	●	●	●
	Lawrence Livermore Nat'l. Lab. (LLNL)	8004003	Lawrence Livermore National Laboratory	●	●	●	●	●
		8004004	LLNL Subcontractors	●	●	●		●
		8004009	LLNL Security	●	●	●	●	●
		8004024	LLNL Plant Services	●	●	●	●	●
		8005003	Lawrence Livermore Nat'l Lab. - Nevada	●	●	●		
	Stanford Linear Acc. Center (SLAC)	8008003	Stanford Linear Accelerator Center	●	●	●	●	●
Ohio	Ops. and Other Facilities	4500001	Ohio Field Office		●	●	●	●
		4510001	Miamisburg Area Office		●	●	●	●
		4510006	Miamisburg Office Subs				●	●
		4517003	Battelle Memorial Institute - Columbus				●	
	Fernald Environmental*	4521001	Fernald Area Office		●	●	●	●
		4521004	Fernald Office Service Subcontractors		●	●		●
		4523702	Fernald Envir. Rest. Mgmt. Corp (FERMCO)		●	●	●	●
		4523706	FERMCO Subcontractors			●	●	●
		2503702	Fernald Envir. Rest. Mgmt. Corp.	●				
	Mound Plant**	0520001	Dayton Area Office	●				
		0526002	EG&G Mound Applied Technologies	●				
		4516002	EG&G Mound Applied Technologies		●	●	●	●
		4516004	EG&G Mound Subcontractors		●	●	●	●
		4516009	EG&G Mound Security Forces		●	●	●	●
	West Valley Project***	3009004	West Valley Nuclear Services, Inc.	●				
		4530001	West Valley Area Office				●	
		4539004	West Valley Nuclear Services, Inc.		●	●	●	●
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	7700001	Rocky Flats Office	●	●	●	●	●
		7700006	Rocky Flats Office Subs	●	●			
		7700007	Rocky Flats Office Subs	●	●	●	●	●
		7707002	Rocky Flats Prime Contractors	●	●	●	●	●
		7707004	Rocky Flats Subcontractors	●	●	●	●	●
		7707005	J.A. Jones – Rocky Flats	●	●			
		7707006	EG&G Rocky Flats Subcontractors	●	●			
		7707009	EG&G Rocky Flats Security Forces		●			
		7709009	Wackenhut Services – Rocky Flats	●	●			
		7711004	Kaiser-Hill RFETS			●		
Richland	Hanford Site	7500503	Battelle Memorial Institute (PNL)	●	●	●	●	●
		7500705	Bechtel Power Co.		●	●	●	●
		7501004	Boeing Computer Services				●	
		7502504	Hanford Environmental Health Foundation	●	●	●	●	●
		7503005	Kaiser Engineers Hanford - Cost Const.	●	●	●	●	●
		7505004	Fluor Daniel - Hanford				●	●
		7505005	Fluor Daniel Northwest				●	●
		7505006	Fluor Daniel Northwest Services				●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1993-1997 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported****				
				'93	'94	'95	'96	'97
Richland	Hanford Site	7505012	Babcock Wilcox Hanford				●	●
		7505013	Babcock Wilcox Protection, Inc.				●	●
		7505024	Rust Services Hanford				●	●
		7505025	Rust Federal Services Northwest				●	●
		7505034	Duke Engineering Services Hanford				●	●
		7505035	Duke Engineering & Services Northwest, Inc.				●	●
		7505044	NUMATEC Hanford				●	●
		7505054	Lockheed Martin Hanford				●	●
		7505055	Lockheed Martin Services, Inc.				●	●
		7505064	Dyncorp Hanford				●	●
		7505075	SGN Eurisys Services Corp.				●	●
		7506001	Richland Field Office	●	●	●	●	●
		7508805	US Corps of Engineers - RL	●	●	●		
		7509004	Westinghouse Hanford Services	●	●	●	●	●
		7509104	Westinghouse Hanford Service Subs	●	●	●	●	●
Savannah River	Savannah River Site (SRS)	8500204	American Telephone & Telegraph	●				
		8500505	Bechtel Construction - SR	●	●	●	●	●
		8501002	Westinghouse Savannah River Co.	●	●	●	●	●
		8501004	Service America	●	●	●	●	
		8501014	Westinghouse S.R. Subcontractors	●	●	●	●	●
		8501024	Diversco	●	●	●	●	
		8501034	Industrial Phases - SR	●				
		8503001	S.R. Army Corps of Engineers	●	●	●	●	●
		8505001	S.R. Forest Station	●	●	●	●	
		8505501	Savannah River Field Office	●	●	●	●	●
		8507004	Miscellaneous DOE Contractors-SR	●	●	●	●	●
		8507504	Southern Bell Tel. & Tel.	●	●	●	●	●
		8509003	Univ. of Georgia Ecology Laboratories	●	●	●	●	●
		8509509	Wackenhut Services, Inc. - SR	●	●	●	●	●
			Not included in this report (see Appendix D)					
Pittsburgh Naval Reactor Office	Pittsburgh Naval Reactor Office	6007001	Pittsburgh N.R. Office					
		6007504	Westinghouse Plant Apparatus Division					
		6008003	Westinghouse Electric (BAPL)					
		6009003	Westinghouse Electric (NRF)					
Schenectady Naval Reactor Office	Schenectady Naval Reactor Office	6009014	Newport News Reactor Services					
		9004003	LM-KAPL - Kesselring					
		9004005	Gen. Dynam. - Kesselring - Electric Boat					
		9005003	LM-KAPL - Knolls					
		9005004	LM-KAPL - Knolls Subs					
		9007003	LM-KAPL - Windsor					
		9007005	LM-KAPL - Windsor - Electric Boat					
		9009001	Schenectady N.R. Office					

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
**** Those organizations no longer reporting radiation exposure information have either ceased operations requiring the monitoring and reporting of radiation records, are no longer under contract or subcontract at the DOE facility, or have changed organization codes or the name of the organization.

A.3 Facility Type Codes

The following is the list of facility type codes reported to REMS in accordance with DOE Manual 231.1-1 [11]. A facility type code is reported with each individual's dose record indicating the facility type where the majority of the individual's dose was accrued during the monitoring year.

Exhibit A-3.
Facility Type Codes.

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

See complete Facility Type descriptions shown in Appendix C.

A.4 Phase of Operation

In addition to the Facility Type listing that has been reported in the past, the DOE Office of Environment, Safety and Health is interested in obtaining information on the operational status of these facilities. This information will be codified in terms of a Phase of Operation to describe the operating status of a facility. The listing that follows covers each of the phases of operation from construction to the final stage of surveillance and maintenance once a site has undergone environmental restoration.

The phase of operation will be recorded for the calendar year for which the phase of operation is most appropriate. For facilities that transition between phases during a year, the phase that is appropriate for the majority of the calendar year should be recorded. The Phase of Operation will be recorded and submitted along with the Facility Type as part of the monitored individual's dose record. Reporting format and specifications will be included in subsequent revisions to DOE M231.1-1 [11].

Each DOE facility falls into one of the Phase of Operations shown in *Exhibit A-4*. In general, each phase follows in sequential order, although a facility may forgo one or more phases or may not follow the order listed here.

This is the proposed table for the phases of operation of DOE facilities. Please submit comments, additions, or revisions to this table, to EH-52 (see Appendix E for address). If end users feel this additional supporting information will be useful to them, then DOE M231.1-1 [11] will be so modified.

Exhibit A-4.
Phase of Operation - Lifecycle for a DOE Facility.

Code	Phase of Operation	Definition
A	Construction (includes Major Renovation)	New facilities that are brought on line to replace or augment existing facilities. This phase includes major renovations for existing facilities but does not include environmental restoration construction.
B	Operation/ Maintenance	Includes the normal, mission-related operations and maintenance of the reported Facility Type.
C	Stabilization	Facilities that have been declared to be surplus (assigned to the environment restoration program). This includes facilities where all operations have been suspended but environmental restoration activities have not begun. This may include periods of surveillance and maintenance prior to environmental restoration activities.
D	Remediation	Period during which corrective actions that are necessary to bring the facility into regulatory compliance are being performed.
E	Decontamination and Decommissioning	Decontamination is the act of removing a chemical, biological, or radiologic contaminant from, or neutralizing its potential effect on, a person, object or environment by washing, chemical action, mechanical cleaning, or other techniques. Decommissioning is the process of closing and securing a facility.
F	Waste Management	This phase includes the management of wastes generated during the environment restoration process. (D,E)
G	Surveillance and Maintenance	This phase includes those activities that provide for the safety and protection of a facility after the environmental restoration phase.
Z	Other	All DOE facilities should fit into one of the above categories. "Other" should be used only in highly unusual circumstance.

These phases comprise Environmental Restoration

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Appendix B

Additional Data

B-1a: Operations Office/Site Dose Data (1995)

Operations/ Field Office	Site	1995 Collective TEDE (person-rem)	Percent Change from 1994	Number with Meas. Dose	Percent Change from 1994	Avg. Meas. TEDE (rem)	Percent Change from 1994	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1994
Albuquerque	Ops. and Other Facilities	1.6	**300%** ▲	40	54% ▲	0.040	**150%** ▲	0%	-
	Los Alamos Nat'l. Lab. (LANL)	234.9	24% ▲	2,583	6% ▲	0.091	17% ▲	49%	10% ▲
	Pantex Plant (PP)	36.9	27% ▲	329	-5% ▼	0.112	33% ▲	24%	62% ▲
	Sandia Nat'l. Lab. (SNL)	11.1	-8% ▼	343	37% ▲	0.032	-33% ▼	0%	-100% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project	1.3	-91% ▼	58	-85% ▼	0.022	-43% ▼	0%	-
Chicago	Ops. and Other Facilities	6.5	-21% ▼	135	-42% ▼	0.048	35% ▲	0%	-100% ▼
	Argonne Nat'l. Lab. - East (ANL-E)	37.2	-8% ▼	297	6% ▲	0.125	-13% ▼	36%	-24% ▼
	Argonne Nat'l. Lab. - West (ANL-W)	37.6	43% ▲	335	-2% ▼	0.112	46% ▲	10%	-5% ▼
	Brookhaven Nat'l. Lab. (BNL)	145.8	58% ▲	973	12% ▲	0.150	40% ▲	33%	15% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	13.4	-6% ▼	473	-10% ▼	0.028	5% ▲	0%	-
DOE HQ	DOE Headquarters (includes DNFSB)	0.1	-96% ▼	8	-81% ▼	0.012	-81% ▼	0%	-
Idaho	Idaho Site	284.0	20% ▲	1,501	-10% ▼	**0.189**	32% ▲	**62%**	49% ▲
Nevada	Nevada Test Site (NTS)	0.5	-77% ▼	9	-55% ▼	0.051	-48% ▼	0%	-
Oakland	Ops. and Other Facilities	1.3	60% ▲	20	0%	0.064	53% ▲	0%	-
	Lawrence Berkeley Lab. (LBL)	4.5	-21% ▼	76	-17% ▼	0.059	-5% ▼	17%	89% ▲
	Lawrence Livermore Nat'l. Lab. (LLNL)	13.0	-31% ▼	159	9% ▲	0.082	-37% ▼	14%	-71% ▼
	Stanford Linear Accelerator Center (SLAC)	20.2	24% ▲	236	8% ▲	0.086	16% ▲	10%	-2% ▼
Oak Ridge	Ops. and Other Facilities	6.2	-9% ▼	167	-35% ▼	0.037	37% ▲	0%	-
	Oak Ridge Site	76.9	11% ▲	1,804	12% ▲	0.043	0%	16%	135% ▲
	Paducah Gaseous Diff. Plant (PGDP)	9.0	33% ▲	225	49% ▲	0.040	-11% ▼	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	27.5	-9% ▼	1,623	94% ▲	0.017	-53% ▼	4%	4% ▲
Ohio	Ops. and Other Facilities	0.0	0%	5	**150%** ▲	0.007	-70% ▼	0%	-
	Fernald Environmental Mgmt. Project	30.4	26% ▲	955	3% ▲	0.032	23% ▲	0%	-
	Mound Plant	6.4	-30% ▼	175	-41% ▼	0.036	21% ▲	9%	45% ▲
	West Valley Project	26.9	11% ▲	311	7% ▲	0.087	4% ▲	14%	-28% ▼
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	265.3	14% ▲	3,427	-6% ▼	0.077	22% ▲	12%	**303%** ▲
Richland	Hanford Site	**290.7**	35% ▲	2,500	-21% ▼	0.116	71% ▲	34%	62% ▲
Savannah River	Savannah River Site (SRS)	255.5	-19% ▼	**4,846**	-23% ▼	0.053	5% ▲	13%	-40% ▼
Totals		**1,844.7**	**12%** ▲	**23,613**	**-7%** ▼	**0.078**	**20%** ▲	**30%**	**30%** ▲

Note: Boxed values indicate the greatest value in each column.

B-1b: Operations Office/Site Dose Data (1996)

		1996							
Operations/ Field Office	**Site**	Collective TEDE (person-rem)	Percent Change from 1995	Number with Meas. Dose	Percent Change from 1995	Avg. Meas. TEDE (rem)	Percent Change from 1995	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1995
Albuquerque	Ops. and Other Facilities	3.6	126% ▲	37	-8% ▼	0.098	144% ▲	28%	-
	Los Alamos Nat'l. Lab. (LANL)	184.1	-22% ▼	1,984	-23% ▼	0.093	2% ▲	44%	-10% ▼
	Pantex Plant (PP)	28.1	-24% ▼	327	-1% ▼	0.086	-23% ▼	13%	-45% ▼
	Sandia Nat'l. Lab. (SNL)	16.7	51% ▲	485	41% ▲	0.034	7% ▲	25%	-
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0.4	-67% ▼	26	-55% ▼	0.016	-27% ▼	0%	-
Chicago	Ops. and Other Facilities	13.5	106% ▲	182	35% ▲	0.074	53% ▲	4%	-
	Argonne Nat'l. Lab. - East (ANL-E)	18.5	-50% ▼	202	-32% ▼	0.092	-27% ▼	31%	-14% ▼
	Argonne Nat'l. Lab. - West (ANL-W)	43.6	16% ▲	331	-1% ▼	0.132	17% ▲	18%	70% ▲
	Brookhaven Nat'l. Lab. (BNL)	116.8	-20% ▼	1,448	49% ▲	0.081	-46% ▼	40%	20% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	16.2	21% ▲	538	14% ▲	0.030	6% ▲	4%	-
DOE HQ	DOE Headquarters (includes DNFSB)	0.3	180% ▲	6	-25% ▼	0.044	**273%** ▲	0%	-
	North Korea Project	13.3	-	36	-	**0.370**	-	**78%**	-
Idaho	Idaho Site	164.1	-42% ▼	1,299	-13% ▼	0.126	-33% ▼	52%	-17% ▼
Nevada	Nevada Test Site (NTS)	1.0	120% ▲	19	111% ▲	0.054	4% ▲	0%	-
Oakland	Ops. and Other Facilities	0.0	-99% ▼	6	-70% ▼	0.003	-95% ▼	0%	-
	Lawrence Berkeley Lab. (LBL)	4.6	3% ▲	100	32% ▲	0.046	-21% ▼	0%	-100% ▼
	Lawrence Livermore Nat'l. Lab. (LLNL)	14.9	15% ▲	187	18% ▲	0.080	-2% ▼	24%	76% ▲
	Stanford Linear Accelerator Center (SLAC)	19.3	-4% ▼	312	32% ▲	0.062	-28% ▼	3%	-66% ▼
Oak Ridge	Ops. and Other Facilities	11.9	93% ▲	200	20% ▲	0.060	61% ▲	33%	-
	Oak Ridge Site	88.6	15% ▲	1,582	-12% ▼	0.056	31% ▲	21%	30% ▲
	Paducah Gaseous Diff. Plant (PGDP)	18.6	106% ▲	290	29% ▲	0.064	60% ▲	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	29.9	9% ▲	758	-53% ▼	0.039	133% ▲	12%	191% ▲
Ohio	Ops. and Other Facilities	0.0	0%	5	0%	0.007	0%	0%	-
	Fernald Environmental Mgmt. Project	27.4	-10% ▼	804	-16% ▼	0.034	7% ▲	6%	-
	Mound Plant	20.1	**216%** ▲	403	**130%** ▲	0.050	37% ▲	41%	**372%** ▲
	West Valley Project	11.2	-59% ▼	231	-26% ▼	0.048	-44% ▼	6%	-61% ▼
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**267.6**	3% ▲	3,430	0%	0.078	3% ▲	8%	-22% ▼
Richland	Hanford Site	265.7	-9% ▼	2,761	10% ▲	0.096	-17% ▼	18%	-46% ▼
Savannah River	Savannah River Site (SRS)	251.8	-1% ▼	**4,736**	-2% ▼	0.053	1% ▲	21%	61% ▲
Totals		**1,651.9**	**-10%** ▼	**22,725**	**-4%** ▼	**0.073**	**-7%** ▼	**24%**	**-20%** ▼

Note: Boxed values indicate the greatest value in each column.

B-1c: Operations Office/Site Dose Data (1997)

Operations/ Field Office	Site	1997							
		Collective TEDE (person-rem)	Percent Change from 1996	Number with Meas. Dose	Percent Change from 1996	Avg. Meas. TEDE (rem)	Percent Change from 1996	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1996
Albuquerque	Ops. and Other Facilities	0.5	-86% ▼	25	-32% ▼	0.020	-80% ▼	0%	-100% ▼
	Los Alamos Nat'l. Lab. (LANL)	192.2	4% ▲	2,333	18% ▲	0.082	-11% ▼	44%	1% ▲
	Pantex Plant (PP)	11.1	-61% ▼	213	-35% ▼	0.052	-39% ▼	0%	-100% ▼
	Sandia Nat'l. Lab. (SNL)	9.7	-42% ▼	196	-60% ▼	0.049	44% ▲	35%	43% ▲
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0.3	-31% ▼	36	38% ▲	0.008	-50% ▼	0%	-
Chicago	Ops. and Other Facilities	4.5	-67% ▼	134	-26% ▼	0.033	-55% ▼	0%	-100% ▼
	Argonne Nat'l. Lab. - East (ANL-E)	19.0	3% ▲	238	18% ▲	0.080	-13% ▼	21%	-34% ▼
	Argonne Nat'l. Lab. - West (ANL-W)	18.9	-57% ▼	249	-25% ▼	0.076	-42% ▼	3%	-83% ▼
	Brookhaven Nat'l. Lab. (BNL)	68.9	-41% ▼	1,463	1% ▲	0.047	-42% ▼	14%	-65% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	25.0	54% ▲	859	60% ▲	0.029	-4% ▼	5%	30% ▲
DOE HQ	DOE Headquarters (includes DNFSB)	0.2	-23% ▼	5	-17% ▼	0.041	-8% ▼	0%	-
	North Korea Project	8.3	-38% ▼	24	-33% ▼	**0.344**	-7% ▼	**71%**	-9% ▼
Idaho	Idaho Site	115.3	-30% ▼	1,141	-12% ▼	0.101	-20% ▼	24%	-53% ▼
Nevada	Nevada Test Site (NTS)	1.3	32% ▲	25	32% ▲	0.054	0%	0%	-
Oakland	Ops. and Other Facilities	1.4	-	50	**733%** ▲	0.028	**833%** ▲	0%	-
	Lawrence Berkeley Lab. (LBL)	5.2	13% ▲	128	28% ▲	0.041	-12% ▼	0%	-
	Lawrence Livermore Nat'l. Lab. (LLNL)	18.1	22% ▲	186	-1% ▼	0.097	22% ▲	37%	53% ▲
	Stanford Linear Accelerator Center (SLAC)	14.2	-26% ▼	117	-63% ▼	0.121	95% ▲	17%	**467%** ▲
Oak Ridge	Ops. and Other Facilities	6.6	-45% ▼	135	-33% ▼	0.049	-18% ▼	25%	-24% ▼
	Oak Ridge Site	77.7	-12% ▼	1,614	2% ▲	0.048	-14% ▼	14%	-35% ▼
	Paducah Gaseous Diff. Plant (PGDP)	2.5	-87% ▼	36	-88% ▼	0.069	7% ▲	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	0.2	-99% ▼	3	-100% ▼	0.079	100% ▲	0%	-100% ▼
Ohio	Ops. and Other Facilities	0.1	**83%** ▲	2	-60% ▼	0.032	357% ▲	0%	-
	Fernald Environmental Mgmt. Project	18.4	-33% ▼	520	-35% ▼	0.035	4% ▲	3%	-51% ▼
	Mound Plant	5.8	-71% ▼	197	-51% ▼	0.029	-41% ▼	0%	-100% ▼
	West Valley Project	6.9	-38% ▼	174	-25% ▼	0.040	-18% ▼	8%	43% ▲
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**323.2**	21% ▲	3,187	-7% ▼	0.101	30% ▲	14%	75% ▲
Richland	Hanford Site	235.4	-11% ▼	2,058	-25% ▼	0.114	19% ▲	37%	104% ▲
Savannah River	Savannah River Site (SRS)	165.3	-34% ▼	**3,327**	-30% ▼	0.050	-7% ▼	12%	-43% ▼
Totals		**1,356.1**	**-18%** ▼	**18,675**	**-18%** ▼	**0.073**	**0%**	**23%**	**-5%** ▼

Note: Boxed values indicate the greatest value in each column.

B-2: Internal Dose by Operations/Site, 1995 - 1997

Operations/ Field Office	Site	No. of Individuals with New Intakes*			Collective CEDE Dose from Intake (person-rem)			Average CEDE (rem)		
		1995	1996	1997	1995	1996	1997	1995	1996	1997
Albuquerque	Ops. and Facilities	17	9	6	0.214	0.085	0.085	0.013	0.009	0.014
	LANL	134	90	76	1.264	5.287	10.481	0.009	0.059	**0.138** ◀
	Pantex	48	7	3	0.101	0.016	0.003	0.002	0.002	0.001
	Sandia	-	-	-	-	-	-	-	-	-
Chicago	Ops. and Other Facilities	50	91	51	0.478	0.474	0.126	0.010	0.005	0.002
	ANL-E	28	13	12	0.391	0.301	0.322	0.014	0.023	0.027
	ANL-W	-	-	1	-	-	0.070	-	-	0.070
	BNL	61	72	66	3.157	2.962	2.282	0.052	0.041	0.035
Idaho	Idaho Site	16	17	276	0.398	3.729	**27.928** ◀	0.025	0.219	0.101
Nevada	NTS	-	-	4	-	-	0.473	-	-	0.118
Oakland	LBL	5	2	9	0.237	0.112	0.238	0.047	0.056	0.026
	LLNL	3	6	9	0.006	0.013	0.066	0.002	0.002	0.007
Oak Ridge	Ops. and Other Facilities	45	27	47	3.227	6.802	4.185	0.072	**0.252** ◀	0.089
	Oak Ridge Site	**673** ◀	399	**700** ◀	**12.904** ◀	4.661	8.234	0.019	0.012	0.012
	Paducah	17	40	1	0.048	0.651	0.023	0.003	0.016	0.023
	Portsmouth	6	112	2	0.049	8.628	0.003	0.008	0.077	0.002
Ohio	OH			1	-	-	0.004	-	-	0.004
	Fernald	108	65	24	0.732	1.050	0.231	0.007	0.016	0.010
	Mound Plant	78	72	103	1.141	0.355	0.543	0.015	0.005	0.005
	WVNS	-	-	1	-	-	0.049	-	-	0.049
Rocky Flats	Rocky Flats	17	27	43	4.867	1.736	2.748	**0.286** ◀	0.064	0.064
Richland	Hanford Site	13	22	7	0.709	0.822	0.446	0.055	0.037	0.064
Savannah River	Savannah River Site	533	**528** ◀	467	5.389	**15.840** ◀	2.826	0.010	0.030	0.006
Totals		**1,852**	**1,599**	**1,909**	**35.312**	**53.524**	**61.366**	**0.019**	**0.033**	**0.032**

Facilities with no new intakes: UMTRA, Fermi Lab, DOE-HQ, Oakland Ops., SLAC, Sandia.

* Only includes intakes that occurred during the monitoring year. Individuals may be counted more than once.

Note: Arrowed values indicate the greatest value in each column.

In 1997, Grand Junction began reporting internal dose from radon-222 for the first time (see Section 3.3.3). This resulted in a large increase in internal dose reported by Idaho in 1997.

B-3: Neutron Dose Distribution by Operations/Site, 1997

Operations	Site	No Meas. Dose	Meas. <0.1	0.1-0.25	0.25-0.5	0.5-0.75	0.75-1.0	1-2	>2	Total Monitored*	No. of Individuals with Meas. Dose	% of Individuals with Meas. Dose	Collective Neutron Dose (person-rem)	Average Meas. Neutron Dose (rem)
Albuquerque	Albuquerque	1,056	5	1	-	-	-	-	-	1,062	6	1%	0.201	0.034
	Los Alamos National Lab. (LANL)	6,865	1,661	139	82	23	5	4	-	8,779	**1,914**	**22%**	**102.315**	0.053
	Pantex Plant (PP)	7,014	66	3	-	-	-	-	-	7,083	69	1%	2.487	0.036
	Sandia National Lab. (SNL)	3,572	9	-	1	-	-	-	-	3,582	10	0%	0.423	0.042
	UMTRA	369	-	-	-	-	-	-	-	369	-	0%	-	-
Chicago	Chicago Operations	1,090	-	-	-	-	-	-	-	1,090	-	0%	-	-
	Argonne Nat'l. Lab. - East (ANL-E)	2,900	135	16	2	-	-	-	-	3,053	153	5%	5.810	0.038
	Argonne Nat'l. Lab. - West (ANL-W)	859	6	1	-	-	-	-	-	866	7	1%	0.412	0.059
	Brookhaven Nat'l. Lab. (BNL)	5,186	783	14	1	-	-	-	-	5,984	798	13%	14.122	0.018
	Fermi Nat'l. Accelerator Lab. (FERMI)	2,346	17	2	-	-	-	-	-	2,365	19	1%	1.080	0.057
DOE HQ	DOE Headquarters	28	4	1	-	-	-	-	-	33	5	15%	0.185	0.037
	North Korea Project	45	-	-	-	-	-	-	-	45	-	0%	-	-
Idaho	Idaho Site	6,373	51	-	-	-	-	-	-	6,424	51	1%	1. 579	0.031
Nevada	Nevada Test Site (NTS)	1,828	5	-	-	-	-	-	-	1,833	5	0%	0.105	0.021
Oakland	Oakland Operations	284	-	-	-	-	-	-	-	284	-	0%	-	-
	Lawrence Berkeley Lab.(LBL)	1,865	14	-	-	-	-	-	-	1,879	14	1%	0.277	0.020
	Lawrence Livermore Nat'l. Lab. (LLNL)	7,565	50	7	-	-	-	-	-	7,622	57	1%	2.452	0.043
	Stanford Linear Accelerator Center (SLAC)	2,056	7	5	1	-	-	-	-	2,069	13	1%	1.376	0.106
Oak Ridge	Oak Ridge Operations	2,251	-	-	-	-	-	-	-	2,251	-	0%	-	-
	Oak Ridge Site	14,669	81	32	12	2	1	-	-	**14,797**	128	1%	14.050	**0.110**
	Paducah Gaseous Diff. Plant (PGDP)	441	1	-	-	-	-	-	-	442	1	0%	0.037	0.037
	Portsmouth Gaseous Diff. Plant (PORTS)	144	-	-	-	-	-	-	-	144	-	0%	-	-
Ohio	Ohio Field Office	70	1	-	-	-	-	-	-	71	1	1%	0.047	0.047
	Fernald Environmental Mgmt. Project	2,706	-	-	-	-	-	-	-	2,706	-	0%	-	-
	Mound Plant	1,012	36	8	-	-	-	-	-	1,056	44	4%	2.214	0.050
	West Valley	1,206	-	-	-	-	-	-	-	1,206	-	0%	-	-
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	4,954	695	323	35	2	-	-	-	6,009	1,055	18%	93.959	0.089
Richland	Hanford Site	11,344	239	17	2	2	-	-	-	11,604	260	2%	10.930	0.042
Savannah	Savannah River Site (SRS)	11,764	634	62	13	-	-	-	-	12,473	709	6%	36.549	0.052
	Totals	**101,862**	**4,500**	**631**	**149**	**29**	**6**	**4**	**0**	**107,181**	**5,319**	**5%**	**290.610**	**0.055**

* Represents the total number of monitoring records. The number of individuals specifically monitored for neutron radiation cannot be determined.

B-4: Distribution of Deep Dose Equivalent (DDE) and Total Effective Dose Equivalent (TEDE), 1974-1997

Deep Dose Equivalent (DDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

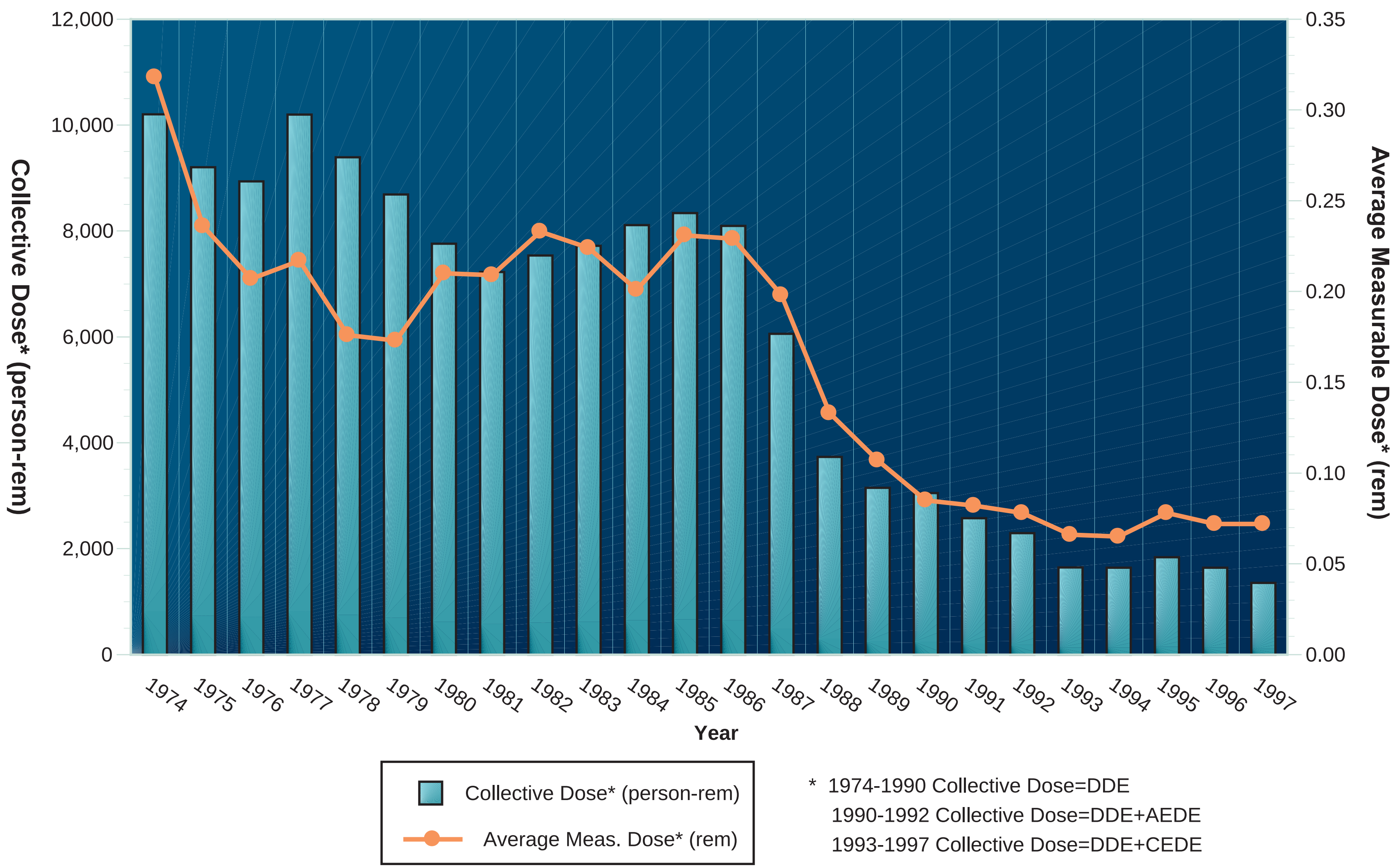
Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. DDE	Coll. DDE (person-rem)	Avg. Meas. DDE
1974	37,060	29,735	1,531	652	149	40	4								69,171	32,111	**10,202**	**0.318**
1975	41,390	36,795	1,437	541	122	28				1					80,314	38,924	9,202	0.236
1976	38,408	41,321	1,296	387	70	6	1								81,489	43,081	8,938	0.207
1977	41,572	44,730	1,499	540	103	23			1	2				2	88,472	46,900	10,199	0.217
1978	43,317	51,444	1,311	439	53	11									96,575	**53,258**	9,390	0.176
1979	48,529	48,553	1,281	416	33	10	1							2	98,825	50,296	8,691	0.173
1980	43,663	35,385	1,113	387	16										80,564	36,901	7,760	0.210
1981	43,775	33,251	967	263	29	5									78,290	34,515	7,223	0.209
1982	47,420	30,988	990	313	56	28									79,795	32,375	7,538	0.233
1983	48,340	32,842	1,225	294	49	31									82,781	34,441	7,720	0.224
1984	46,056	38,821	1,223	312	31	11									86,454	40,398	8,113	0.201
1985	54,582	34,317	1,362	356	51	8				1					90,677	36,095	8,340	0.231
1986	53,586	33,671	1,279	349	35	1		1					1		88,923	35,337	8,095	0.229
1987	45,241	28,995	1,210	283	36										75,765	30,524	6,056	0.198
1988	48,704	27,492	502	34											76,732	28,028	3,735	0.133
1989	56,363	28,925	428	21											85,737	29,374	3,151	0.107
1990	76,798	31,110	140	17											108,065	31,267	2,230	0.071
1991	92,526	27,149	95												119,770	27,244	1,762	0.065
1992	98,900	24,769	42												123,711	24,811	1,504	0.061
1993	103,905	23,050	86			1									127,042	23,137	1,534	0.066
1994	92,245	24,189	77												116,511	24,266	1,600	0.066
1995	104,793	22,330	153												**127,276**	22,483	1,809	0.080
1996	101,529	21,720	74	1											123,324	21,795	1,598	0.073
1997	89,805	17,331	45												107,181	17,376	1,285	0.074

Total Effective Dose Equivalent (TEDE)*

Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. TEDE	Coll. TEDE (person-rem)	Avg. Meas. TEDE
1990	71,991	35,780	226	47	8	8	1	2		1				1	108,065	**36,074**	**3,052**	**0.085**
1991	88,444	31,086	193	25	9	8		2		1				2	119,770	31,326	2,574	0.082
1992	94,297	29,240	132	22	9	6		2	1		1			1	123,711	29,414	2,295	0.078
1993	101,947	25,002	87			2				1	1			2	127,042	25,095	1,644	0.066
1994	91,121	25,310	79		1										116,511	25,390	1,643	0.065
1995	103,663	23,454	157		1	1									**127,276**	23,613	1,845	0.078
1996	100,599	22,641	80	2	1								1		123,324	22,725	1,652	0.073
1997	88,506	18,624	48	1	1	1									107,181	18,675	1,356	0.073

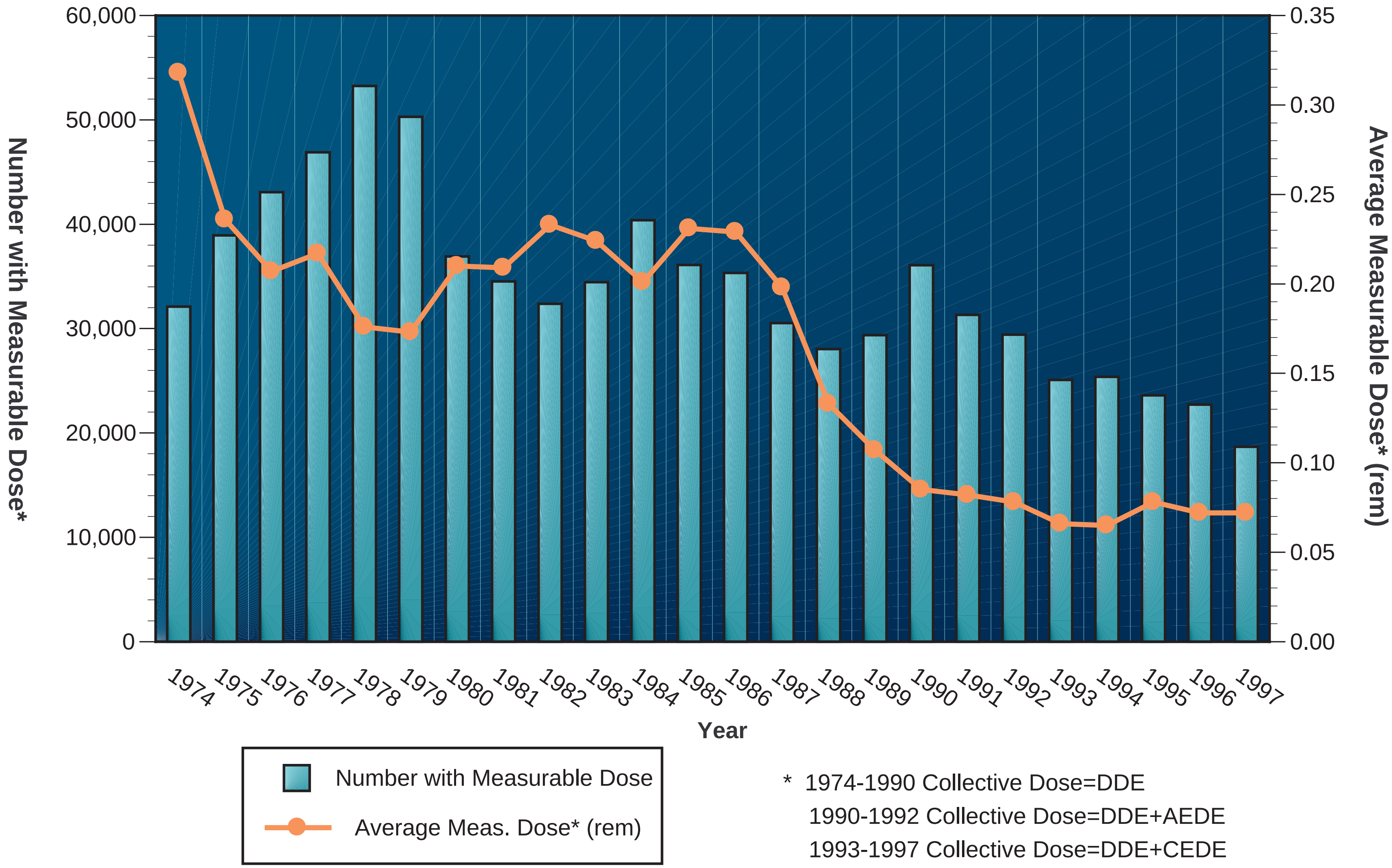
* 1990-1992 TEDE=DDE+AEDE 1993-1997 TEDE=DDE+CEDE Note: Arrowed values indicate the greatest value in each column.

B-5: Collective TEDE and Average Measurable Dose 1974-1997



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1997 Collective Dose=DDE+CEDE

B-6: Number with Measurable Dose and Average Measurable Dose 1974-1997



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1997 Collective Dose=DDE+CEDE

B-7a: Distribution of TEDE by Facility Type - 1995

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	6,921	1,277	238	136	38	20	9					8,639	20%	1,718	168.527	0.098
Fuel/Uran. Enrich.	11,669	1,825	72	16	2							13,584	14%	1,915	39.230	0.020
Fuel Fabrication	2,673	986	46	19	4							3,728	28%	1,055	39.545	0.037
Fuel Processing	3,257	1,123	173	119	61	17	12					4,762	32%	1,505	162.958	0.108
Maint. and Support	16,576	2,324	285	135	42	18	16					19,396	15%	2,820	210.894	0.075
Other	17,464	2,035	203	120	51	30	70		1			19,974	13%	2,510	280.871	**0.112**
Reactor	1,724	705	115	59	15	2						2,620	**34%**	896	68.710	0.077
Research, General	18,280	2,579	366	193	54	29	48					21,549	15%	3,269	311.100	0.095
Research, Fusion	909	111	10	10	3							1,043	13%	134	8.953	0.067
Waste Proc./Mgmt.	6,580	2,019	311	98	25	3	2					9,038	27%	2,458	156.936	0.064
Weapons Fab. & Test	17,610	4,288	724	229	79	12				1		**22,943**	23%	**5,333**	**397.022**	0.074
Totals	**103,663**	**19,272**	**2,543**	**1,134**	**374**	**131**	**157**	**0**	**1**	**1**	**0**	**127,276**	**19%**	**23,613**	**1,844.746**	**0.078**

Note: Arrowed values indicate the greatest value in each column.

B-7b: Distribution of TEDE by Facility Type - 1996

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	8,948	1,998	217	65	40	20	5					11,293	21%	2,345	152.025	0.065
Fuel/Uran. Enrich.	8,400	817	67	20	1	2	1					9,308	10%	908	38.301	0.042
Fuel Fabrication	2,300	815	32	14	3							3,164	27%	864	28.970	0.034
Fuel Processing	2,634	1,163	177	96	36	13	12				1	4,132	36%	1,498	151.224	**0.101** ◄
Maint. and Support	14,226	2,388	304	148	30	7	9					17,112	17%	2,886	195.230	0.068
Other	21,665	2,173	179	82	49	13	17	1				**24,179** ◄	10%	2,514	168.074	0.067
Reactor	1,437	768	85	47	10	2						2,349	**39%** ◄	912	56.119	0.062
Research, General	17,866	2,390	382	199	73	20	29	1	1			20,961	15%	3,095	295.711	0.096
Research, Fusion	656	133	19	7	2	2						819	20%	163	11.366	0.070
Waste Proc./Mgmt.	7,016	2,031	278	96	14	2	1					9,438	26%	2,422	142.080	0.059
Weapons Fab. & Test	15,451	4,083	701	229	81	18	6					20,569	25%	**5,118** ◄	**412.830** ◄	0.081
Totals	**100,599**	**18,759**	**2,441**	**1,003**	**339**	**99**	**80**	**2**	**1**	**0**	**1**	**123,324**	**18%**	**22,725**	**1,651.930**	**0.073**

Note: Arrowed values indicate the greatest value in each column.

B-7c: Distribution of TEDE by Facility Type - 1997

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Accelerator	8,927	2,282	178	77	19	6						11,489	22%	2,562	114.379	0.045
Fuel/Uran. Enrich.	2,958	130	16	2	1							3,107	5%	149	6.178	0.041
Fuel Fabrication	2,405	501	35	8	1							2,950	18%	545	18.839	0.035
Fuel Processing	2,948	1,098	128	17	11	4	3					4,209	30%	1,261	67.426	0.053
Maint. and Support	12,599	1,779	195	120	53	23	6			1		14,776	15%	2,177	179.989	0.083
Other	17,472	2,005	235	87	49	23	20					19,891	12%	2,419	187.287	0.077
Reactor	1,461	622	63	37	4	3						2,190	**33%** ◀	729	42.313	0.058
Research, General	16,842	2,119	350	138	35	25	12	1	1			19,523	14%	2,681	225.950	0.084
Research, Fusion	554	111	11	2	6	2						686	19%	132	10.548	0.080
Waste Proc./Mgmt.	5,949	1,363	181	54	6	4	1					7,558	21%	1,609	94.498	0.059
Weapons Fab. & Test	16,391	3,252	749	314	79	11	6					**20,802** ◀	21%	**4,411** ◀	**408.697** ◀	**0.093** ◀
Totals	**88,506**	**15,262**	**2,141**	**856**	**264**	**101**	**48**	**1**	**1**	**1**	**0**	**107,181**	**17%**	**18,675**	**1,356.104**	**0.073**

Note: Arrowed values indicate the greatest value in each column.

Weapons Fabrication and Testing remains the facility type with the highest collective dose and number of individuals with measurable dose. This year they were also the highest average measurable TEDE; up slightly from last year. It should be noted that Rocky Flats and Savannah River account for the majority of the dose reported under this facility type even though these sites are no longer actively involved in this activity.

B-8a: Collective TEDE by Facility Type, 1995

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	**Totals**
Albuquerque	Ops. and Other Facilities										0.3	1.3	**1.6**
	Los Alamos National Lab. (LANL)	23.6				68.7	0.1	**130.0**	1.0	2.6	0.1	8.9	**235.0**
	Pantex Plant (PP)										36.9		**36.9**
	Sandia National Lab. (SNL)	0.3				1.5	3.3	4.0		0.4	0.3	1.2	**11.0**
	UMTRA											1.3	**1.3**
Chicago	Ops. and Other Facilities					2.8		0.4	3.3			0.1	**6.6**
	Argonne Nat'l. Lab. - East (ANL-E)	6.7				2.6		11.9		4.1		12.0	**37.3**
	Argonne Nat'l. Lab. - West (ANL-W)			0.3		0.8	5.5	31.0					**37.6**
	Brookhaven Nat'l. Lab. (BNL)	**102.1**				6.0	9.9	8.9		1.3		17.6	**145.8**
	Fermi Nat'l. Accelerator Lab. (FERMI)	13.4											**13.4**
DOE HQ	DOE Headquarters											0.1	**0.1**
Idaho	Idaho Site				**94.2**	9.0	**19.2**	6.7		6.6		**148.3**	**284.0**
Nevada	Nevada Test Site (NTS)										0.5		**0.5**
Oakland	Ops. and Other Facilities							1.2				0.1	**1.3**
	Lawrence Berkeley Lab.(LBL)	1.2						3.3					**4.5**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.4	1.9		1.1			1.2	**4.7**		2.0	1.7	**13.0**
	Stanford Linear Accelerator Center (SLAC)	20.2											**20.2**
Oak Ridge	Ops. and Other Facilities	0.8						0.5		1.8		3.1	**6.2**
	Oak Ridge Site		0.9					42.1			12.6	21.4	**77.0**
	Paducah Gaseous Diff. Plant (PGDP)		9.0										**9.0**
	Portsmouth Gaseous Diff. Plant (PORTS)		**27.5**										**27.5**
Ohio	Ops. and Other Facilities												**0.0**
	Fernald Environmental Mgmt. Project			**30.4**									**30.4**
	Mound Plant					4.1					1.9	0.3	**6.3**
	West Valley											26.9	**26.9**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**265.1**	0.2	**265.3**
Richland	Hanford Site				7.0	**97.5**	17.4	54.9		**81.5**		32.4	**290.7**
Savannah River	Savannah River Site (SRS)			8.8	61.8	16.7	13.4	14.9		58.7	77.4	3.9	**255.6**
	Totals	**168.5**	**39.2**	**39.5**	**163.0**	**210.9**	**68.7**	**311.1**	**9.0**	**156.9**	**397.0**	**280.9**	**1,844.7**

Note: Arrowed values indicate the greatest value in each column.

B-8b: Collective TEDE by Facility Type, 1996

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	**Totals**
Albuquerque	Ops. and Other Facilities									0.1	0.5	3.1	**3.6**
	Los Alamos National Lab. (LANL)	15.9				55.7	0.1	**100.4◄**	0.3	2.4	0.0	9.3	**184.1**
	Pantex Plant (PP)										28.1	0.0	**28.1**
	Sandia National Lab. (SNL)	0.7				0.6	5.4	4.5	0.1	0.6	4.2	0.6	**16.7**
	UMTRA											0.4	**0.4**
Chicago	Ops. and Other Facilities					7.1		0.3	**6.0◄**			0.1	**13.5**
	Argonne Nat'l. Lab. - East (ANL-E)	7.5				0.4		8.4		1.5		0.7	**18.5**
	Argonne Nat'l. Lab. - West (ANL-W)			0.5		1.0	5.7	36.3				0.0	**43.6**
	Brookhaven Nat'l. Lab. (BNL)	**87.0◄**				6.0	9.8	7.2		1.3		5.5	**116.8**
	Fermi Nat'l. Accelerator Lab. (FERMI)	16.2											**16.2**
DOE HQ	DOE Headquarters					0.0						0.3	**0.3**
	North Korea											13.3	**13.3**
Idaho	Idaho Site				**78.6◄**	6.1	**15.5◄**	9.0		6.0		**49.0◄**	**164.1**
Nevada	Nevada Test Site (NTS)										1.0		**1.0**
Oakland	Ops. and Other Facilities											0.0	**0.0**
	Lawrence Berkeley Lab.(LBL)	2.4						2.2					**4.6**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.0	2.3			1.6		1.2	4.9	0.0	1.9	3.0	**14.9**
	Stanford Linear Accelerator Center (SLAC)	19.3											**19.3**
Oak Ridge	Ops. and Other Facilities	2.9						0.4		7.8		0.9	**11.9**
	Oak Ridge Site		1.1					60.1			10.9	16.5	**88.6**
	Paducah Gaseous Diff. Plant (PGDP)		5.0									13.5	**18.6**
	Portsmouth Gaseous Diff. Plant (PORTS)		**29.9◄**										**29.9**
Ohio	Ops. and Other Facilities					0.0							**0.0**
	Fernald Environmental Mgmt. Project			**27.4◄**									**27.4**
	Mound Plant					6.7					11.7	1.7	**20.1**
	West Valley											11.2	**11.2**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**265.7◄**	2.0	**267.6◄**
Richland	Hanford Site			0.3	5.5	**94.0◄**	13.0	45.0		**74.6◄**		33.4	**265.7**
Savannah River	Savannah River Site (SRS)			0.8	67.1	15.7	6.9	20.8		47.8	89.0	3.7	**251.8**
	Totals	**152.0**	**38.3**	**29.0**	**151.2**	**195.2**	**56.1**	**295.7**	**11.4**	**142.1**	**412.8◄**	**168.1**	**1,651.9**

Note: Arrowed values indicate the greatest value in each column.

B-8c: Collective TEDE by Facility Type, 1997

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	**Totals**
Albuquerque	Ops. and Other Facilities									0.1	0.3	0.1	**0.5**
	Los Alamos National Lab. (LANL)	17.3				59.0	0.2	**96.5** ◄	0.3	1.8	0.0	17.0	**192.2**
	Pantex Plant (PP)										11.1	-	**11.1**
	Sandia National Lab. (SNL)	0.7				0.3	4.9	2.4	0.0	0.3	0.3	0.8	**9.7**
	UMTRA											0.3	**0.3**
Chicago	Ops. and Other Facilities					1.1		0.4	2.9			0.0	**4.5**
	Argonne Nat'l. Lab. - East (ANL-E)	9.3				2.4		6.1		1.0		0.2	**19.0**
	Argonne Nat'l. Lab. - West (ANL-W)			0.2		0.5	0.7	17.5				0.0	**18.9**
	Brookhaven Nat'l. Lab. (BNL)	**44.7** ◄				4.9	7.0	8.6		0.8		3.0	**68.9**
	Fermi Nat'l. Accelerator Lab. (FERMI)	25.0											**25.0**
DOE HQ	DOE Headquarters											0.2	**0.2**
	North Korea											8.3	**8.3**
Idaho	Idaho Site				31.8	5.4	**16.7** ◄	4.3		3.4		53.8	**115.3**
Nevada	Nevada Test Site (NTS)										1.3		**1.3**
Oakland	Ops. and Other Facilities							1.4					**1.4**
	Lawrence Berkeley Lab.(LBL)	1.7						3.6					**5.2**
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.1	2.0			1.9		1.8	**7.2** ◄		1.3	3.8	**18.1**
	Stanford Linear Accelerator Center (SLAC)	14.2											**14.2**
Oak Ridge	Ops. and Other Facilities	1.4			0.0			0.4		4.1		0.7	**6.6**
	Oak Ridge Site		1.4					54.1			10.7	11.5	**77.7**
	Paducah Gaseous Diff. Plant (PGDP)		**2.5** ◄										**2.5**
	Portsmouth Gaseous Diff. Plant (PORTS)		0.2										**0.2**
Ohio	Ops. and Other Facilities											0.1	**0.1**
	Fernald Environmental Mgmt. Project			**18.4** ◄									**18.4**
	Mound Plant					0.2					0.1	5.4	**5.8**
	West Valley											6.9	**6.9**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**322.1** ◄	1.1	**323.2** ◄
Richland	Hanford Site			0.1	2.5	**88.1** ◄	6.6	14.0		**50.0** ◄		**73.9** ◄	**235.4**
Savannah River	Savannah River Site (SRS)			0.2	**33.2** ◄	16.0	6.3	15.1		33.0	61.5	0.1	**165.3**
	Totals	**114.4**	**6.2**	**18.8**	**67.4**	**180.0**	**42.3**	**226.0**	**10.5**	**94.5**	**408.7**	**187.3**	**1,356.1**

Note: Arrowed values indicate the greatest value in each column.

Collective TEDE at Rocky Flats increased again in 1997 and continued to be the largest contributor to the Weapons Fabrication and Testing facility type as clean-up activities increase. Fusion Research activities at LLNL increased significantly this year although the overall collective TEDE in this facility type was reduced. All facility types showed an overall significant decrease from 1996.

B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Accelerator Facilities, 1997

ACCELERATORS

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	>1	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
OAK	Stanford Linear Accelerator Center	1,952	79	20	15	1	2	-	2,069	6%	117	14.175	**0.121**	17%
AL	Sandia National Laboratory	290	7	3	-	-	-	-	300	3%	10	0.743	0.074	0%
AL	Los Alamos National Laboratory	520	246	25	15	4	2	-	812	**36%**	292	17.340	0.059	**25%**
CH	Argonne National Laboratory - East	512	129	24	6	1	-	-	672	24%	160	9.325	0.058	6%
CH	Brookhaven National Laboratory	2,193	909	72	33	11	2	-	**3,220**	32%	**1,027**	**44.721**	0.044	18%
OAK	Lawrence Berkeley Laboratory	397	42	3	1	-	-	-	443	10%	46	1.671	0.036	0%
OR	Thomas Jefferson Nat'l. Accel. Facil.	1,274	44	2	1	-	-	-	1,321	4%	47	1.370	0.029	0%
CH	Fermilab	1,506	822	29	6	2	-	-	2,365	**36%**	859	24.970	0.029	5%
OAK	Lawrence Livermore National Lab.	266	4	-	-	-	-	-	270	1%	4	0.064	0.016	0%
RL	Battelle Memorial Institute (PNL)	3	-	-	-	-	-	-	3	0%	-	-	-	0%
NV	Defense Nuclear Agency-Kirtland AFB	1	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	EG&G Special Technologies Lab.	5	-	-	-	-	-	-	5	0%	-	-	-	0%
AL	Johnson Controls, Inc.	2	-	-	-	-	-	-	2	0%	-	-	-	0%
OR	Oak Ridge Field Office	5	-	-	-	-	-	-	5	0%	-	-	-	0%
AL	Protection Technologies Los Alamos	1	-	-	-	-	-	-	1	0%	-	-	-	0%
	Totals	**8,927**	**2,282**	**178**	**77**	**19**	**6**	**0**	**11,489**	**22%**	**2,562**	**114.379**	**0.045**	**14%**

Note: Arrowed values indicate the greatest value in each column.

Overall, the collective TEDE has been reduced significantly as well as the percentage of the collective TEDE above 0.5 rem primarily due to reduced maintenance activities at BNL. BNL slightly increasing the number of people with measurable TEDE while reducing the collective TEDE, the Average Measurable TEDE, and the percentage of TEDE above 0.5 rem by approximately one half or more. All other sites had increased collective TEDE over 1996 except LBL and Thomas Jefferson Nat'l. Accel. Facility.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 1997

FUEL FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
ENRICHMENT															
OAK	Lawrence Livermore National Lab.	618	16	4	1	1	-	-	-	640	3%	22	2.015	**0.092** ◄	**25%** ◄
OR	Lockheed Martin Energy Systems (Portsmouth)	141	2	1	-	-	-	-	-	144	2%	3	0.237	0.079	0%
OR	Lockheed Martin Energy Systems (Paducah)	406	25	10	1	-	-	-	-	442	**8%** ◄	36	**2.478** ◄	0.069	0%
OR	Lockheed Martin Energy Systems (K-25)	1,793	87	1	-	-	-	-	-	**1,881** ◄	5%	**88** ◄	1.448	0.016	0%
	Total	**2,958**	**130**	**16**	**2**	**1**	**0**	**0**	**0**	**3,107**	**5%**	**149**	**6.178**	**0.041**	**8%**
FABRICATION															
OH	FERMCO	1,403	391	32	6	1	-	-	-	**1,833** ◄	23%	**430** ◄	**16.166** ◄	**0.038** ◄	**3%** ◄
CH	Argonne National Lab. – West	25	5	-	-	-	-	-	-	30	17%	5	0.185	0.037	0%
RL	Fluor Daniel – Hanford	-	3	-	-	-	-	-	-	3	**100%** ◄	3	0.099	0.033	0%
OH	FERMCO Subcontractors	712	85	3	2	-	-	-	-	802	11%	90	2.216	0.025	0%
RL	Lockheed Martin Hanford	1	1	-	-	-	-	-	-	2	50%	1	0.012	0.012	0%
RL	Babcock Wilcox Hanford	1	1	-	-	-	-	-	-	2	50%	1	0.011	0.011	0%
SR	Westinghouse S.R. Subcontractors	32	5	-	-	-	-	-	-	37	14%	5	0.054	0.011	0%
SR	Westinghouse Savannah River Co.	154	10	-	-	-	-	-	-	164	6%	10	0.096	0.010	0%
SR	Bechtel Construction – SR	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Duke Engineering Services Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	DynCorp Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
OH	Fernald Area Office	68	-	-	-	-	-	-	-	68	0%	-	-	-	0%
OH	Fernald Office Service Subcontractors	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	NUMATEC Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Savannah River Field Office	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
	Total	**2,405**	**501**	**35**	**8**	**1**	**0**	**0**	**0**	**2,950**	**18%**	**545**	**18.839**	**0.035**	**3%**

Note: Arrowed values indicate the greatest value in each column.

Enrichment facilities operation doses are now reported to the NRC beginning in 1997. Other doses in this facility type are from primarily environmental restoration/legacy wastes operations of those sites. Fuel Fabrication continues to be dominated by Fernald activities which have seen a significant reduction in the collective TEDE since 1996.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 1997 (Continued)

FUEL FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
PROCESSING															
RL	Fluor Daniel – Hanford	3	2	5	4	-	-	-	-	14	**79%**	11	2.384	**0.217**	0%
ID	LMITCO – Services	1,064	194	58	8	10	4	3	-	1,341	21%	277	**31.701**	0.114	**40%**
SR	Bechtel Construction – SR	185	91	10	3	-	-	-	-	289	36%	104	4.493	0.043	0%
SR	Westinghouse Savannah River Co.	1,359	750	54	2	1	-	-	-	**2,166**	37%	**807**	27.692	0.034	2%
RL	Duke Engineering Services Hanford	5	4	-	6	-	-	-	-	9	44%	4	0.116	0.029	0%
SR	Wackenhut Services, Inc., – SR	92	21	-	-	-	-	-	-	113	19%	21	0.476	0.023	0%
SR	Westinghouse S.R. Subcontractors	92	21	1	-	-	-	-	-	114	19%	22	0.428	0.019	0%
OR	RMI Company	1	1	-	-	-	-	-	-	2	50%	1	0.016	0.016	0%
ID	LMITCO Subcontractors – Construction	45	6	-	-	-	-	-	-	51	12%	6	0.053	0.009	0%
SR	Savannah River Field Office	43	7	-	-	-	-	-	-	50	14%	7	0.059	0.008	0%
SR	Miscellaneous DOE Contractors – SR	5	1	-	-	-	-	-	-	6	17%	1	0.008	0.008	0%
RL	Babcock Wilcox Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	Idaho Field Office	19	-	-	-	-	-	-	-	19	0%	-	-	-	0%
ID	LMITCO Subcontractor – Coleman	33	-	-	-	-	-	-	-	33	0%	-	-	-	0%
RL	Rust Services Hanford	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
	Total	**2,948**	**1,098**	**128**	**17**	**11**	**4**	**3**	**0**	**4,209**	**30%**	**1,261**	**67.426**	**0.053**	**20%**

Note: Arrowed values indicate the greatest value in each column.

Lockheed Martin (Idaho) and Westinghouse Savannah River continue to dominate the fuel processing facility type in the number of individuals monitored and collective TEDE.

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 1997

MAINTENANCE AND SUPPORT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	Fluor Daniel Northwest Services	167	80	19	29	20	16	1	-	-	-	332	**50%** ◄	165	**42.630** ◄	**0.258** ◄	**63%** ◄
CH	Argonne National Laboratory - East	372	3	1	6	-	-	-	-	-	-	382	3%	10	2.403	0.240	0%
RL	Babcock Wilcox Hanford	182	14	-	3	1	1	-	-	-	-	201	9%	19	2.669	0.140	50%
AL	Los Alamos National Laboratory	1,009	316	18	18	16	5	5	-	-	1	1,388	27%	**379** ◄	40.787	0.108	61%
SR	Bechtel Construction - SR	230	49	8	5	4	-	-	-	-	-	296	22%	66	6.695	0.101	34%
RL	Fluor Daniel - Hanford	829	259	76	31	7	1	-	-	-	-	1,203	31%	374	37.495	0.100	14%
OAK	Lawrence Livermore National Lab.	1,847	16	4	1	-	-	-	-	-	-	1,868	1%	21	1.598	0.076	0%
RL	Babcock Wilcox Protection, Inc.	78	7	1	1	-	-	-	-	-	-	87	10%	9	0.546	0.061	0%
RL	Duke Engineering Services Hanford	92	16	1	1	-	-	-	-	-	-	110	16%	18	1.038	0.058	0%
RL	Fluor Daniel Northwest	283	33	2	3	-	-	-	-	-	-	321	12%	38	2.130	0.056	0%
OAK	LLNL Plant Services	324	5	1	-	-	-	-	-	-	-	330	2%	6	0.319	0.053	0%
AL	Johnson Controls, Inc.	958	286	32	15	3	-	-	-	-	-	1,294	26%	336	17.670	0.053	9%
ID	LMITCO - Services	672	95	5	2	2	-	-	-	-	-	776	13%	104	5.420	0.052	22%
CH	Argonne National Laboratory - West	28	13	-	-	-	-	-	-	-	-	41	32%	13	0.527	0.041	0%
CH	Battelle Mem. Inst. - Columbus (Old)	390	26	3	-	-	-	-	-	-	-	419	7%	29	1.113	0.038	0%
CH	Brookhaven National Laboratory	911	125	12	2	-	-	-	-	-	-	1,050	13%	139	4.878	0.035	0%
SR	Westinghouse S.R. Subcontractors	211	29	1	1	-	-	-	-	-	-	242	13%	31	1.023	0.033	0%
SR	Westinghouse Savannah River Co.	1,653	252	10	2	-	-	-	-	-	-	**1,917** ◄	14%	264	8.194	0.031	0%
AL	Los Alamos Area Office	29	4	1	-	-	-	-	-	-	-	34	15%	5	0.145	0.029	0%
RL	SGN Eurisys Services Corp.	16	3	-	-	-	-	-	-	-	-	19	16%	3	0.082	0.027	0%
RL	Bechtel Power Co.	23	1	-	-	-	-	-	-	-	-	24	4%	1	0.027	0.027	0%
RL	Lockheed Martin Hanford	196	2	-	-	-	-	-	-	-	-	218	10%	22	0.593	0.027	0%
OAK	LLNL Security	241	1	-	-	-	-	-	-	-	-	242	0%	1	0.024	0.024	0%
RL	Lockheed Martin Services, Inc.	66	2	-	-	-	-	-	-	-	-	68	3%	2	0.047	0.024	0%
RL	Rust Services Hanford	248	26	-	-	-	-	-	-	-	-	274	9%	26	0.539	0.021	0%
SR	Savannah River Field Office	109	2	-	-	-	-	-	-	-	-	111	2%	2	0.041	0.021	0%
AL	Sandia National Laboratory	546	17	-	-	-	-	-	-	-	-	563	3%	17	0.344	0.020	0%
RL	NUMATEC Hanford	34	2	-	-	-	-	-	-	-	-	36	6%	2	0.037	0.019	0%

Note: Arrowed values indicate the greatest value in each column.

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 1997 (Continued)

MAINTENANCE AND SUPPORT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	DynCorp Hanford	105	9	-	-	-	-	-	-	-	-	114	8%	9	0.158	0.018	0%
RL	Battelle Memorial Institute (PNL)	19	1	-	-	-	-	-	-	-	-	20	5%	1	0.017	0.017	0%
OH	EG&G Mound Applied Technologies	63	9	-	-	-	-	-	-	-	-	72	13%	9	0.141	0.016	0%
RL	Duke Eng. & Serv. Northwest, Inc.	8	1	-	-	-	-	-	-	-	-	9	11%	1	0.015	0.015	0%
OH	EG&G Mound Subcontractors	63	5	-	-	-	-	-	-	-	-	68	7%	5	0.074	0.015	0%
RL	Richland Field Office	16	4	-	-	-	-	-	-	-	-	20	20%	4	0.058	0.015	0%
ID	Idaho Field Office	112	1	-	-	-	-	-	-	-	-	113	1%	1	0.012	0.012	0%
RL	Westinghouse Hanford Service Subs	7	1	-	-	-	-	-	-	-	-	8	13%	1	0.012	0.012	0%
RL	Rust Federal Services Northwest	29	3	-	-	-	-	-	-	-	-	32	9%	3	0.035	0.012	0%
AL	Protection Technologies Los Alamos	291	35	-	-	-	-	-	-	-	-	326	11%	35	0.397	0.011	0%
SR	Miscellaneous DOE Contractors - SR	15	4	-	-	-	-	-	-	-	-	19	21%	4	0.038	0.010	0%
SR	Univ. of Georgia Ecology Lab.	8	2	-	-	-	-	-	-	-	-	10	20%	2	0.018	0.009	0%
NV	Computer Sciences Corp.	4	-	-	-	-	-	-	-	-	-	4	0%	-	-	-	0%
HQ	DOE Headquarters	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	Idaho Office Subs	1	-	-	-	-	-	-	-	-	-	1	0%	-	-		0%
ID	LMITCO Subcontractor - Coleman	25	-	-	-	-	-	-	-	-	-	25	0%	-	-	-	0%
ID	LMITCO Subcontractor - Parsons	2	-	-	-	-	-	-	-	-	-	2	0%	-	-	-	0%
OH	Miamisburg Area Office	5	-	-	-	-	-	-	-	-	-	5	0%	-	-	-	0%
OH	Miamisburg Office Subs	3	-	-	-	-	-	-	-	-	-	3	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
OH	Ohio Field Office	2	-	-	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. Services	2	-	-	-	-	-	-	-	-	-	2	0%	-	-	-	0%
SR	SR Army Corps of Engineers	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Wackenhut Services, Inc. – NV	30	-	-	-	-	-	-	-	-	-	30	0%	-	-	-	0%
SR	Wackenhut Services, Inc. - SR	42	-	-	-	-	-	-	-	-	-	42	0%	-	-	-	0%
	Total	**12,599**	**1,779**	**195**	**120**	**53**	**23**	**6**	**0**	**0**	**1**	**14,776**	**15%**	**2,177**	**179.989**	**0.083**	**35%**

Note: Arrowed values indicate the greatest value in each column.

There was an overall reduction in the collective dose in 1997, however, average doses increased slightly and the percent above 0.5 rem nearly doubled due to fewer overall maintenance and support personnel. Fluor-Daniel (Hanford/Northwest Services) and LANL continue to be the primary contributors to the collective TEDE (45% and 23% respectively) for this facility type.

B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Reactor Facilities, 1997

REACTOR FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
AL	Sandia National Laboratory	58	21	2	1	1	3	-	-	86	33%	28	4.876	**0.174** ◄	70%
ID	LMITCO - Services	180	92	36	18	1	-	-	-	327	45%	147	**16.661** ◄	0.113	4%
RL	Fluor Daniel – Hanford	65	33	6	8	-	-	-	-	112	42%	47	4.610	0.098	0%
AL	Los Alamos National Laboratory	6	1	1	-	-	-	-	-	8	25%	2	0.188	0.094	0%
CH	Brookhaven National Laboratory	266	59	12	10	1	-	-	-	348	24%	82	6.964	0.085	7%
RL	Babcock Wilcox Hanford	76	12	-	-	1	-	-	-	89	15%	13	0.946	0.073	**72%** ◄
RL	Fluor Daniel Northwest Services	14	2	-	-	-	-	-	-	16	13%	2	0.074	0.037	0%
RL	Lockheed Martin Hanford	30	3	1	-	-	-	-	-	34	12%	4	0.147	0.037	0%
RL	Duke Engineering Services Hanford	40	20	-	-	-	-	-	-	60	33%	20	0.720	0.036	0%
CH	Argonne National Laboratory – West	94	23	-	-	-	-	-	-	117	20%	23	0.705	0.031	0%
RL	NUMATEC Hanford	6	1	-	-	-	-	-	-	7	14%	1	0.030	0.030	0%
RL	SGN Eurisys Services Corp.	9	1	-	-	-	-	-	-	10	10%	1	0.024	0.024	0%
SR	Wackenhut Services, Inc. – SR	34	46	-	-	-	-	-	-	80	58%	46	0.975	0.021	0%
RL	Rust Services Hanford	18	4	-	-	-	-	-	-	22	18%	4	0.073	0.018	0%
SR	Bechtel Construction - SR	56	37	-	-	-	-	-	-	93	40%	37	0.671	0.018	0%
SR	Westinghouse Savannah River Co.	404	259	5	-	-	-	-	-	**668** ◄	40%	**264** ◄	4.574	0.017	0%
ID	Idaho Field Office	5	2	-	-	-	-	-	-	7	29%	2	0.021	0.011	0%
SR	Westinghouse S.R. Subcontractors	44	2	-	-	-	-	-	-	46	4%	2	0.020	0.010	0%
SR	Savannah River Field Office	19	3	-	-	-	-	-	-	22	14%	3	0.027	0.009	0%
SR	Miscellaneous DOE Contractors – SR	-	1	-	-	-	-	-	-	1	**100%** ◄	1	0.007	0.007	0%
RL	Babcock Wilcox Protection, Inc.	13	-	-	-	-	-	-	-	13	0%	-	-	-	0%
RL	Battelle Memorial Institute (PNL)	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Bechtel Power Co.	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
RL	DynCorp Hanford	11	-	-	-	-	-	-	-	11	0%	-	-	-	0%
ID	LMITCO Subcontractor - Coleman	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
ID	LMITCO Subcontractor - Parsons	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Lockheed Martin Services, Inc.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Richland Field Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Rust Federal Services Northwest	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
	Total	**1,461**	**622**	**63**	**37**	**4**	**3**	**0**	**0**	**2,190**	**33%**	**729**	**42.313**	**0.058**	**12%**

Note: Arrowed values indicate the greatest value in each column.

Overall, all categories were slightly reduced in 1997. Lockheed Martin - Idaho had an increase both in the average TEDE and the collective TEDE. Sandia remained with the highest average measurable TEDE and the highest numbers of personnel above 0.5 rem.

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 1997

RESEARCH, GENERAL

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
CH	Argonne National Laboratory – East	1,871	34	5	2	-	2	1	-	-	-	1,915	2%	44	6.090	**0.138**	**54%**
AL	Los Alamos National Laboratory	1,659	664	90	50	23	18	10	1	1	-	2,516	34%	**857**	**96.439**	0.113	49%
OR	Lockheed Martin Energy Research (ORNL)	6,237	430	107	41	8	4	1	-	-	-	**6,828**	9%	591	54.059	0.091	17%
CH	Argonne National Laboratory – West	470	143	50	12	1	-	-	-	-	-	676	30%	206	17.481	0.085	3%
RL	DynCorp Hanford	3	1	-	-	-	-	-	-	-	-	4	25%	1	0.082	0.082	0%
OAK	Lawrence Livermore National Lab.	617	17	3	2	-	-	-	-	-	-	639	3%	22	1.756	0.080	0%
ID	LMITCO - Services	357	49	8	4	-	-	-	-	-	-	418	15%	61	4.252	0.070	0%
CH	Brookhaven National Laboratory	688	102	13	9	2	-	-	-	-	-	814	15%	126	8.582	0.068	13%
RL	Battelle Memorial Institute (PNL)	642	166	28	8	1	1	-	-	-	-	846	24%	204	13.811	0.068	11%
SR	Westinghouse Savannah River Co.	764	228	30	8	-	-	-	-	-	-	1,030	26%	266	13.712	0.052	0%
OAK	Lawrence Berkeley Laboratory	1,354	75	6	1	-	-	-	-	-	-	1,436	6%	82	3.576	0.044	0%
CH	New Brunswick Laboratory	44	7	1	-	-	-	-	-	-	-	52	15%	8	0.279	0.035	0%
SR	Bechtel Construction - SR	28	17	1	-	-	-	-	-	-	-	46	**39%**	18	0.588	0.033	0%
RL	Duke Engineering Services Hanford	20	2	-	-	-	-	-	-	-	-	22	9%	2	0.065	0.033	0%
OR	Oak Ridge Inst. for Sci. & Educ. (ORISE)	37	12	-	-	-	-	-	-	-	-	49	24%	12	0.370	0.031	0%
SR	Westinghouse S.R. Subcontractors	42	12	-	-	-	-	-	-	-	-	54	22%	12	0.353	0.029	0%
AL	Sandia National Laboratory	1,436	76	5	1	-	-	-	-	-	-	1,518	5%	82	2.369	0.029	0%
OAK	Rockwell International, Rocketdyne ETEC	200	47	3	-	-	-	-	-	-	-	250	20%	50	1.423	0.028	0%
SR	Savannah River Field Office	63	13	-	-	-	-	-	-	-	-	76	17%	13	0.276	0.021	0%
SR	Miscellaneous DOE Contractors – SR	18	8	-	-	-	-	-	-	-	-	26	31%	8	0.164	0.021	0%
RL	Fluor Daniel Northwest	10	1	-	-	-	-	-	-	-	-	11	9%	1	0.020	0.020	0%
CH	Ames Laboratory (Iowa State)	117	6	-	-	-	-	-	-	-	-	123	5%	6	0.110	0.018	0%

Note: Arrowed values indicate the greatest value in each column.

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 1997 (Continued)

RESEARCH, GENERAL

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	SGN Eurisys Services Corp.	11	2	-	-	-	-	-	-	-	-	13	15%	2	0.026	0.013	0%
SR	Univ. of Georgia Ecology Laboratory	14	1	-	-	-	-	-	-	-	-	15	7%	1	0.013	0.013	0%
AL	Protection Technologies Los Alamos	9	2	-	-	-	-	-	-	-	-	11	18%	2	0.021	0.011	0%
AL	Johnson Controls, Inc.	14	2	-	-	-	-	-	-	-	-	16	13%	2	0.017	0.009	0%
SR	Wackenhut Services, Inc. – SR	25	2	-	-	-	-	-	-	-	-	27	7%	2	0.016	0.008	0%
RL	Babcock Wilcox Hanford	8	-	-	-	-	-	-	-	-	-	8	0%	-	-	-	0%
HQ	DOE Headquarters	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Fluor Daniel – Hanford	3	-	-	-	-	-	-	-	-	-	3	0%	-	-	-	0%
ID	Idaho Field Office	11	-	-	-	-	-	-	-	-	-	11	0%	-	-	-	0%
OAK	LLNL Subcontractors	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	LMITCO Subcontractor - Coleman	2	-	-	-	-	-	-	-	-	-	2	0%	-	-	-	0%
ID	LMITCO Subcontractor - Parsons	4	-	-	-	-	-	-	-	-	-	4	0%	-	-	-	0%
RL	Lockheed Martin Hanford	7	-	-	-	-	-	-	-	-	-	7	0%	-	-	-	0%
AL	Los Alamos Area Office	2	-	-	-	-	-	-	-	-	-	2	0%	-	-	-	0%
AL	Nat. Renewable Energy Lab (NREL) - GO	9	-	-	-	-	-	-	-	-	-	9	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	32	-	-	-	-	-	-	-	-	-	32	0%	-	-	-	0%
RL	NUMATEC Hanford	4	-	-	-	-	-	-	-	-	-	4	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. – NTS	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Rust Services Hanford	3	-	-	-	-	-	-	-	-	-	3	0%	-	-	-	0%
SR	SR Army Corps of Engineers	4	-	-	-	-	-	-	-	-	-	4	0%	-	-	-	0%
	Total	**16,842**	**2,119**	**350**	**138**	**35**	**25**	**12**	**1**	**1**	**0**	**19,523**	**14%**	**2,681**	**225.950**	**0.084**	**28%**

Note: Arrowed values indicate the greatest value in each column.

LANL continued to have the highest number of individuals with measurable TEDE and the highest collective dose (~43% of the total). ORNL had the highest total monitored individuals and ~24% of the total collective TEDE. All facilities have reductions in collective TEDE and average measurable TEDE.

B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, Fusion, 1997

RESEARCH, FUSION

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
OAK	Lawrence Livermore National Laboratory	188	18	4	1	6	2	-	-	219	14%	31	**7.244** ◄	**0.234** ◄	**76%** ◄
CH	Princeton Plasma Physics Laboratory	293	81	6	1	-	-	-	-	**381** ◄	**23%** ◄	**88** ◄	2.943	0.033	0%
AL	Los Alamos National Laboratory	56	11	1	-	-	-	-	-	68	18%	12	0.341	0.028	0%
AL	Sandia National Laboratory	17	1	-	-	-	-	-	-	18	6%	1	0.020	0.020	0%
	Total	**554**	**111**	**11**	**2**	**6**	**2**	**0**	**0**	**686**	**19%**	**132**	**10.548**	**0.080**	**52%**

Note: Arrowed values indicate the greatest value in each column.

LLNL and the Princeton Plasma Physics Laboratory were the primary contributors to collective TEDE in 1997. The average measurable dose and collective dose increased significantly at LLNL with a decrease in personnel monitored. The overall collective dose for this program had a reduction in collective dose of approximately 7%.

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 1997

WASTE PROCESSING

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	Fluor Daniel Northwest Services	13	4	1	-	2	1	-	-	21	38%	8	2.263	**0.283** ◄	**88%** ◄
OR	Bechtel National, Inc. – (FUSRAP)	338	14	4	3	-	-	1	-	360	6%	22	3.907	0.178	42%
RL	Babcock Wilcox Hanford	273	55	16	11	1	1	-	-	357	24%	84	9.651	0.115	15%
AL	Johnson Controls, Inc.	-	-	1	-	-	-	-	-	1	**100%** ◄	1	0.105	0.105	0%
RL	Fluor Daniel – Hanford	552	266	73	38	3	1	-	-	933	41%	381	**35.766** ◄	0.094	7%
RL	NUMATEC Hanford	55	6	1	-	-	-	-	-	62	11%	7	0.480	0.069	0%
CH	Brookhaven National Laboratory	46	12	2	-	-	-	-	-	60	23%	14	0.804	0.057	0%
RL	Duke Engineering Services Hanford	45	6	1	-	-	-	-	-	52	13%	7	0.358	0.051	0%
RL	DynCorp Hanford	32	2	-	-	-	-	-	-	34	6%	2	0.100	0.050	0%
CH	Argonne National Laboratory – East	58	18	3	–	-	-	-	-	79	27%	21	1.034	0.049	0%
ID	LMITCO - Services	195	62	8	-	-	-	-	-	265	26%	70	3.350	0.048	0%
RL	Bechtel Power Co.	6	1	-	-	-	-	-	-	7	14%	1	0.047	0.047	0%
RL	Lockheed Martin Hanford	266	14	2	-	-	-	-	-	282	6%	16	0.681	0.043	0%
SR	Westinghouse Savannah River Co.	2,155	549	53	1	-	-	-	-	**2,758** ◄	22%	**603** ◄	24.421	0.040	0%
SR	Bechtel Construction - SR	305	172	11	-	-	1	-	-	489	38%	184	7.168	0.039	12%
AL	Los Alamos National Laboratory	157	40	3	1	-	-	-	-	201	22%	44	1.675	0.038	0%
RL	Fluor Daniel Northwest	30	3	-	-	-	-	-	-	33	9%	3	0.085	0.028	0%
OR	Morrison-Knudsen (WSSRAP)	238	9	-	-	-	-	-	-	247	4%	9	0.231	0.026	0%
RL	Rust Services Hanford	192	20	-	-	-	-	-	-	212	9%	20	0.440	0.022	0%
SR	Westinghouse S.R. Subcontractors	169	61	2	-	-	-	-	-	232	27%	63	1.278	0.020	0%
RL	SGN Eurisys Services Corp.	23	6	-	-	-	-	-	-	29	21%	6	0.118	0.020	0%
RL	Richland Field Office	-	2	-	-	-	-	-	-	2	**100%** ◄	2	0.034	0.017	0%
SR	Wackenhut Services, Inc. – SR	3	2	-	-	-	-	-	-	5	40%	2	0.026	0.013	0%

Note: Arrowed values indicate the greatest value in each column.

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 1997 (Continued)

WASTE PROCESSING

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
AL	Carlsbad Area Misc. Contractors	360	8	-	-	-	-	-	-	368	2%	8	0.103	0.013	0%
AL	Sandia National Laboratory	98	22	-	-	-	-	-	-	120	18%	22	0.272	0.012	0%
SR	Savannah River Field Office	71	8	-	-	-	-	-	-	79	10%	8	0.091	0.011	0%
RL	Babcock Wilcox Protection, Inc.	2	1	-	-	-	-	-	-	3	33%	1	0.010	0.010	0%
RL	Battelle Memorial Institute (PNL)	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
AL	Carlsbad Area Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Duke Eng. & Services Northwest, Inc.	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
ID	Idaho Field Office	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
OAK	Lawrence Livermore National Lab.	70	-	-	-	-	-	-	-	70	0%	-	-	-	0%
ID	LMITCO Subcontractor - Coleman	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
ID	LMITCO Subcontractor - Parsons	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Lockheed Martin Services, Inc.	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
AL	Los Alamos Area Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
SR	Miscellaneous DOE Contractors – SR	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
NV	Nevada Field Office	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	64	-	-	-	-	-	-	-	64	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. - NTS	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	Rust Federal Services Northwest	7	-	-	-	-	-	-	-	7	0%	-	-	-	0%
NV	Science Applications Int'l. Corp.- NV	15	-	-	-	-	-	-	-	15	0%	-	-	-	0%
OH	West Valley Nuclear Services, Inc.	65	-	-	-	-	-	-	-	65	0%	-	-	-	0%
RL	Westinghouse Hanford Services	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
AL	WIPP Project Integration Office	14	-	-	-	-	-	-	-	14	0%	-	-	-	0%
	Total	**5,949**	**1,363**	**181**	**54**	**6**	**4**	**1**	**0**	**7,558**	**21%**	**1,609**	**94.498**	**0.059**	**9%**

Note: Arrowed values indicate the greatest value in each column.

Hanford (Fluor Daniel/BWH) and Savannah River (Westinghouse/Bechtel) remain the dominant contributors to collective TEDE (52% and 35% respectively). All facilities and personnel dose categories have at least limited reductions in 1997 with overall collective TEDE reduced by 36%.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Weapons Fabrication, 1997

WEAPONS FABRICATION

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
SR	Westinghouse S.R. Subcontractors	16	3	-	1	1	-	-	-	21	24%	5	1.022	**0.204** ◄	**54%** ◄
SR	Westinghouse Savannah River Co.	259	129	65	51	22	3	-	-	529	51%	270	49.025	0.182	32%
OH	EG&G Mound Applied Technologies	5	-	1	-	-	-	-	-	6	17%	1	0.129	0.129	0%
RFO	Rocky Flats Prime Contractors	551	1,368	477	220	54	7	6	-	2,683	80%	**2,132** ◄	**256.235** ◄	0.120	17%
SR	Bechtel Construction – SR	46	31	18	5	-	-	-	-	100	54%	54	5.757	0.107	0%
OAK	Lawrence Livermore National Lab.	942	15	1	2	-	-	-	-	960	2%	18	1.281	0.071	0%
RFO	Rocky Flats Subcontractors	1,261	631	148	28	1	-	-	-	2,069	39%	808	55.799	0.069	1%
RFO	Rocky Flats Office	113	165	4	2	-	-	-	-	284	60%	171	9.802	0.057	0%
NV	Reynolds Elec. & Engr. Co. – NTS	1,276	19	4	-	-	-	-	-	1,299	2%	23	1.295	0.056	0%
SR	Wackenhut Services, Inc. – SR	53	98	6	-	-	-	-	-	157	66%	104	5.606	0.054	0%
AL	Mason & Hanger – Amarillo	6,278	175	19	5	-	-	-	-	**6,477** ◄	3%	199	10.606	0.053	0%
AL	Albuquerque Field Office	159	4	1	-	-	-	-	-	164	3%	5	0.201	0.040	0%
AL	Battelle – Pantex	239	13	1	-	-	-	-	-	253	6%	14	0.465	0.033	0%
SR	Savannah River Field Office	20	4	-	-	-	-	-	-	24	17%	4	0.110	0.028	0%
RFO	Rocky Flats Office Subs	27	8	1	-	-	-	-	-	36	21%	9	0.234	0.026	0%
NV	B.N. – NTS Subcontractors	1	2	-	-	-	-	-	-	3	67%	2	0.049	0.025	0%
AL	Sandia National Laboratory	482	11	-	-	-	-	-	-	493	2%	11	0.237	0.022	0%
OR	Lockheed Martin Energy Sys. (Y-12)	4,084	561	3	-	1	1	-	-	4,650	12%	566	10.669	0.019	13%
AL	Martin Marietta Specialty Comp. Inc.	368	7	-	-	-	-	-	-	375	2%	7	0.105	0.015	0%
AL	Kirtland Area Office	28	2	-	-	-	-	-	-	30	7%	2	0.023	0.012	0%
AL	Los Alamos National Laboratory	9	4	-	-	-	-	-	-	13	31%	4	0.042	0.011	0%
OH	EG&G Mound Subcontractors	-	2	-	-	-	-	-	-	2	**100%** ◄	2	0.005	0.003	0%
AL	Albuquerque Transportation Division	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
AL	Amarillo Area Office	112	-	-	-	-	-	-	-	112	0%	-	-	-	0%
NV	Defense Nuclear Agency-Kirtland AFB	37	-	-	-	-	-	-	-	37	0%	-	-	-	0%
NV	Environmental Prot. Agency (NERC)	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
SR	Miscellaneous DOE Contractors – SR	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	16	-	-	-	-	-	-	-	16	0%	-	-	-	0%
	Totals	**16,391**	**3,252**	**749**	**314**	**79**	**11**	**6**	**0**	**20,802**	**21%**	**4,411**	**408.697**	**0.093**	**15%**

Note: Arrowed values indicate the greatest value in each column.

Rocky Flats Prime Contractors continued to be responsible for the largest number of individuals with measurable dose and the highest collective dose for the Weapons Fabrication Facility type. Westinghouse Savannah River Company had only a small number of individuals with measurable TEDE which accounted for their high average. Rocky Flats Prime Contractors also had the highest number of individuals with doses above 0.5 rem (65).

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1997

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
HQ	Nuclear Assurance Corp. (NAC)	4	3	4	3	2	-	4	-	20	80%	16	7.850	**0.491**	**75%**
RL	Bechtel Power Co.	1,061	153	35	19	29	17	11	-	1,325	20%	264	**61.442**	0.233	72%
RL	Fluor Daniel Northwest Services	52	11	1	6	1	1	-	-	72	28%	20	4.460	0.223	33%
ID	MK-Ferguson Co. - ID	4	2	-	1	-	-	-	-	7	43%	3	0.387	0.129	0%
ID	Lockheed Martin Idaho Tech. Co.-Services	1,954	62	4	5	3	4	-	-	2,032	4%	78	9.013	0.116	59%
ID	LMITCO Subcontractors - Constructon	522	246	102	26	12	1	-	-	909	43%	**387**	44.351	0.115	19%
RL	Duke Engineering Services Hanford	120	8	1	1	-	-	-	-	130	8%	10	0.844	0.084	0%
HQ	Pacific Northwest Lab. - Korea	2	2	1	-	-	-	-	-	5	60%	3	0.220	0.073	0%
AL	Johnson Controls, Inc.	106	33	5	5	-	-	-	-	149	29%	43	3.120	0.073	0%
OAK	Lawrence Livermore National Lab.	2,322	56	2	2	-	-	1	-	**2,383**	3%	61	3.797	0.062	30%
CH	Argonne National Laboratory - East	2	2	1	-	-	-	-	-	5	60%	3	0.169	0.056	0%
OH	EG&G Mound Security Forces	31	1	-	-	-	-	-	-	32	3%	1	0.051	0.051	0%
RL	Battelle Memorial Institute (PNL)	771	76	5	1	1	-	-	-	854	10%	83	3.745	0.045	16%
AL	Los Alamos National Laboratory	1,518	288	12	4	-	-	4	-	1,826	17%	308	13.764	0.045	42%
HQ	DOE Headquarters	26	4	1	-	-	-	-	-	31	16%	5	0.205	0.041	0%
CH	Brookhaven National Laboratory	417	67	6	2	-	-	-	-	492	15%	75	2.999	0.040	0%
OH	West Valley Nuclear Services, Inc.	967	162	10	1	1	-	-	-	1,141	15%	174	6.929	0.040	8%
RL	Fluor Daniel Northwest	304	11	1	-	-	-	-	-	316	4%	12	0.463	0.039	0%
HQ	DOE North Korea Project	11	3	-	-	-	-	-	-	14	21%	3	0.115	0.038	0%
HQ	CenTech 21 – North Korea	-	2	-	-	-	-	-	-	2	**100%**	2	0.075	0.038	0%
AL	Sandia National Laboratory	430	21	2	-	-	-	-	-	453	5%	23	0.809	0.035	0%
RL	Babcock Wilcox Hanford	399	11	1	-	-	-	-	-	411	3%	12	0.410	0.034	0%
RL	Fluor Daniel - Hanford	322	30	2	-	-	-	-	-	354	9%	32	1.042	0.033	0%
OH	Miamisburg Area Office	20	2	-	-	-	-	-	-	22	9%	2	0.064	0.032	0%
OH	EG&G Mound Applied Technologies	494	150	14	3	-	-	-	-	661	25%	167	5.210	0.031	0%
OR	Rust Engineering Company	866	338	23	8	-	-	-	-	1,235	30%	369	11.491	0.031	0%
RL	Rust Services Hanford	179	9	-	-	-	-	-	-	188	5%	9	0.255	0.028	0%
RL	Babcock Wilcox Protection, Inc.	48	5	-	-	-	-	-	-	53	9%	5	0.134	0.027	0%

Note: Arrowed values indicate the greatest value in each column.

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1997 (Continued)

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
OR	Jacobs Environmental Restoration Team	116	2	-	-	-	-	-	-	118	2%	2	0.052	0.026	0%
ID	LMITCO Subcontractor - Coleman	12	1	-	-	-	-	-	-	13	8%	1	0.023	0.023	0%
RL	Westinghouse Hanford Service Subs	38	2	-	-	-	-	-	-	40	5%	2	0.045	0.023	0%
RL	Richland Field Office	1,151	45	1	-	-	-	-	-	1,197	4%	46	1.021	0.022	0%
AL	Los Alamos Area Office	19	4	-	-	-	-	-	-	23	17%	4	0.083	0.021	0%
AL	Allied-Signal, Inc.	114	4	-	-	-	-	-	-	118	3%	4	0.080	0.020	0%
RL	Lockheed Martin Hanford	68	3	-	-	-	-	-	-	71	4%	3	0.060	0.020	0%
ID	Idaho Field Office	33	4	-	-	-	-	-	-	37	11%	4	0.070	0.018	0%
RFO	Rocky Flats Office	870	66	1	-	-	-	-	-	937	7%	67	1.099	0.016	0%
OH	EG&G Mound Subcontractors	203	12	-	-	-	-	-	-	215	6%	12	0.183	0.015	0%
OR	RMI Company	107	42	-	-	-	-	-	-	149	28%	42	0.624	0.015	0%
SR	Miscellaneous DOE Contractors – SR	1	1	-	-	-	-	-	-	2	50%	1	0.013	0.013	0%
RL	Hanford Environmental Health Foun.	34	1	-	-	-	-	-	-	35	3%	1	0.012	0.012	0%
CH	Argonne National Laboratory - West	-	2	-	-	-	-	-	-	2	**100%** ◀	2	0.023	0.012	0%
RL	SGN Eurisys Services Corp.	14	1	-	-	-	-	-	-	15	7%	1	0.011	0.011	0%
CH	Chicago Field Office	96	2	-	-	-	-	-	-	98	2%	2	0.020	0.010	0%
CH	Environmental Meas. Lab.	12	1	-	-	-	-	-	-	13	8%	1	0.010	0.010	0%
AL	Kansas City Area Office	6	1	-	-	-	-	-	-	7	14%	1	0.010	0.010	0%
SR	Savannah River Field Office	14	1	-	-	-	-	-	-	15	7%	1	0.010	0.010	0%
AL	MK-Ferguson Co. - UMTRA	48	10	-	-	-	-	-	-	58	17%	10	0.099	0.010	0%
SR	Westinghouse Savannah River Co.	250	9	-	-	-	-	-	-	259	3%	9	0.079	0.009	0%
AL	MK-Ferguson Subs - UMTRA	285	26	-	-	-	-	-	-	311	8%	26	0.195	0.008	0%
AL	Protection Technologies Los Alamos	80	7	-	-	-	-	-	-	87	8%	7	0.051	0.007	0%
NV	B.N. - NTS Subcontractors	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	Babcock & Wilcox Idaho, Inc.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
CH	Battelle Memorial Inst. - Columbus (Old)	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
SR	Bechtel Construction - SR	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
NV	Bechtel Nevada - NTS	5	-	-	-	-	-	-	-	5	0%	-	-	-	0%
NV	Defense Nuclear Agency-Kirtland AFB	11	-	-	-	-	-	-	-	11	0%	-	-	-	0%

Note: Arrowed values indicate the greatest value in each column.

B-17: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1997 (Continued)

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas. 0-0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	Percent of TEDE above 0.5 rem
RL	Duke Eng. & Services Northwest, Inc.	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
RL	DynCorp Hanford	10	-	-	-	-	-	-	-	10	0%	-	-	-	0%
NV	EG&G Kirtland	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
NV	EG&G Santa Barbara	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
ID	Idaho Office Subs	3	-	-	-	-	-	-	-	3	0%	-	-	-	0%
RL	Kaiser Engineers Hanford - Cost Const	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
ID	LMITCO Subcontractor - Parsons	6	-	-	-	-	-	-	-	6	0%	-	-	-	0%
OR	Lockheed Martin Energy Systems (K-25)	15	-	-	-	-	-	-	-	15	0%	-	-	-	0%
OR	Lockheed Martin Energy Systems (Y-12)	188	-	-	-	-	-	-	-	188	0%	-	-	-	0%
ID	Lockheed Martin Idaho Tech. Co.-Const.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
RL	Lockheed Martin Services, Inc.	9	-	-	-	-	-	-	-	9	0%	-	-	-	0%
AL	Mason & Hanger - Amarillo	241	-	-	-	-	-	-	-	241	0%	-	-	-	0%
OH	Miamisburg Office Subs	25	-	-	-	-	-	-	-	25	0%	-	-	-	0%
NV	Nevada Field Office	161	-	-	-	-	-	-	-	161	0%	-	-	-	0%
NV	Nevada Miscellaneous Contractors	24	-	-	-	-	-	-	-	24	0%	-	-	-	0%
NV	Nevada Operations	10	-	-	-	-	-	-	-	10	0%	-	-	-	0%
RL	NUMATEC Hanford	24	-	-	-	-	-	-	-	24	0%	-	-	-	0%
NV	Nye County Sheriff	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
OH	Ohio Field Office	14	-	-	-	-	-	-	-	14	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. - NTS	51	-	-	-	-	-	-	-	51	0%	-	-	-	0%
NV	Reynolds Elec. & Engr. Co. Services	50	-	-	-	-	-	-	-	50	0%	-	-	-	0%
RL	Rust Federal Services Northwest	13	-	-	-	-	-	-	-	13	0%	-	-	-	0%
SR	Southern Bell Tel. & Tel.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
OAK	U. of Cal./Davis, Radiobiology Lab-LEHR	34	-	-	-	-	-	-	-	34	0%	-	-	-	0%
OH	University of Georgia Ecology Lab.	1	-	-	-	-	-	-	-	1	0%	-	-	-	0%
HQ	US Dept. of State - North Korea	4	-	-	-	-	-	-	-	4	0%	-	-	-	0%
RL	Westinghouse Hanford Services	2	-	-	-	-	-	-	-	2	0%	-	-	-	0%
SR	Westinghouse S.R. Subcontractors	26	-	-	-	-	-	-	-	26	0%	-	-	-	0%
	Total	**17,472**	**2,005**	**235**	**87**	**49**	**23**	**20**	**0**	**19,891**	**12%**	**2,419**	**187.287**	**0.077**	**39%**

Note: Arrowed values indicate the greatest value in each column.

There was an 11% increase in collective TEDE for the Other facility type for 1996 to 1997. The largest single contributor was Bechtel Power Company at Hanford, a 550% increase since 1996. LMITCO Construction Subcontractors in Idaho also experienced a 250% increase in collective TEDE and had the highest number of individuals with measurable TEDE in 1997 in the Other facility type.

B-18: Internal Dose by Facility Type and Nuclide, 1995-1997

Facility Type	Nuclide*	No. of Individuals with New Intakes**			Collective CEDE (person-rem)			Average CEDE (rem)		
		1995	1996	1997	1995	1996	1997	1995	1996	1997
Accelerator	Hydrogen-3	15	13	16	0.272	0.191	0.322	0.018	0.015	0.020
	Other	6			0.008			0.001		
	Uranium	1	1	1	0.014	0.014	0.001	0.014	0.014	0.001
	Total	**22**	**14**	**17**	**0.294**	**0.205**	**0.323**	**0.013**	**0.015**	**0.019**
Fuel Fabrication	Hydrogen-3	2	2		0.008	0.009		0.004	0.005	
	Plutonium			3			0.048			0.016
	Thorium	25	31	8	0.228	0.612	0.132	0.009	0.020	0.017
	Uranium	83	34	13	0.504	0.438	0.051	0.006	0.013	0.004
	Total	**110**	**67**	**24**	**0.740**	**1.059**	**0.231**	**0.007**	**0.016**	**0.010**
Fuel Processing	Americium	1			0.059			0.059		
	Hydrogen-3	83	126	123	0.261	0.299	0.264	0.003	0.002	0.002
	Mixed	1			0.042			0.042		
	Plutonium	8	7	3	1.478	**11.955** ◄	0.344	0.185	1.708	0.115
	Uranium			1			0.016			0.016
	Total	**93**	**133**	**127**	**1.840**	**12.254**	**0.624**	**0.020**	**0.092**	**0.005**
Fuel/Uranium Enrichment	Other		1			0.002			0.002	
	Technetium		2	8		0.006	0.009	0.009	0.003	0.001
	Thorium	3	112	1	0.027	8.628	0.001	0.009	0.077	0.001
	Uranium	43	33	34	0.231	0.176	0.157	0.005	0.005	0.005
	Total	**46**	**148**	**43**	**0.258**	**8.812**	**0.167**	**0.006**	**0.060**	**0.004**
Maintenance and Support	Americium	19	12		0.398	0.031		0.021	0.003	
	Hydrogen-3	104	121	94	0.357	0.654	0.522	0.003	0.005	0.006
	Mixed and Other	2	8	1	0.122	0.040	0.069	0.061	0.005	0.069
	Plutonium	12	8	5	1.664	0.273	3.203	0.139	0.034	**0.641** ◄
	Thorium	2		5	0.645		0.020	**0.323** ◄		0.004
	Uranium	48	28	11	0.372	0.176	0.035	0.008	0.006	0.003
	Total	**187**	**177**	**116**	**3.558**	**1.174**	**3.849**	**0.019**	**0.007**	**0.033**
Other	Hydrogen-3	9	10	78	0.022	0.038	0.499	0.002	0.004	0.006
	Other	9	5	1	0.382	0.025	0.049	0.042	0.005	0.049
	Plutonium	17	5	3	5.133	3.334	0.177	0.302	0.667	0.059
	Radon-222			270			**27.834** ◄			0.103
	Uranium	40	70	260	3.124	1.475	1.641	0.078	0.021	0.006
	Total	**75**	**90**	**612**	**8.661**	**4.872**	**30.200**	**0.115**	**0.054**	**0.049**
Reactor	Hydrogen-3	338	**328** ◄	304	4.787	4.049	3.305	0.014	0.012	0.011
	Mixed & Other			3			0.022			0.007
	Total	**338**	**328**	**307**	**4.787**	**4.049**	**3.327**	**0.014**	**0.012**	**0.011**
Research, Fusion	Hydrogen-3	48	87	53	0.251	0.477	0.153	0.005	0.005	0.003
	Total	**48**	**87**	**53**	**0.251**	**0.477**	**0.153**	**0.005**	**0.005**	**0.003**
Research, General	Americium		4	3		0.541	0.059		0.135	0.020
	Hydrogen-3	52	36	36	0.286	0.294	0.177	0.006	0.008	0.005
	Mixed & Other	21	14	11	0.870	0.201	0.255	0.045	0.014	0.023
	Plutonium	8	6	14	0.577	5.022	7.232	0.072	**0.837** ◄	0.517
	Uranium	41	33	20	0.345	0.208	0.136	0.008	0.006	0.007
	Total	**122**	**92**	**84**	**2.078**	**6.079**	**7.859**	**0.017**	**0.066**	**0.094**
Waste Processing	Americium			1			0.004			0.004
	Hydrogen-3	38	20	8	0.133	0.469	0.015	0.004	0.023	0.002
	Mixed & Other	10	3	2	0.468	0.015	0.221	0.047	0.005	0.111
	Plutonium		12			1.600			0.133	
	Thorium		5	3		0.393	0.669		0.079	0.223
	Uranium	17	22	16	0.585	6.409	3.858	0.034	0.291	0.241
	Total	**65**	**62**	**30**	**1.186**	**8.886**	**4.767**	**0.018**	**0.143**	**0.158**
Weapons Fab. and Testing	Americium			5			0.501			0.100
	Hydrogen-3	121	54	22	0.618	0.210	0.193	0.005	0.004	0.009
	Plutonium	18	28	38	4.862	2.113	2.045	0.270	0.075	0.053
	Uranium	**607** ◄	318	**431** ◄	**6.179** ◄	3.484	7.127	0.010	0.011	0.016
	Total	**746**	**400**	**496**	**11.659**	**5.807**	**9.866**	**0.016**	**0.015**	**0.019**
Totals		**1,852**	**1,599**	**1,909**	**35.312**	**53.524**	**61.366**	**0.019**	**0.033**	**0.032**

* Intakes grouped by nuclide. Intakes involving multiple nuclides were grouped into "mixed".
Nuclides where fewer than 10 individuals had intakes were grouped as "other".
**Individuals may be counted more than once.
Note: Arrowed values indicate the greatest value in each column.

Radon-222 was added to the list in the Other facility type in 1997 and resulted in the largest collective dose. The highest average internal dose was due to plutonium at Maintenance and Support facilities in 1997, a significant change from 1996. Weapons Fabrication and Testing increased the number of individuals with new intakes.

B-19a: Distribution of TEDE by Labor Category, 1995

Total Effective Dose Equivalent (TEDE)
Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	>2	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	51	7	1	1					60	15%	9	0.521	0.058
Construction	5,935	1,887	263	110	20	8	12		8,235	28%	2,300	164.232	0.071
Laborers	1,113	516	125	59	17	10	2		1,842	40%	729	76.317	0.105
Management	15,762	1,492	88	31	12	3	2	1	17,391	9%	1,629	78.946	0.048
Misc.	22,173	3,141	259	69	19	4	3	1	25,669	14%	3,496	169.447	0.048
Production	3,388	2,061	358	226	113	18	3		6,167	**45%**	2,779	282.010	0.101
Scientists	27,343	3,173	231	81	15	3	10		**30,856**	11%	3,513	153.724	0.044
Service	4,236	880	63	15	3		1		5,198	19%	962	37.031	0.038
Technicians	8,219	2,705	780	304	83	31	26		12,148	32%	3,929	429.095	0.109
Transport	1,172	279	18	10	6				1,485	21%	313	17.979	0.057
Unknown	14,271	3,131	357	228	86	54	98		18,225	22%	**3,954**	**435.444**	**0.110**
Totals	**103,663**	**19,272**	**2,543**	**1,134**	**374**	**131**	**157**	**2**	**127,276**	**19%**	**23,613**	**1,844.746**	**0.078**

Note: Arrowed values indicate the greatest value in each column.

B-19b: Distribution of TEDE by Labor Category, 1996

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	>4	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	53	7	1									61	13%	8	0.379	0.047
Construction	8,200	2,129	304	108	28	10	9					10,788	24%	2,588	176.814	0.068
Laborers	867	429	49	49	11	2	2					1,409	**38%**	542	48.967	0.090
Management	15,451	1,083	94	29	6							16,663	7%	1,212	57.154	0.047
Misc.	16,807	4,503	362	86	31	19	11					21,819	23%	**5,012**	259.840	0.052
Production	4,281	1,790	324	217	80	14	8				1	6,714	36%	2,433	267.423	0.110
Scientists	28,509	3,503	228	63	17	9	8					**32,337**	12%	3,828	164.366	0.043
Service	4,418	501	44	18	3	1	2					4,987	11%	569	31.678	0.056
Technicians	7,964	2,364	758	315	94	25	19	1				11,540	31%	3,576	**416.642**	**0.117**
Transport	1,179	371	13	8	6	3						1,580	25%	401	18.760	0.047
Unknown	12,870	2,079	264	110	63	16	21	1	1			15,425	17%	2,555	209.937	0.082
Totals	**100,599**	**18,759**	**2,441**	**1,003**	**339**	**99**	**80**	**2**	**1**	**0**	**1**	**123,323**	**18%**	**22,724**	**1,651.960**	**0.073**

Note: *Arrowed values indicate the greatest value in each column.*

B-19c: Distribution of TEDE by Labor Category, 1997

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas. 0-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	>4	>5	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
Agriculture	43	5	2		1							51	16%	8	1.072	0.134
Construction	5,017	1,383	183	85	27	15	2					6,712	25%	1,695	125.741	0.074
Laborers	742	331	84	39	28	17	10					1,251	**41%**	509	81.893	**0.161**
Management	10,558	1,224	135	34	7	2						11,960	12%	1,402	75.409	0.053
Misc.	10,451	1,822	224	45	2							12,544	17%	2,093	98.201	0.046
Production	2,853	1,404	250	103	27	6	4					4,647	39%	1,794	144.308	0.080
Scientists	23,221	2,732	242	58	9	9	2					26,273	12%	3,052	136.118	0.044
Service	3,419	579	33	16	5	1						4,053	16%	634	35.025	0.055
Technicians	5,632	1,820	598	292	87	19	8					8,456	33%	2,824	**336.295**	0.119
Transport	1,278	154	18	4		1						1,455	12%	177	8.364	0.047
Unknown	25,292	3,808	372	180	71	31	22	1	1	1		**29.779**	15%	**4,487**	313.678	0.069
Totals	**88,506**	**15,262**	**2,141**	**856**	**264**	**101**	**48**	**1**	**1**	**1**	**0**	**107,181**	**17%**	**18,675**	**1,356.104**	**0.073**

Note: Arrowed values indicate the greatest value in each column.

Unknown has become the largest category of personnel monitored with measurable dose due to aggressive subcontracting/outsourcing efforts that may not report labor categories to dosimetry organizations. Technicians was the labor category with the highest collective dose again in 1997 but, Laborers received the highest average measurable dose (up significantly for 1996) and they remained the highest percent monitored with measurable dose.

B-20: Internal Dose by Labor Category, 1995 - 1997

Labor Category	Number of Individuals with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Construction	206	226	278	1.739	7.707	5.580	0.008	0.034	0.020
Laborers	73	41	91	0.565	0.900	9.687	0.008	0.022	0.106
Management	121	105	100	6.889	1.472	1.779	**0.057**	0.014	0.018
Misc.	217	219	283	**7.297**	12.655	2.214	0.034	**0.058**	0.007
Production	**549**	**370**	320	5.881	**16.286**	4.224	0.011	0.044	0.013
Scientist	157	200	214	4.879	4.366	4.137	0.031	0.022	0.019
Service	50	46	42	0.329	0.282	0.214	0.007	0.006	0.005
Technicians	245	219	219	4.946	3.705	5.786	0.020	0.016	0.026
Transport	5	10	2	0.040	0.504	0.312	0.008	0.050	**0.156**
Unknown	229	163	**360**	2.747	5.647	**27.433**	0.012	0.035	0.076
Totals	**1,852**	**1,599**	**1,909**	**35.312**	**53.524**	**61.366**	**0.019**	**0.033**	**0.032**

* Only included intakes that occurred during the monitoring year. Individuals may be counted more than once.

Note: Arrowed values indicate the greatest value in each column.

The Unknown labor category has increased significantly in the number of individuals with new intakes and also accounts for over 47% of the collective internal dose. Laborers account for the highest (17%) known labor category collective internal dose and the highest average internal dose. Technicians are the highest collective and average internal dose labor category. The unknown categories are often subcontractors who do not provide information on occupational categories to the reporting organizations. The increase from 1996 to 1997 for the Unknown labor category is due largely to radon-222 inclusion at Grand Junction (reported with Idaho) for the first time in 1997.

B-21: Dose Distribution by Labor Category and Occupation, 1997

Labor Category	Occupation	Less Than Meas.	Meas. <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1-2	2-3	3-4	>4	Total Monitored	Percent with Meas.	No. with Meas.	Collective TEDE	Average Meas. TEDE
Agriculture	Groundskeepers	43	5	2	-	1	-	-	-	-	-	51	16%	8	1.072	0.134
Construction	Carpenters	235	91	20	4	-	-	-	-	-	-	350	33%	115	7.049	0.061
	Electricians	1,187	350	40	18	1	-	-	-	-	-	1,596	26%	409	22.289	0.054
	Masons	18	7	-	-	-	-	-	-	-	-	25	28%	7	0.139	0.020
	Mechanics/Repairers	913	364	31	11	1	-	-	-	-	-	1,320	31%	407	17.473	0.043
	Miners/Drillers	87	-	-	-	-	-	-	-	-	-	87	0%	-	-	-
	Misc. Repair/Construction	2,024	344	48	24	7	1	1	-	-	-	2,449	17%	425	31.291	0.073
	Painters	128	43	7	-	-	-	-	-	-	-	178	28%	50	2.481	0.050
	Pipe Fitter	425	184	37	28	18	14	1	-	-	-	707	40%	282	45.019	0.159
Laborers	Handlers/Laborers/Helpers	742	331	84	39	28	17	10	-	-	-	1,251	41%	509	81.893	0.161
Management	Admin. Support and Clerical	3,975	455	52	4	2	-	-	-	-	-	4,488	11%	513	24.694	0.048
	Manager - Administrator	6,570	769	83	30	5	2	-	-	-	-	7,459	12%	889	50.715	0.057
	Sales	13	-	-	-	-	-	-	-	-	-	13	0%	-	-	-
Misc.	Military	47	-	-	-	-	-	-	-	-	-	47	0%	-	-	-
	Miscellaneous	10,404	1,822	224	45	2	-	-	-	-	-	12,497	17%	2,093	98.201	0.046
Production	Machine Setup/Operators	43	13	3	1	-	-	-	-	-	-	59	35%	16	0.931	0.058
	Machinists	269	48	17	3	-	-	1	-	-	-	338	20%	69	6.368	0.092
	Misc. Precision/Production	193	9	2	-	-	-	-	-	-	-	204	5%	11	0.467	0.042
	Operators, Plant/System/Util.	2,130	1,273	211	100	27	6	3	-	-	-	3,750	43%	1,620	131.481	0.081
	Sheet Metal Workers	114	45	11	-	-	-	-	-	-	-	170	33%	56	3.314	0.059
	Welders and Solderers	104	16	5	1	-	-	-	-	-	-	126	17%	22	1.747	0.079
Scientists	Doctors and Nurses	257	17	1	1	-	-	-	-	-	-	276	7%	19	1.045	0.055
	Engineer	8,302	1,058	93	21	7	5	1	-	-	-	9,487	13%	1,185	56.323	0.047
	Health Physicist	436	134	10	6	-	1	-	-	-	-	587	25%	151	8.009	0.053
	Misc. Professional	5,914	707	75	13	-	1	-	-	-	-	6,710	12%	796	34.001	0.042
	Scientist	8,312	816	63	17	2	2	1	-	-	-	9,213	10%	901	36.740	0.041
Service	Firefighters	466	53	-	-	-	-	-	-	-	-	519	10%	53	1.427	0.026
	Food Service Employees	28	2	-	-	-	-	-	-	-	-	30	7%	2	0.050	0.025
	Janitors	535	48	9	1	-	-	-	-	-	-	593	10%	58	3.294	0.057
	Misc. Service	587	47	6	6	-	-	-	-	-	-	646	9%	59	4.389	0.074
	Security Guards	1,803	429	18	9	5	1	-	-	-	-	2,265	20%	462	25.865	0.055
Technicians	Engineering Technicians	1,094	176	49	36	14	6	4	-	-	-	1,379	21%	285	43.280	0.152
	Health Technicians	380	108	46	22	10	2	-	-	-	-	568	33%	188	27.365	0.146
	Misc. Technicians	2,074	345	69	16	3	2	-	-	-	-	2,509	17%	435	30.725	0.070
	Radiation Monitors/Techs.	909	692	306	130	32	5	1	-	-	-	2,075	**56%** ◄	1,166	142.144	0.121
	Science Technicians	451	163	74	71	23	3	3	-	-	-	788	44%	337	64.116	**0.190** ◄
	Technicians	724	336	54	17	5	1	-	-	-	-	1,137	36%	413	28.665	0.069
Transport	Bus Drivers	24	2	-	-	-	-	-	-	-	-	26	8%	2	0.033	0.017
	Equipment Operators	274	84	14	2	-	1	-	-	-	-	375	27%	102	5.987	0.058
	Misc. Transport	401	22	4	1	-	-	-	-	-	-	428	6%	27	1.388	0.051
	Pilots	1	-	-	-	-	-	-	-	-	-	1	0%	-	-	-
	Truck Drivers	579	46	-	-	-	-	-	-	-	-	625	7%	46	0.956	0.021
Unknown	Unknown	25,292	3,808	372	180	71	31	22	1	1	1	**29,779** ◄	15%	**4,487** ◄	**313.678** ◄	0.069
Totals		**88,509**	**15,266**	**2,135**	**855**	**262**	**101**	**47**	**1**	**1**	**1**	**107,181**	**17%**	**18,675**	**1,356.104**	**0.073**

Note: Arrowed values indicate the greatest value in each column.

The largest labor category shifted from Miscellaneous to Unknown in 1997 which accounted for 23% of the collective TEDE. These two categories combined contributed 30% of the collective TEDE, 39% of the total monitored, and 25% of those individuals with measurable dose. There were fewer Radiation Monitors/Technicians but their 56% with measurable dose remained constant from 1996 to 1997. The collective TEDE was a reduction in 1997, however it is now the highest known labor category for collective dose followed by Plant/System/Utility Operators. Science technicians have the highest average measurable TEDE while the highest individual doses reported were in the unknown category.

B-22: Internal Dose Distribution by Site and Nuclide, 1997

Operations/ Field Office	Site	Nuclide	Number of Individuals Receiving Doses in Each Dose Range										Total Individuals with Meas. CEDE	Collective CEDE (person-rem)	Average CEDE (rem)
			Meas. -0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	>4.0			
Albuquerque	Ops. and Other Facilities	Hydrogen-3	4	2									6	0.085	0.014
	Los Alamos Nat'l. Lab (LANL)	Hydrogen-3	37	3									40	0.263	0.007
		Other	1										1	0.001	0.001
		Plutonium			1		2		2		2		7	10.100	**1.443**
		Uranium	27	1									28	0.117	0.004
	Pantex Plant (PP)	Hydrogen-3	3										3	0.003	0.001
Chicago	Ops. and Other Facilities	Hydrogen-3	43										43	0.103	0.002
		Plutonium	3										3	0.003	0.001
		Thorium	5										5	0.020	0.004
	Argonne Nat'l. Lab - East (ANL-E)	Americium	2	1									3	0.060	0.020
		Hydrogen-3	1										1	0.003	0.003
		Plutonium	4	4									8	0.259	0.032
	Argonne Nat'l. Lab - West (ANL-W)	Plutonium		1									1	0.070	0.070
	Brookhaven Nat'l. Lab (BNL)	Hydrogen-3	39	20	7								66	2.282	0.035
Idaho	Idaho Site	Other	2										2	0.020	0.010
		Plutonium	1	1									2	0.037	0.019
		Radon-222		181	74	13	2						270	**27.834**	0.103
		Uranium	1	1									2	0.037	0.019
Nevada	NTS	Americium		2	2								4	0.473	0.118
Oakland	Lawrence Berkeley Lab. (LBL)	Hydrogen-3	7	1	1								9	0.238	0.026
	Lawrence Livermore Nat'l. Lab. (LLNL)	Hydrogen-3	9										9	0.066	0.007
Oak Ridge	Ops. and Other Facilities	Uranium	28	11	4	3			1				47	4.185	0.089
	Oak Ridge Site	Americium	1										1	0.003	0.003
		Hydrogen-3	21										21	0.033	0.002
		Other	6	2	1								9	0.253	0.028
		Plutonium		1									1	0.070	0.070
		Technetium	8										8	0.009	0.001
		Uranium	569	87	2		1	1					**660**	7.866	0.012
	Paducah Gaseous Diff. Plant (PGDP)	Uranium		1									1	0.023	0.023
	Portsmouth Gaseous Diff. Plant (PORTS)	Thorium	1										1	0.001	0.001
		Uranium	1										1	0.002	0.002
Ohio	Ops. and Other Facilities	Hydrogen-3	1										1	0.004	0.004
	Fernald Environmental Mgmt. Project	Plutonium	2	1									3	0.048	0.016
		Thorium	4	4									8	0.132	0.017
		Uranium	12	1									13	0.051	0.004
	Mound Plant	Hydrogen-3	66	6									72	0.477	0.007
		Uranium	31										31	0.066	0.002
	WVNS	Mixed		1									1	0.049	0.049
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	Americium		1									1	0.028	0.028
		Plutonium	24	8	4	1	1						38	2.045	0.053
		Uranium	3				1						4	0.675	0.168
Richland	Hanford Site	Mixed	1	2	1								4	0.292	0.073
		Other	1										1	0.001	0.001
		Plutonium	1		1								2	0.153	0.077
Savannah River	Savannah River Site (SRS)	Hydrogen-3	449	14									463	1.893	0.004
		Plutonium	1		2		1						4	0.933	0.233
Totals			**1,420**	**358**	**100**	**17**	**8**	**1**	**3**	**0**	**2**	**0**	**1,909**	**61.366**	**0.032**

Radon-222 has been added in 1997 at Grand Junction (reported with Idaho) and is the largest contributor of collective CEDE. At LANL, plutonium collective CEDE more than doubled while the average CEDE was reduced significantly. Uranium collective CEDE was reduced significantly in 1997 due to a reduction of individuals with measurable CEDE (the average remained steady). Rocky Flats internal dose from plutonium increased slightly due to an increase in clean-up activities. The overall increase in collective internal dose and total individual with measurable internal dose was due to the 270 individuals monitored for Radon-222 at Grand Junction.

B-23: Extremity Dose Distribution by Operations/Site, 1997

Operations	Site	No Meas. Dose	Meas. –0.1	0.1-1	1-5	5-10	10-20	20-30	30-40	>40	Total Monitored*	No. with Meas.	No. Above Monitoring Threshold. (5 rem)**	Collective Extremity Dose (person-rem)	Average Meas. Extremity Dose (rem)
Albuquerque	Albuquerque	1,049	13	-	-	-	-	-	-	-	1,062	13	-	0.313	0.024
	Los Alamos National Lab. (LANL)	8,370	73	257	67	7	2	1	2	-	8,779	409	12	403.189	0.986
	Pantex Plant (PP)	6,941	46	85	11	-	-	-	-	-	7,083	142	-	51.506	0.363
	Sandia National Lab. (SNL)	3,529	31	18	3	1	-	-	-	-	3,582	53	1	20.088	0.379
	UMTRA	369	-	-	-	-	-	-	-	-	369	-	-	-	-
Chicago	Chicago Operations	1,048	33	9	-	-	-	-	-	-	1,090	42	-	3.691	0.088
	Argonne Nat'l. Lab. - East (ANL-E)	2,907	102	36	3	2	2	1	-	-	3,053	146	5	80.060	0.548
	Argonne Nat'l. Lab. - West (ANL-W)	819	13	30	4	-	-	-	-	-	866	47	-	18.835	0.401
	Brookhaven Nat'l. Lab. (BNL)	4,764	1,010	201	9	-	-	-	-	-	5,984	1,220	-	91.580	0.075
	Fermi Nat'l. Accelerator Lab. (FERMI)	2,357	2	4	2	-	-	-	-	-	2,365	8	-	4.230	0.529
DOE HQ	DOE Headquarters	33	-	-	-	-	-	-	-	-	33	-	-	-	-
	North Korea Project	45	-	-	-	-	-	-	-	-	45	-	-	-	-
Idaho	Idaho Site	6,286	70	56	12	-	-	-	-	-	6,424	138	-	37.903	0.275
Nevada	Nevada Test Site (NTS)	1,816	13	4	-	-	-	-	-	-	1,833	17	-	1.656	0.097
Oakland	Oakland Operations	230	51	3	-	-	-	-	-	-	284	54	-	1.503	0.028
	Lawrence Berkeley Lab.(LBL)	1,843	15	12	7	1	1	-	-	-	1,879	36	2	43.577	**1.210**
	Lawrence Livermore Nat'l. Lab. (LLNL)	7,506	51	48	15	2	-	-	-	-	7,622	116	2	64.139	0.553
	Stanford Linear Accelerator Center (SLAC)	2,069	-	-	-	-	-	-	-	-	2,069	-	-	-	-
Oak Ridge	Oak Ridge Operations	2,251	-	-	-	-	-	-	-	-	2,251	-	-	-	-
	Oak Ridge Site	14,688	24	68	17	-	-	-	-	-	14,797	109	-	68.941	0.632
	Paducah Gaseous Diff. Plant (PGDP)	442	-	-	-	-	-	-	-	-	442	-	-	-	-
	Portsmouth Gaseous Diff. Plant (PORTS)	144	-	-	-	-	-	-	-	-	144	-	-	-	-
Ohio	Ohio Field Office	71	-	-	-	-	-	-	-	-	71	-	-	-	-
	Fernald Environmental Mgmt. Project	2,697	7	2	-	-	-	-	-	-	2,706	9	-	0.924	0.103
	Mound Plant	1,043	5	8	-	-	-	-	-	-	1,056	13	-	2.024	0.156
	West Valley	1,188	12	6	-	-	-	-	-	-	1,206	18	-	2.488	0.138
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	2,841	2,126	898	137	15	2	-	-	-	6,009	3,168	**17**	735.615	0.232
Richland	Hanford Site	8,017	2,363	964	255	3	2	-	-	-	11,604	**3,587**	5	**926.788**	0.258
Savannah River	Savannah River Site (SRS)	9,147	2,360	870	94	2	-	-	-	-	12,473	3,326	2	498.244	1.150
	Totals	**94,510**	**8,420**	**3,569**	**636**	**33**	**9**	**2**	**2**	**0**	**107,181**	**12,671**	**46**	**3,057.294**	**0.241**

* Represents the total number of monitoring records. The number of individuals provided extremity monitoring cannot be determined.

** All extremity doses above 5 rem were for the upper extremities (hands and forearms). DOE annual limit for extremities is 50 rem. 10 CFR 835.402(a)(1)(ii) requires extremity monitoring for a shallow dose equivalent to the skin or extremity of 5 rem or more in a year.

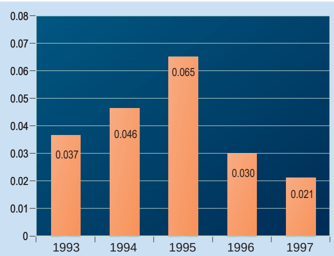
The collective extremity dose and the largest number of individuals with extremity measurments were at Hanford, followed closely by Rocky Flats. Savannah River and LANL also had significant collective dosimetry dose and the highest average extremity doses (LBL had the highest extremity dose). LANL and ANL-E had the largest individual extremity measurements.

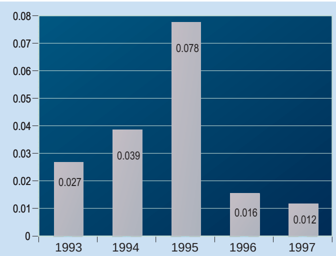
B-24: Summary Results of Statistical Tests for the Seven Highest-Dose Sites

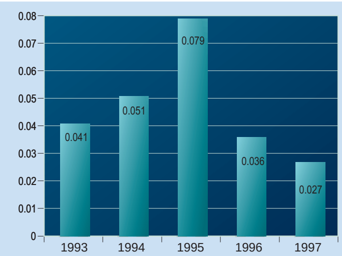
Results of statistical analysis for the seven highest-dose sites are presented in Exhibit B-24. The approach used a combination of pairwise T-tests and 2 nonparametric tests. The T-tests for differences among means relied on the Least Significant Difference technique commonly used in analysis of variance, which uses a pooled variance to conduct pairwise T-tests on all possible pairs of means. Although this method is the most powerful way to test for differences between two years, it runs a higher risk than other methods of generating false positive results when used for multi-year comparisons. To minimize this risk, the T-test results were confirmed using two nonparametric tests. These methods don't require a normal distribution, and can test whether two or more distributions remained roughly the same shape. The nonparametric tests used here include analysis of variance using ranks rather than raw data values, and the Kruskall-Wallis test. Cases with some positive and some negative results may suggest that the differences result from a few extreme values, rather than a change in the remainder of the distribution. The results of the statistical analysis for all of DOE are presented in Section 3.2.6.

Site	Logarithmic Mean of the TEDE (rem)				Logarithmic Mean of the Neutron Dose (rem)			Logarithmic Mean of the Extremity Dose (rem)		
	Change 96-97	'96-'97 △ Mean	'96-'97 △ Dist.	Trends	'96-'97 △ Mean	'96-'97 △ Dist.	Trends	'96-'97 △ Mean	'96-'97 △ Dist.	Trends
Brookhaven National Lab.	↓	✔	○	The TEDE: 1996 & 1997 means decreased after 3 years of significant increases.	✘	○	Neutron values for 1996 & 1997 lower than all other years.	✘	✔	Extremity values for 1996 & 1997 lower than all other years.
Hanford	↓	✘	✔	Mean TEDE increased in levels between 1993-1994 and 1995-1997.	✘	✔	Neutron dose has had a significant decrease since 1993.	✘	✔	Extremity dose significantly increased since 1993 and 1994.
Idaho	↑	✔	✔	1997 seems to have returned to 1994 & 1995 levels; significant drop in all years since 1993.	✘	✔	No significant change in means since 1993.	✘	✔	Significant downward trend since an increase in 1995.

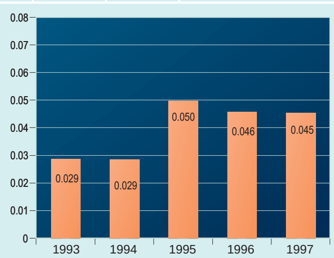
Brookhaven National Lab.

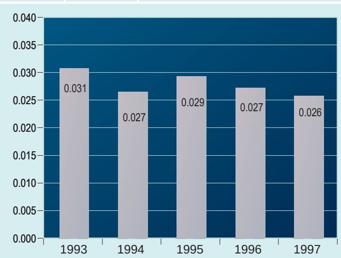


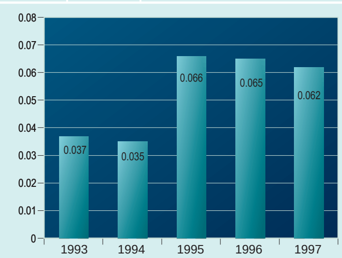




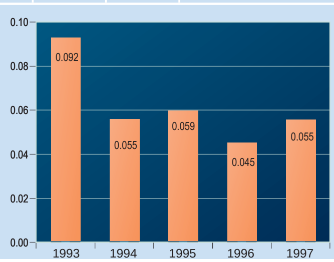
Hanford

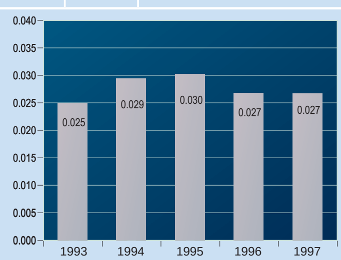


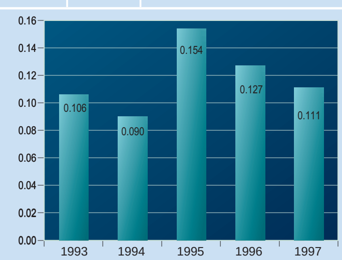




Idaho



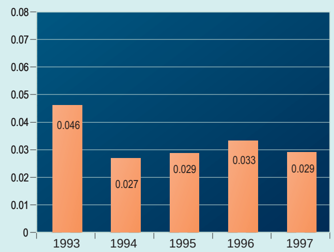


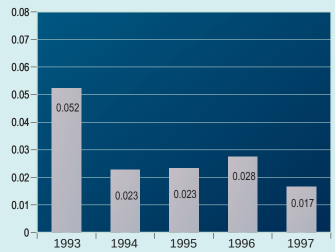


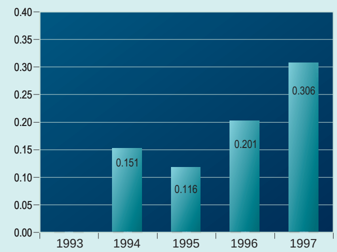
△ Mean = Change in logarithmic mean. △ Dist. = Change in Distribution ✔ Significant change. ✘ No significant change. ○ Mixed results.

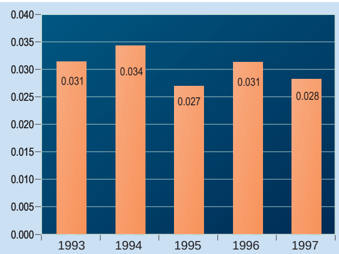
B-24: Summary Results of Statistical Tests for the Seven Highest-Dose Sites (continued)

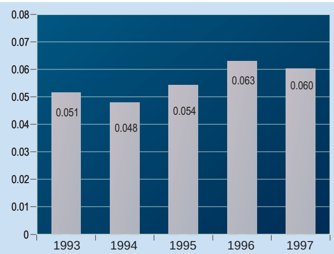
Site	Logarithmic Mean of the TEDE (rem)				Logarithmic Mean of the Neutron Dose (rem)			Logarithmic Mean of the Extremity Dose (rem)		
	Change 96-97	'96-'97 △ Mean	'96-'97 △ Dist.	Trends	'96-'97 △ Mean	'96-'97 △ Dist.	Trends	'96-'97 △ Mean	'96-'97 △ Dist.	Trends
Los Alamos National Lab.	⬇	✔	○	The decrease to lower values since 1993 is significant, except for 1996.	✔	✔	Decrease since 1993 is significant.	✔	✔	Significant rising trend from 1995 to 1997.
Oak Ridge Site	⬇	✔	✔	1997 shows slight but significant decrease.	✘	○	Only 1994-1996 difference (highest to lowest) is significant.	✘	✔	Significant increasing trend over 5 years.
Rocky Flats	⬆	✔	✔	Steady upward trend; changes in all years are significant.	✔	✔	Small but significant increase since 1994.	✔	✔	Significant change in means from .05 rem in 1994-1995 to .07 rem in 1996-1997.
Savannah River	⬆	✔	✔	Significant upward trend since 1994.	✔	○	1994 significantly higher and 1997 significantly lower than remaining years.	✔	✔	Significant drop from 1993-1994; significant increases in 1996 & 1997.

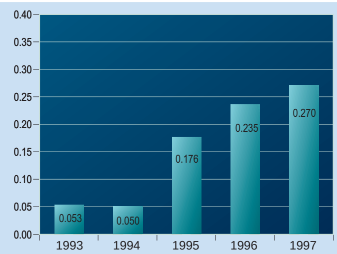


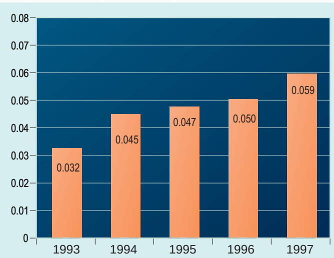


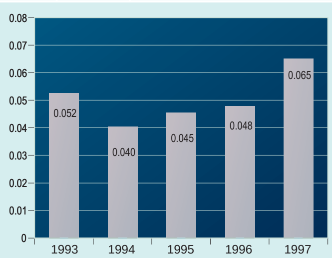


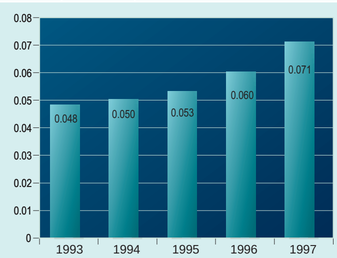


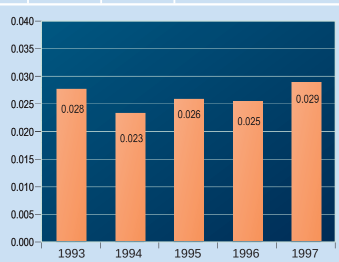


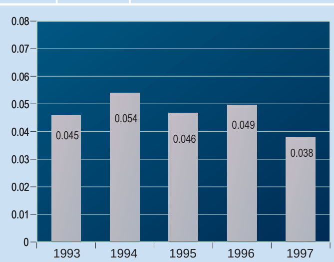


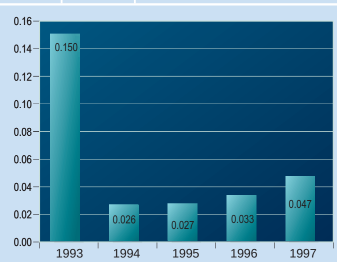












△ Mean = Change in logarithmic mean. △ Dist. = Change in Distribution ✔ Significant change. ✘ No significant change. ○ Mixed results.

Facility Type Code Descriptions

DOE Order 5484.1 [10] requires contractors to indicate for each reported individual the facility contributing the predominant portion of that individual's effective dose equivalent. In cases when this cannot be distinguished, the facility type indicated should represent the facility type wherein the greatest portion of work service was performed.

The facility type indicated must be one of 11 general facility categories shown in *Exhibit C-1*. Because it is not always a straightforward procedure to determine the appropriate facility type for each individual, the assignment of an individual to a particular facility type is a policy decision of each contractor.

The facility descriptions that follow indicate the types of facilities included in each category. Also included are the types of work performed at the facilities and the sources of the majority of the radiation exposures.

Accelerator

The DOE administers approximately a dozen laboratories that perform significant accelerator-based research. The accelerators range in size from small single-room electrostatic devices to a 4-mile circumference synchrotron, and their energies range from keV to TeV.

The differences in accelerator types, sizes, and energies result in differences in the radiation types and dose rates associated with the accelerator facilities. In general, radiation doses to employees at the facilities are attributable to neutrons and X-rays, as well as muons at some larger facilities. Dose rates inside the primary shielding can range up to 0.2 rem/hr as a result of X-ray production near some machine components. Outside the shielding, however, X-ray exposure rates are very low, and neutron dose rates are generally less than 0.005 rem/hr. Average annual doses at these facilities are slightly higher than the overall average for DOE; however, the collective dose is lower than the collective dose for most other DOE facility categories because of the relatively small number of employees at accelerator facilities. Regarding internal exposures, tritium and short-lived airborne activation products exist at some accelerator facilities, although annual internal doses are generally quite low.

Fuel/Uranium Enrichment

The DOE involvement in the nuclear fuel cycle generally begins with uranium enrichment operations and facilities [14]. The current method of enrichment is isotopic separation using the gaseous diffusion process, which involves diffusing uranium through a porous membrane and using the different atomic weights of the uranium isotopes to achieve separation.

Although current facility designs and physical controls result in low doses from internally deposited uranium, the primary radiological hazard is the potential for inhalation of airborne uranium [14]. Because of the low specific activity of uranium, external dose rates are usually a few millirem per hour or less. Most of the external doses that are received are attributable to gamma

Exhibit C-1: Facility Type Codes

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

exposures, although neutron exposures can occur, especially when work is performed near highly enriched uranium. Both the average and collective external doses at these facilities are among the lowest of any DOE facility category.

Fuel Fabrication

Activities at fuel fabrication facilities involve the physical conversion of uranium compounds to usable forms, usually rod-shaped metal. Radiation exposures to personnel at these facilities are attributable almost entirely to gamma and beta radiation. However, beta radiation is considered the primary external radiation hazard because of high beta dose rates (up to several hundred mrad per hour) at the surface of uranium rods [14]. For example, physical modification of uranium metal by various metalworking operations, such as machining and lathing operations, requires protection against beta radiation exposures to the skin, eyes, and extremities. Average external doses at fuel fabrication facilities are generally higher than at other types of DOE facilities; however, collective doses are relatively low because the number of employees is low. Internal doses from inhalation of uranium are kept very low.

Fuel Processing

The DOE administers several facilities that reprocess spent reactor fuel. These facilities separate the plutonium produced in reactors for use in defense programs. They also separate the fission products and uranium; the fission products are normally designated as radioactive waste products, while the uranium can be refabricated for further use as fuel.

The very high radioactivity of fission products in spent nuclear fuel results in employees at fuel processing facilities consistently having among the highest average doses of any DOE facility type. However, the collective dose at these facilities is less significant because of the small total number of employees. Penetrating doses are attributable primarily to gamma photons, although some neutron exposures do occur. Skin and extremity doses from handling samples are also significant, although only a few employees typically receive skin doses greater than 5 rem/year. Strict controls are in place at fuel reprocessing facilities to prevent internal depositions; however, several measurable intakes typically occur per year. Plutonium isotopes represent the majority of the internal depositions, and annual effective dose equivalents from the depositions are typically less than 0.5 rem.

Maintenance and Support

Most DOE sites have facilities dedicated to maintaining and supporting the site. In addition, some employees may be classified under this facility type if their main function is to provide site maintenance and support, even though they may not be located at a single facility dedicated to that purpose.

Because many maintenance and support activities at DOE sites do not involve work near sources of ionizing radiation, the average dose equivalent per monitored employee is typically among the lowest of any facility type. However, those employees who do perform work near radiation sources receive relatively high average annual doses, as is indicated by the relatively high average annual dose per employee who receives a measurable exposure. Also, collective doses are relatively high because there is a large number of these employees relative to the number classified under other facility types. The sources of ionizing radiation exposure are primarily gamma photons. However, variations in the types of work performed and work locations result in exposures of all types, including exposures to beta particles, x-rays, neutrons, and airborne radioactivity.

Reactor

The DOE and its predecessors have built and operated dozens of nuclear reactors since the mid-1940s. These facilities have included plutonium and tritium production reactors, prototype reactors for energy production, research reactors, reactors designed for special purposes such as production of medical radioisotopes, and reactors designed for the propulsion of naval vessels.

In 1992, many of the DOE reactors were not operating. As a result, personnel exposures at DOE reactor facilities were attributable primarily to gamma photons and beta particles from contaminated equipment and plant areas, spent reactor fuel, activated reactor components, and other areas containing fission or activation products encountered during plant maintenance and decommissioning operations. Neutron exposures do occur at operating reactors, although the resulting doses are a very small fraction of the collective penetrating doses. Gamma dose rates in some plant areas can be very high (up to several rems per hour), requiring extensive protective measures. The average and collective external doses relative to other facility types are highly dependent on the status of reactor operations. Inhalation of airborne radioactive material such as H-3 is a concern in some plant areas. However, protective measures, such as area ventilation or use of respiratory-protection equipment, result in low internal doses.

Research, General

The DOE contractors perform research at many DOE facilities, including all of the national laboratories. Research is performed in general areas including biology, biochemistry, health physics, materials science, environmental science, epidemiology, and many others. Research is also performed in more specific areas such as global warming, hazardous waste disposal, energy conservation, and energy production.

The spectrum of research involving ionizing radiation or radioactive materials being performed at DOE facilities results in a wide variety of radiological conditions. Depending on the research performed, personnel may be exposed to virtually any type of external radiation, including beta particles, gamma photons, x-rays, and neutrons. In addition, there is the potential for inhalation of radioactive material. Area dose rates and individual annual doses are highly variable. Relative to other facility types, average annual individual doses are slightly above average at general research facilities. The collective dose equivalent is higher than at most other facility types because of the many individuals employed at general research facilities.

Research, Fusion

DOE currently operates both major and small facilities that participate in research on fusion energy. In general, both penetrating and shallow radiation doses are minimal at these facilities because the dose rates near the equipment are both low and intermittent. The external doses that do occur are attributable primarily to x-rays from energized equipment. Relative to other DOE facility types, average individual doses and collective doses are typically the lowest at fusion research facilities. Regarding internal exposures, airborne tritium is a concern at some fusion research facilities, although the current level of operation results in minimal doses.

Waste Processing/Management

Most DOE sites have facilities dedicated to the processing and disposal of radioactive waste. In general, the dose rates to employees when handling waste are very low because of the low specific activities or the effectiveness of shielding materials. As a result, very few employees at these facilities receive annual doses greater than 0.1 rem. At two DOE sites, however, large-scale waste processing facilities exist to properly dispose of radioactive waste products generated during the nuclear fuel cycle. At these facilities, radiation doses to some employees can be relatively high, sometimes exceeding 1 rem/year. Penetrating doses at waste processing facilities are attributable primarily to gamma photons; however, neutron exposures are significant at the large-scale facilities. Skin doses are generally not a significant problem. Overall, average annual doses at waste processing/management facilities are among the highest of any DOE facility type, which is attributable primarily to the two large-scale facilities and the shift in DOE mission from national defense production to waste management and environmental restoration. The annual collective doses are closer to the average of all facility types, however, because of the relatively small number of employees at this type of facility.

Weapons Fabrication and Testing

The primary function of a facility in this category is to fabricate weapons-grade material for the production or testing of nuclear weapons. At the testing facilities, radiation doses received by personnel are generally minimal because of the strict controls over personnel access to testing areas, although extremity doses can be relatively high from handling neutron-activated materials. Radiation doses are a greater concern at facilities where weapons and weapons-grade nuclear material are handled. At these facilities, neutron radiation dose rates can be significant when processing relatively small quantities of ^{238}Pu or larger quantities of mixed plutonium isotopes [15]. Penetrating doses from gamma photons and plutonium x-rays can also be significant in some situations, as can skin and extremity doses from plutonium x-rays. Overall, average individual annual doses at these facilities are slightly higher than the DOE average. The collective doses received by employees at these facilities are generally higher than the collective doses at other facility types because of the large number of individuals employed.

Also of significant concern at these facilities is inhalation of plutonium, where inhalation of very small amounts can result in doses exceeding limits. To prevent plutonium intakes, strict controls are in place including process containment, contamination control procedures, and air monitoring and bioassay programs [15]. As a result, significant internal exposures are very rare at these facilities.

Other

Individuals included in this facility type can be generally classified under three categories: (1) those who worked in a facility that did not match one of the ten facility types described above; (2) those who did not work for any appreciable time at any specific facility, such as transient workers; or (3) those for whom facility type was not indicated on the report forms. Examples of a facility type not included in the ten described above include construction and irradiation facilities. In general, employees classified under this facility type receive annual doses significantly less than the annual doses averaged over all DOE facilities. However, the wide variation in the type of work performed by these individuals results in a wide variation in the types and levels of exposures. Although exposures to gamma photons are predominant, some individuals may be exposed to beta particles, x-rays, neutrons, or airborne radioactive material.

Appendix D
Limitations of Data

The following is a description of the limitations of the data currently available in the DOE Radiation Exposure Monitoring System (REMS). While these limitations have been taken into consideration in the analysis presented in this report, readers should be alert to these limitations and consider their implications when drawing conclusions from these data.

Individual Dose Records vs Dose Distribution

Prior to 1987, exposure data were reported from each facility in terms of a statistical dose distribution wherein the number of individuals receiving a dose within specific dose ranges was reported. The collective dose was then calculated from the distribution by multiplying the number of individuals in each dose range by the midpoint value of the dose range. Starting in 1987, reports of individual exposures were collected that recorded the specific dose for each monitored individual. The collective dose can be accurately determined by summing the total dose for each individual. The dose distribution reporting method prior to 1987 resulted in up to a 20% overestimation of collective dose. The reason is that the distribution of doses within a range is usually skewed toward the lower end of the range. If the midpoint of the range is multiplied by the number of people in the range, the product overestimates the collective dose.

Monitoring Practices

Radiation monitoring practices differ widely from site to site and are based on the radiation hazards and work practices at each site. Sites use different dosimeters and have different policies on which workers to monitor. While all sites have achieved compliance with the DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurements, there are still differences in the dosimeters used that can contribute to differences in the collective dose from site to site. The number of monitored individuals can significantly impact the site's collective dose. Some sites supply dosimeters to virtually all workers. While this tends to inflate the number of monitored workers with no dose, it also can add a large number of very low dose workers to the total number of workers with measurable dose, thereby lowering the site's average measurable dose. Even at low doses, these workers add significantly to the site collective dose. In contrast, other sites only monitor workers who exceed the monitoring requirement threshold (as specified in 10 CFR 835.402). This tends to reduce the number of monitored workers and reports only those workers receiving doses in the higher dose ranges. This can decrease the site's collective dose while increasing the average measurable dose.

AEDE vs CEDE

Prior to 1990, the dose resulting from penetrating ionizing radiation (external dose) and the dose resulting from the intake of radionuclides (internal dose), was reported separately. In 1993, the DOE changed the internal dose calculation methodology from annual effective dose equivalent (AEDE) to the 50-year committed effective dose equivalent (CEDE). The total effective dose equivalent (TEDE) then became the sum of the CEDE and the deep dose equivalent (DDE). This report presents TEDE data from 1993 through 1997. Internal AEDE data are reported for 1992 and internal CEDE data are reported for 1993 through 1997. Where possible, the legacy component of the AEDE data is highlighted when presenting TEDE data that are trended for the years 1990 to 1992. See Section 2.4 for a discussion of this change in requirements.

Occupation Codes

Each individual's dose record includes the occupation code for the individual while he or she worked at the DOE site during the monitoring year. Occupational codes typically represent the occupation the individual held at the end of the calendar year and may not represent the occupation where the majority of dose was received if the individual held multiple occupations during the year. The occupation codes are very broad categorizations and are grouped into nine general categories. Each year a percentage (up to 20%) of the occupations are listed as unknown, or as miscellaneous. The definitions of each of the labor categories are subject to interpretation by the reporting organization and/or the individual's employer. It is recommended that Sites and Operations Offices evaluate their recordkeeping and reporting process and report the information to the REMS system as specified in DOE M 231.1-1 to improve the analysis of radiation exposure by occupation, and thus make this report more useful to line manager and worker protection decision makers.

Facility Type

The facility type is also recorded with each dose record for the monitoring year. It is intended to reflect the type of facility where the individual received most of their occupational radiation exposure during the monitoring year. While the facility types are clearly defined (see Appendices A and C), the reporting organizations often have difficulty tracking which facility type contributed to the majority of the individual's exposure. Certain individuals tend to work in the proximity of several different facility types throughout the monitoring year and are often included in the "Maintenance and Support (Site-wide)" facility type. The facility type for temporary contract workers and visitors is often not reported and is defaulted to "unknown."

In addition to these uncertainties, the phase of operation of the facility types is not currently reported. A facility type of "accelerator" may be reported when in fact, the accelerator has not been in operation for a considerable time and may be in the process of stabilization, decommissioning, or decontamination. In addition, several sites have commented that they have difficulty assigning the facility type, because many of the facilities are no longer operational. For example, some sites commented that a reactor that is being decommissioned is no longer considered a "reactor" facility type. Other sites continue to categorize a facility based on the original intent or design of the facility, regardless of its current status.

DOE Headquarters will be reviewing the Facility Type codification scheme and modifying the reporting requirements to standardize the use of facility type classifications and improve the quality of the data and the data analysis. DOE will also pursue the usefulness of collecting data on the operational phase of facilities with end-users of this report. A "phase of operation" status code could be added to the occupational radiation reporting requirements for individual dose records (see Appendix A-4). In combination with the facility type codes already reported, this would provide an indication of the operational mode and type of activities being conducted at a given facility. This will become increasingly important as more facilities transition from stabilization activities into D&D. It is recommended that Sites and Operations Offices begin reviewing their data collection process in anticipation of collecting the phase of operation data in the future.

Organization Code

Facilities report data to the central repository based on an "organization code." This code identifies the Operations or Field Office, the reporting facility, and the contractor or subcontractor that is reporting the exposure information. The organization code changes over time as DOE Offices are reorganized. In some cases, new Operations or Field Offices are created, in other cases a Field Office may change organizations and begin reporting with another Field Office. Two such changes are noteworthy within the past several years. The Fernald Field Office began reporting independently in 1993. Prior to 1993 it reported under the Oak Ridge Field Office. In 1994, Fernald was incorporated into the newly created Ohio Field Office. The Ohio Field Office began reporting in 1994. For this reason, the Fernald data are shown under the Ohio Field Office. The Mound Plant and West Valley Project also changed Operations Office during the past 3 years and are now shown under the Ohio Field Office. Footnotes indicate the change in Operations Offices.

Occurrence Reports

Occurrence reports involving radiation exposure and personnel contamination events are additional indicators of the effectiveness of radiation protection efforts at DOE. These events will continue to be analyzed and presented in this report. Particular attention will be given to exposure events that were categorized as having resulted from management problems and unknown sources of radiation. Because this root cause category was added to the occurrence reporting requirements in 1995, insufficient data exist to identify a trend at this time. However, these events are of particular concern due to the potential for exposure and the large number of these occurrences in 1996 and 1997. It is recommended that sites reporting these occurrences review and remediate situations that result in these exposure occurrences.

Additional Data Requirements

To provide analysis of the activities at DOE sites with respect to radiation exposure (see Section 3.5), it is necessary to augment the information reported to the REMS database. For the past 3 years, DOE Headquarters has requested additional information from the seven sites with the highest collective dose. This information includes a summary of activities, project descriptions, and ALARA planning documentation. DOE Headquarters will continue to request this information in subsequent years. It is recommended that sites submit this information with their annual records.

Naval Reactor Facilities

The exposure information for the Schenectady and Pittsburgh Naval Reactor facilities is not included in this report. Readers should note that the dose information for the overall DOE complex presented in this report may differ from other reports or sources of information because of the exclusion of these data.

Exposure information for Naval Reactor programs can be found in the most recent version of the following series of reports (where XX represents the report year):

- NT-XX-2 – "Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities",
- NT-XX-3 – "Occupational Radiation Exposure from U.S. Naval Reactors' Department of Energy Facilities".

Updates to the Data

The data in the REMS database are subject to correction and update on a continual basis. Data for prior years are subject to correction as well as the data for the most recent year included in this report. The most common reason for correction to a dose record is because of a final dose determination of an internal dose long after the original dose record was submitted to REMS. This delay is due to the time needed to assess the bioassay results and determine the dose from long-lived radionuclides. It is recommended that sites review their dose record update and reporting process, specifically for internal dose determination, and consider the addition of a mechanism whereby they report dose updates to REMS in a timely fashion when updates occur. Corrections will be reflected in subsequent annual reports. For the most up-to-date status of radiation exposure information, contact:

Ms. Nirmala Rao
REMS Project Manager
U.S. Department of Energy
Office of Worker Protection Programs and
Hazards Management (EH-52)
Germantown, MD 20874

Access to Radiation Exposure Information

Radiation Exposure Monitoring System

The data used to compile this report were obtained from the DOE Radiation Exposure Monitoring System (REMS), which serves as the central repository of radiation exposure information for DOE Headquarters. Recently, the REMS has undergone an extensive redesign effort in combination with the efforts involved in revising the annual report. One of the main goals of the redesign effort is to allow researchers better access to the REMS data. However, there is considerable diversity in the goals and needs of these researchers. For this reason, a multi-tiered approach has been developed to allow researchers flexibility in accessing the REMS data.

Exhibit E-1 lists the various ways of accessing the DOE radiation exposure information contained in REMS. A description is given for each access method as well as requirements for access and skill sets needed for each method. Descriptions of the intended research audience and experience level (for computer systems) are also provided. To obtain further information, a contact name and phone number are provided.

A brief summary of the multi-tier access to the REMS information is shown in *Exhibit E-1*.

The data contained in the REMS system are subject to periodic update. Data for the current or previous years may be updated as corrections or additions are submitted by the sites. For this reason, the data presented in published reports may not agree with the current data in the REMS database. These updates typically have a relatively small impact on the data and should not affect the general conclusions and analysis of the data presented in this report.

Comprehensive Epidemiologic Data Resource

Of interest to researchers in radiation exposure is the health risk associated with worker exposure to radiation. While the health risk from occupational exposure is not treated in this report, it has been extensively researched by DOE. The Comprehensive Epidemiologic Data Resource (CEDR) serves as a central resource for radiation health risk studies at the DOE.

Epidemiologic studies on health effects of radiation exposures have been supported by the DOE for more than 30 years. The results of these studies, which initially focused on the evaluation of mortality among workers employed in the nuclear weapons complex, have been published in scientific literature. However, the data collected during the conduct of the studies were not widely shared. CEDR has now been established as a public-use database to broaden independent access and use of these data. At its introduction in 1993, CEDR included primarily occupational studies of the DOE workforce, including demographic, employment, exposure, and mortality follow-up information on more than 420,000 workers. In the past 2 years, the program's holdings have been expanded to include data from both occupational and community health studies, such as those examining the impact of fallout from nuclear weapons testing, community dose reconstructions, data from the decades of follow-up on atomic bomb survivors, and health surveillance reports on current DOE workers.

CEDR accomplishes this by a hierarchical structure that accommodates analysis and working files generated during a study, as well as files of documentation that are critical for understanding the data. CEDR provides easy access to its holdings through the Internet or dial-up connections, phone and mail interchanges, and provides an extensive catalog of its holdings. CEDR has become a unique resource comprising the majority of data that exist on the risks of radiation exposure.

For further information concerning the CEDR system, contact:

Ms. Barbara G. Brooks
Program Manager
Office of Epidemiologic Studies, EH-62
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

E-mail: barbara.brooks@hq.doe.gov
Or access the CEDR internet web page at
http://cedr.lbl.gov

Exhibit E-1: Methods of Accessing REMS Information

REMS Information Access Method	Experience Requirements			Software Requirements[3]	Eligibility Requirements	To Get Access
	Knowledge of REMS Data	Computer Expertise				
		User	System Adminstrator-Setup			
Hardcopy Annual Report	**None.** Data explained in report.	**N/A**	**N/A**	**None.**	**None.**	Contact EH-52[1] to request that you be added to Annual Report mailing list.
Web Page	**Low.** General knowledge/interest in radiation data.	**Minimal** computer skills. Only a knowledge of how to use the Web browser, and an Internet connection.	**Medium.** Supply LAN connection to Internet or Internet Provider. Support Web browser.	Internet access. Web browser client software.	**None.**	Connect to http://rems.eh.doe.gov/
InfoMaker - Pre-defined reports	**Medium.** Need to know the data limitations of the data in REMS, and what the exposure data represent.	**Minimal.** Familiarity with Windows applications. Need to understand difference between Query and Reports.	**Medium.** Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
InfoMaker - Ad Hoc Queries	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**Medium** (to High). Some knowledge of SQL highly recommended. Should be familiar with "Report generation"-type software.	**Medium.** Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Client query tool other than InfoMaker	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**High.** Need to be skilled in SQL and connecting to the system. Need to be skilled in the use of whatever query tool is used.	**Medium.** Support for LAN connection to Internet or Internet Provider. Support user query software.	Internet access (TCP/IP). Oracle SQLNet. ODBC Drivers. Query Tool client. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Running SQL on the REMS Server	**High.** Need to thoroughly understand the data dictionary, relationships and structure of the database. Limitations of the data.	**High.** Need to be skilled in SQL and connecting to the system.	**Medium.** Support for LAN connection to Internet or Internet Provider. Support TELNet software.	Internet access (TCP/IP). TeLNet software.	Category 2 use only. TeLNet authorization required for firewall.	Contact OIM[2] to request access.

① EH-52 contact Ms. Nirmala Rao at — Phone: (301) 903-2297, Fax: (301) 903-7773, E-mail: Nimi.Rao@hq.doe.gov
② OIM contact Mr. Pat Heinig at — Phone: (301) 903-9850, Fax: (301) 903-0118
③ See REMS User Manual for detailed software requirements.
④ Category 1 - All data in the REMS system, including Privacy Act data such as name and social security number of the monitored individual.
Category 2 - Access to non-sensitive radiation monitoring information per monitored individual. See REMS Reference Manual for details.

Appendix F

User Survey

DOE and DOE Contractor Employees Annual Radiation Exposure Report

User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the DOE and DOE Contractor Employees Annual Radiation Exposure Report. **Your feedback is important.** Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to:

Ms. Nirmala Rao
DOE EH-52 270/cc
19901 Germantown Road
Germantown, MD 20874

Questions concerning the survey should be directed to Ms. Rao at (301) 903-2297

---

1. Identification:

Name: ....

Title: ....

Mailing Address: ....

....

....

....

2. Distribution:

2.1 Do you wish to remain on distribution for the report? ___ yes ___ no

2.2 Do you wish to be added to the distribution? ___ yes ___ no

3. Was the presentation/discussion of dose distribution data for:

DOE-wide .... adequate ___ inadequate ___

Sites.. adequate ___ inadequate ___

Facilities .... adequate ___ inadequate ___

Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

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....

....

4. Was the presentation/discussion of dose trends for:

DOE-wide .... adequate ___ inadequate ___
Sites... adequate ___ inadequate ___
Facilities .... adequate ___ inadequate ___
Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

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5. Was the discussion of ALARA Projects at specific sites:

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

6. Was the discussion of AEDE vs CEDE helpful?

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

7. Would additional/different breakouts of the data be helpful?

Yes ___ No ___

Comments/areas for improvement:

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8. Suggestions for new facility type, occupation, and/or labor codes.

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9. If/when the data become available, would person-rem/hr or person-rem/RWP be useful in this report?

Yes ___ No ___

Comments/areas for improvement:

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....

10. To publish this report in the second quarter and to be able to use it as a management tool, we need the data *as soon as possible* after you have processed it. Please indicate when you can provide the data.

Quarterly ___

Semi-Annually ___

Yearly* ___

*By end of January, February, March

(please circle one)

11. DOE is considering the addition of a code for indicating the Phase of Operation of the facility type that is currently reported with each dose record (see A-4). The Phase of Operation will allow for expanded analysis of the dose information by considering the operational phase of the facility. Please indicate whether this information is available at your site, and the years the information would cover.

Available___ Years:________to_________

Not available___

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Prepared by:
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301 Laboratory Road • Oak Ridge, TN 37830