DOE/EH-0675

DOE Occupational Radiation Exposure

2002 Report

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DEPARTMENT OF ENERGY • UNITED STATES OF AMERICA

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DOE Occupational Radiation Exposure

2002 Report

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

Foreword

The goal of the U.S. Department of Energy (DOE) is to conduct its operations, including radiological operations, to ensure the safety and health of all DOE employees, 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 to levels that are "As Low As Reasonably Achievable" (ALARA).

The *2002 DOE Occupational Radiation Exposure Report* provides a 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 activities, and energy research.

Collective dose at DOE (as measured by the collective external whole body dose) has declined by 85% from 8,340 person-rem (83,400 person-mSv) in 1985 to 1,291 person-rem (12,910 person-mSv) in 2002 due to a cessation in opportunities for radiation exposure during the transition in DOE mission from weapons production to cleanup, deactivation, and decommissioning. Between years 2001 and 2002, the DOE collective Total Effective Dose Equivalent (TEDE) increased by 10% from 1,232 person-rem (12,320 person-mSv) to 1,360 person-rem (13,600 person-mSv) primarily due to increased doses at three of the six DOE sites with the highest radiation dose. Sites that reported increases in the collective dose attributed it to an increase in the number of hours of radiological work performed (at Rocky Flats), increased processing of spent nuclear fuel in K-Basins (at Hanford), and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL). The DOE average measurable TEDE increased by 8% from 0.074 rem (0.74 mSv) in 2001 to 0.080 rem (0.80 mSv) in 2002.

This report is intended to be a valuable tool for managers and workers in their management of radiological safety programs and commitment of resources. The process of data collection, analysis, and report generation is streamlined to provide 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.

Beverly A. Cook
Assistant Secretary
Environment, Safety and Health

Frank B. Russo
Deputy Assistant Secretary
Office of Corporate Performance Assessment

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10 CFR 820	Title 10 Code of Federal Regulation Part 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993
10 CFR 835	Title 10 Code of Federal Regulation Part 835 "Occupational Radiation Protection," December 14, 1993
10 CFR 835, Amendment	Issued on November 4, 1998
ACL	Administrative Control Level
AEDE	Annual Effective Dose Equivalent
AEC	Atomic Energy Commission
ALAP	As Low As Practicable
ALARA	As Low As Reasonably Achievable
ANL-E	Argonne National Laboratory - East
ANL-W	Argonne National Laboratory - West
ANSI	American National Standards Institute
ANSI N13.30-1996	ANSI Note on Performance Criteria for Radioassay
BFV	Back-flush Valves
BHI	Bechtel Hanford, Inc.
BNFL	British Nuclear Fuels Limited
BNL	Brookhaven National Laboratory
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CEDR	Comprehensive Epidemiologic Data Resource
CUP	Cask Unloading Pool
D&D	Decontamination and Decommissioning
DDE	Deep Dose Equivalent
DOE	Department of Energy
DOE HQ	DOE Headquarters
DOE M 231.1-1	Manual for Environment, Safety and Health Reporting, September 10, 1995
DOE Notice 441.1	Radiological Protection for DOE Activities, September 29, 1995
DOE Order 5480.11	Radiation Protection for Occupational Workers, December 1988
DOE Order 5484.1	Environmental Protection, Safety and Health Protection Information Reporting Requirements, February 24, 1981, Change 7, October 17, 1990
DOELAP	DOE Laboratory Accreditation Program
EDE	Effective Dose Equivalent
EH-32	DOE Office of Corporate Performance Assessment
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ES&H	Environment, Safety and Health
ETTP	East Tennessee Technology Park (formerly K-25)
EUO	Enriched Uranium Operations
Fermilab	Fermi National Accelerator Laboratory
FHI	Fluor Hanford, Inc.
FRS	Fuel Receiving and Storage
FSP	Fuel Storage Pool
FTS	Fuel Transfer System
GCR	GPC Crane Room
GPC	General Purpose Cell
HEC	Head End Cells
ICRP	International Commission on Radiological Protection
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISMS	Integrated Safety Management System
LANL	Los Alamos National Laboratory
LARADS	Laser-assisted Ranging and Data System
LBNL	Lawrence Berkeley National Laboratory

TABLE OF ACRONYMS (continued)

LDE	Lens (of the eye) Dose Equivalent
LEHR	Laboratory for Energy-related Health Research
LLNL	Lawrence Livermore National Laboratory
LLPIT	Lessons Learned Process Improvement Team
NCRP	National Council on Radiation Protection and Measurements
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORPS	Occurrence Reporting and Processing System
OSL	Optically Stimulated Luminescent Dosimeters
PBS	Polymeric Barrier System™
PFP	Plutonium Finishing Plant
PGDP	Paducah Gaseous Diffusion Plant
PMC	Process Mechanical Cell
PMCR	PMC Crane Room
PNNL	Pacific Northwest National Laboratory
PORTS	Portsmouth Gaseous Diffusion Plant
PP	Pantex Plant
PPE	Personal Protective Equipment
PSEs	Planned Special Exposures
RadCon	Radiological Control Manual, June 1992
RCO	Radiological Control Operations
RCS	Radiological Control Standard
REC	Radiochemical Engineering Cells
REMS	Radiation Exposure Monitoring System
RFETS	Rocky Flats Environmental Technology Site
RW	Radiological Workers
RWP	Radiological Work Permit
SARF	Supercompactor and Repackaging Facility
SCO	Surface Contaminated Object
SDE	Shallow Dose Equivalent
SDE-ME	Shallow Dose Equivalent to the Maximally Exposed Extremity
SDE-WB	Shallow Dose Equivalent to the Skin of the Whole Body
SIOU	Surface Impoundments Operable Units
SLAC	Stanford Linear Accelerator Center
SNF	Spent Nuclear Fuel
SNL	Sandia National Laboratory
SOC	Standard Occupational Classification
SRS	Savannah River Site
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Dosimeters
TLND	Thermoluminescent Neutron Dosimeter
TODE	Total Organ Dose Equivalent
TRA	Test Reactor Area
TRU	Transuranic
UMTRA	Uranium Mill Tailings Remedial Action
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WIPP	Waste Isolation Pilot Plant
WRAP	Waste Receiving and Processing
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services, Inc.
WVNSCO	West Valley Nuclear Services Company
Y-12 Plant	Y-12 National Security Complex

Executive Summary

The U.S. Department of Energy (DOE) Office of Corporate Performance Assessment (EH-3) publishes the annual *DOE Occupational Radiation Exposure Report*. This report is intended to be a valuable tool for DOE and DOE contractor managers and workers 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 to make the report most useful.

This report includes occupational radiation exposure information for all monitored DOE employees, contractors, subcontractors, and members of the public. 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.

As shown in *Exhibit ES-1*, between years 2001 and 2002, the DOE collective Total Effective Dose Equivalent (TEDE) increased by 10% from 1,232 person-rem (12,320 person-mSv) to 1,360 person-rem (13,600 person-mSv) primarily due to increased doses at three of the six DOE sites with the highest radiation dose. The average dose to workers with measurable dose increased by 8% from 0.074 rem (0.74 mSv) in 2001 to 0.080 rem (0.80 mSv) in 2002, as shown in *Exhibit ES-2,* because of the 10% increase in the collective dose and a 2% increase in the number of workers with measurable dose. The number of individuals with measurable dose increased from 16,687 in 2001 to 17,051 in 2002. The percentage of monitored individuals receiving measurable dose remained the same for 2001 and 2002, at 17%. There were no exposures in excess of the DOE 5 rem (50 mSv) annual TEDE limit and only one exposure in excess of the DOE Administrative Control Level (ACL) of 2 rem (20 mSv) TEDE. There was one individual who received an extremity dose of 111 rem (1,110 mSv) at Lawrence Livermore National Laboratory, which was in excess of the 50 rem (500 mSv) annual extremity limit.

Seventy-nine percent of the collective TEDE for the DOE complex was accrued at six DOE sites in 2002. These six sites are (in descending order of collective dose for 2002) Hanford, Rocky Flats, Savannah River, Los Alamos, Oak Ridge, and Idaho. 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 report under this facility type. For the past 3 years, technicians and production staff have received the highest collective dose of any specified labor category.

Exhibit ES-1:
Collective TEDE Dose (person-rem), 1998-2002.

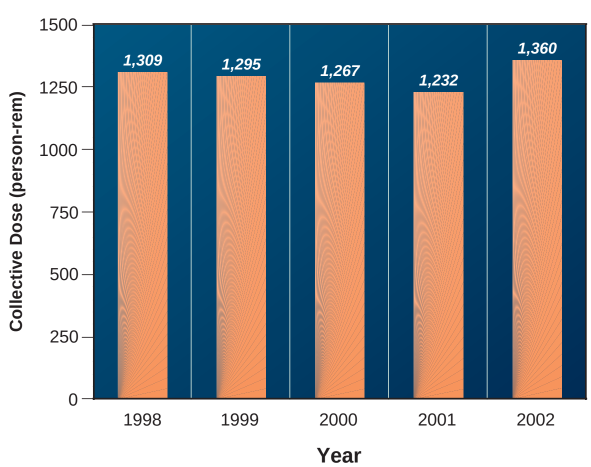
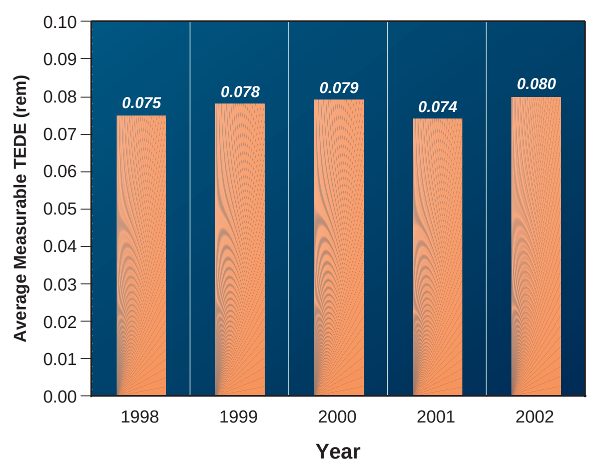


Exhibit ES-2:
Average Measurable TEDE (rem), 1998-2002.

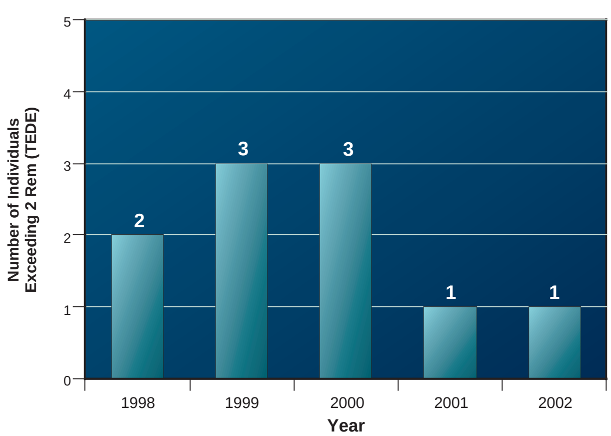


The change in operational status of DOE facilities has had the largest impact on radiation exposure over the past 5 years due to the shift in mission from production to cleanup activities and the shutdown of certain facilities. For 2002, this resulted in an increase in the collective dose as sites handled more radioactive materials for processing, storage, or shipping. Reports submitted by three of the sites that experienced increases in the collective dose indicate that the increases were due to an increase in the number of hours of radiological work performed (at Rocky Flats), increased processing of spent nuclear fuel in K-Basins (at Hanford), and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL).

A statistical analysis was performed to analyze the trend in collective dose over the past 5 years. For the collective TEDE, there were small but significant differences in all years, and the logarithmic mean TEDE per worker reached a 5-year peak of 0.030 rem (0.30 mSv) in 2002. The logarithmic mean TEDE increased from 0.028 rem (0.28 mSv) in 2001 to 0.030 (0.30 mSv) rem in 2002, reflecting both an increase in the dose to individual workers, and a larger number of individuals with measurable dose. The logarithmic mean TEDE per worker ranged from 0.026 rem to 0.029 rem (0.26 mSv to 0.29 mSv) for 1998-2001. However, the 2002 logarithmic mean TEDE remains significantly below the 1997 logarithmic mean TEDE of 0.035 rem (0.35 mSv) per worker.

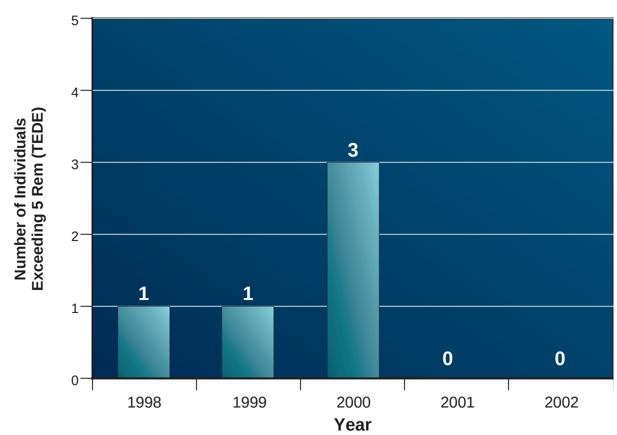
Over the past 5 years, few occupational doses in excess of the 2 rem (20 mSv) ACL and 5 rem (50 mSv) TEDE regulatory limit have occurred at DOE facilities, as shown in *Exhibits ES-3* and *ES-4*. All but one of the doses in excess of 2 rem (20 mSv) in the past 5 years were due to internal dose. Only one individual received a dose in excess of 2 rem (20 mSv) in 2002. No individuals received a dose in excess of the 5 rem (50 mSv) TEDE limit in 2002, but one individual received a dose in excess of the 50 rem (500 mSv) extremity limit.

Exhibit ES-3:
Number of Individuals Exceeding 2 Rem TEDE, 1998-2002.



Note: Number of individuals exceeding 2 rem TEDE includes those individuals that also exceeded 5 rem TEDE shown in Exhibit ES-4.

Exhibit ES-4:
Number of Individuals Exceeding 5 Rem TEDE, 1998-2002.



The collective internal dose (CEDE) increased by 17% between 2001 and 2002. Due to the increase in the collective CEDE and slight increase in the number of internal depositions, the average measurable CEDE increased by 12% from 2001 to 2002 from 0.025 rem (0.25 mSv) to a value of 0.028 rem (0.28 mSv), which is the second lowest average measurable CEDE in the past 5 years.

An analysis was performed on the transient workforce at DOE. A transient worker is defined as an individual monitored at more than one DOE site in a year. The results of this analysis show that the number of transient workers monitored has decreased by 11% from 3,183 in 2001 to 2,848 in 2002 and still remains a very low percentage (2.8%) of the monitored workforce at DOE. The collective dose for these transients increased by 45% from 25.1 person-rem (251 mSv) in 2001 to 36.5 person-rem (365 mSv) in 2002. The average measurable dose to transients increased by 27% from 0.052 rem (0.52 mSv) in 2001 to 0.066 rem (0.66 mSv) in 2002. The average measurable dose to transient workers is 0.066 rem (0.66 mSv) which is 83% of the value for the overall DOE workforce in 2002.

To access this report and other information on occupational radiation exposure at DOE, visit the Radiation Exposure Monitoring System (REMS) web site at:

http://rems.eh.doe.gov

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Introduction

The *U.S. Department of Energy (DOE) Occupational Radiation Exposure Report, 2002* reports occupational radiation exposures incurred by individuals at DOE facilities during the calendar year 2002. This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and members of the public. The 102 DOE organizations submitting radiation exposure reports for 2002 have been grouped into 29 geographic sites across the complex (see Appendix Exhibit B-1c). 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 and appendices listed below. Supporting technical information, tables of data, and additional items identified by users as useful are provided in the appendices.

1.2 Report Availability

Requests for additional copies of this report, access to the data files, or individual dose records used to compile this report should be directed to:

Ms. Nirmala Rao
DOE REMS Project Manager
EH-32, 270 Corporate Square Building
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-0270
E-mail: nimi.rao@eh.doe.gov

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 in 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 ALARA is included.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 2002. The data are analyzed to show trends over the past 5 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.
Appendices	Lists reporting codes and organizations, a detailed breakdown of the data analyzed in this report, limitations of the data, and ways to access the REMS data.

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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 Health 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, contractors are required to maintain exposures as low as reasonably achievable (ALARA).

This section discusses radiation protection standards and requirements in effect for the year 2002. 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 present 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 "Occupational Radiation Protection" [6]. In July 1999, the "RadCon Manual" was formally reissued as the Radiological Control Standard (RCS) [7]. The RCS incorporates changes resulting from the amendment to 10 CFR 835 issued on November 4, 1998.

The 10 CFR 835 rule 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, 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 [8] as implemented by 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993. [9]

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," [10] (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 continued in effect until June 1, 2000, when compliance with the amendment to 10 CFR 835 (issued November 4, 1998) was expected to be fully implemented.

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 [11] requirements for reporting radiation exposure records were split into two directives; DOE Order 231.1, "Environment, Safety, and Health Reporting" [12] which required the reporting of occupational radiation exposure records, and DOE Manual 231.1-1, "Environment, Safety, and Health Reporting Manual" [13], which specified the format and content of the required reports. Both became effective September 30, 1995.

Most sites reported radiation monitoring results under DOE Order 231.1 and Manual 231.1-1 for 1996. Each site implemented the change in requirements as operating contracts were issued or renegotiated. DOE Order 231.1 underwent two subsequent revisions (Change 1 in 1995 and Change 2 in 1996) and was reissued as DOE Order 231.1A [14] in August of 2003. DOE Manual 231.1-1 underwent similar revisions (Change 1 in 1996 and Change 2 in 2000) and is currently in the process of revision.

2.1.1 Monitoring Requirements

10 CFR 835.402(a) 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) in a year. Monitoring for minors and members of the public is required if the TEDE 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 TEDE to the embryo/fetus is likely to exceed 10% of the limit of 0.5 rem (5 mSv) TEDE during the gestation period.

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. External monitoring devices include thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLs), pocket ionization chambers, electronic dosimeters, personnel nuclear accident dosimeters, bubble dosimeters, plastic dosimeters, and combinations of the above.

Beginning in 1986, the DOE Laboratory Accreditation Program (DOELAP) formalized accuracy and precision performance standards for external dosimeters used for dose of record and quality assurance/quality control requirements for external dosimetry programs at facilities within the DOE complex. All DOE facilities requiring accreditation were DOELAP-accredited by the fall of 1995.

External dosimeters have a lower limit of detection of approximately 0.005 to 0.030 rem (0.05 to 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 may 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 monitoring intervals, the radionuclides in question, and their chemical form. Follow-up measurements and analysis may take many months to confirm preliminary findings. DOELAP has developed a Radiobioassay Accreditation Program in conjunction with the publication of American National Standards Institute (ANSI) N13.30-1996, "Performance Criteria for Radiobioassay." Implementation of the program began in November 1998 with issuance of the amendments to 10 CFR 835.402.(d), requiring full compliance by January 1, 2002.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835.202, 206, 207, 208 and are summarized in *Exhibit 2-1*. While some of these sections have been revised, the limits remain the same.

Under 835.204, Planned Special Exposures (PSEs) may be authorized under 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 by 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. No PSEs have occurred since the requirement became effective.

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 in a Controlled Area	§835.208	Total Effective Dose Equivalent	TEDE	0.1 rem

* Limit applies to the embryo/fetus

2.2.1 Administrative Control Levels

Administrative Control Levels (ACLs) were initially established in the "RadCon Manual" and retained in the RCS. 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 needed to approve a higher level of exposure.

The RCS 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 RCS 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. In addition to the annual ACL, the Manual recommends the establishment of a lifetime ACL of "N" rem, where N is the age of the person in years. Special control levels are also recommended to be established for personnel who have lifetime doses exceeding N rem.

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 could be inferred from the linear no-threshold dose response hypothesis that there was 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 and 10 CFR 835 require 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 10 CFR 835, 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 [15]. 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 dose in one of 16 dose equivalent ranges. The revised Order required the reporting of the results of radiation exposure monitoring for each employee and member of the public. 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, monitoring status, and occupation, as well as the reporting organization and facility type.

On August 18, of 2003, DOE approved and issued the revised DOE Order 231.1A. The DOE Manual 231.1-1, which details the format and content of reporting radiation exposure records to the DOE, is in the process of being revised. The revisions affect the content and reporting of radiation exposure records reported to the DOE Radiation Exposure Monitoring System (REMS) repository. Readers should take note of these revisions for the potential future impact on the recording and reporting of occupational exposure to the REMS repository.

Readers should take note of the draft revisions to DOE Order 231.1A and Manual 231.1-1 for the potential future impact on the recording and reporting of occupational exposure to the REMS repository.

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, such as the percent of the maximum permissible body burden. The implementation of DOE Order 5480.11 in 1989 specified that the intakes of radionuclides be converted to internal dose and evaluated against the dose limits using the Annual Effective Dose Equivalent (AEDE) methodology. AEDE as well as CEDE were required for reports to employees.

With the implementation of the "RadCon Manual" in 1993, the required methodology used to determine compliance within the dose limits 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 Nuclear Regulatory Commission (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.

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

This report primarily analyzes dose information for the past 5 years, from 1998 to 2002. 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. When analyzing TEDE data prior to 1993, readers should keep in mind the change in methodology.

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Section Three

Occupational Radiation Dose at DOE

3

Occupational Radiation Dose at DOE

3.1 Analysis of the Data

Analysis and explanation of observed trends in occupational radiation dose data reveal opportunities to improve safety and demonstrate performance. Several indicators were identified from the data submitted to the central data repository, which can be used to evaluate the occupational radiation exposures received at DOE facilities. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

Key indicators for the analysis of aggregate data are: number of records for 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, facility type, and occurrence report information. Additional information is provided concerning activities at sites contributing to the collective dose. To determine the significance of trends, statistical analysis was performed on the data.

3.2 Analysis of Aggregate Data

3.2.1 Number of Records for Monitored Individuals

The number of records for monitored individuals represents the size of the DOE worker population provided with dosimetry. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, subcontractors, and members of the public. The number of monitored individuals is determined from the number of monitoring records submitted by each site. Because individuals may have more than one monitoring record, they may be counted more than once. The number of records for 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, the number of records for workers who receive a measurable dose best represents the exposed workforce.

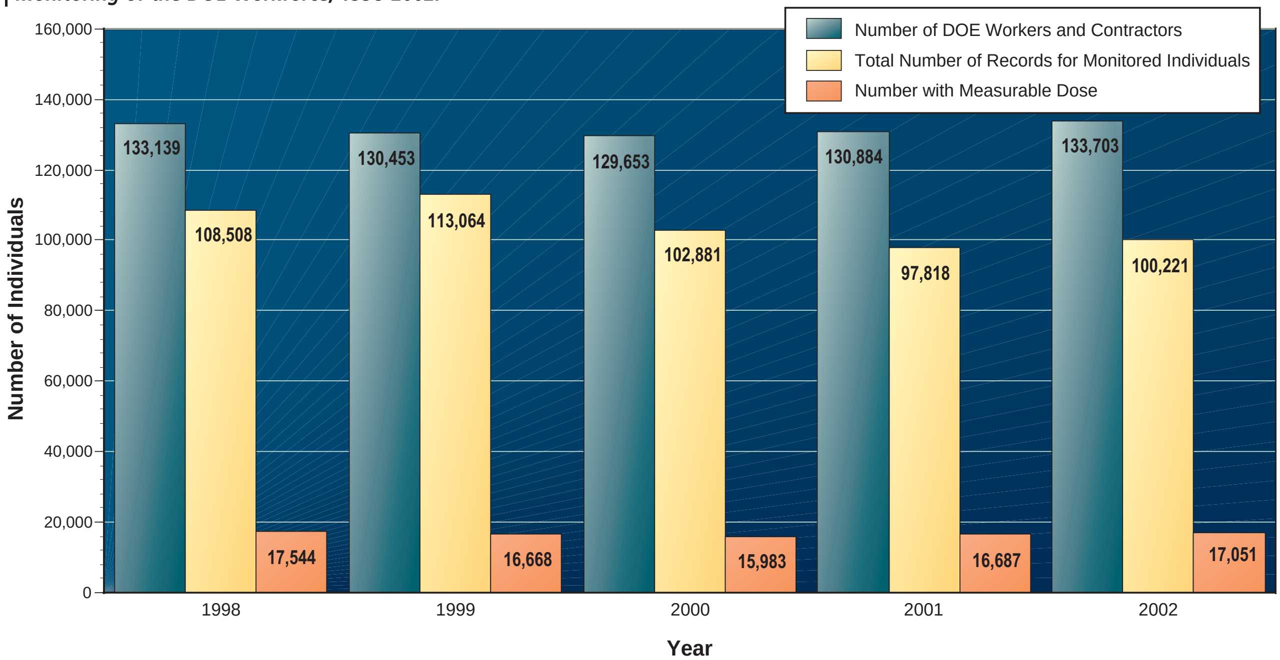
3.2.2 Number of Records for Individuals with Measurable Dose

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 number of DOE workers and contractors, the total number of records for monitored individuals, and the number with measurable dose for the past 5 years. Compared to 2001, the same percentage (75%) of the DOE workforce was monitored for radiation in 2002, and the same percentage (17%) of monitored individuals received a measurable dose. The total number of records of individuals monitored for radiation has decreased over the past 5 years by 8% from 108,508 in 1998 to 100,221 in 2002. The percentage of the DOE workforce monitored for radiation exposure has decreased by 6% from 81% in 1998 to 75% in 2002. However, most (84%) of the monitored individuals over the past 5 years did not receive any measurable

Compared to 2001, the same percentage (75%) of the DOE workforce was monitored for radiation dose in 2002, and the same percentage of monitored individuals received a measurable dose (17%).

Exhibit 3-1:
Monitoring of the DOE Workforce, 1998-2002.



radiation dose. An average of 16% of monitored individuals (13% of the DOE workforce) received a measurable dose during the past 5 years. The percentage of monitored workers receiving measurable dose has remained fairly constant for the past 5 years: 16% in 1998 and 17% in 2002. The overall DOE workforce has increased by 2% from 130,884 in 2001 to 133,703 in 2002.

Seven of the 29 reporting sites (see Appendix Exhibit B-1c) experienced decreases in the number of workers with measurable dose from 2001 to 2002. The largest decreases in total number of workers with measurable dose occurred at Savannah River, Oak Ridge, and Rocky Flats. The largest increases in the number of workers receiving measurable dose occurred at Hanford and Los Alamos National Laboratory (LANL). A discussion of activities at the six highest-dose facilities is included in Section 3.5.

The number of workers with measurable dose increased from 16,687 in 2001 to 17,051 in 2002.

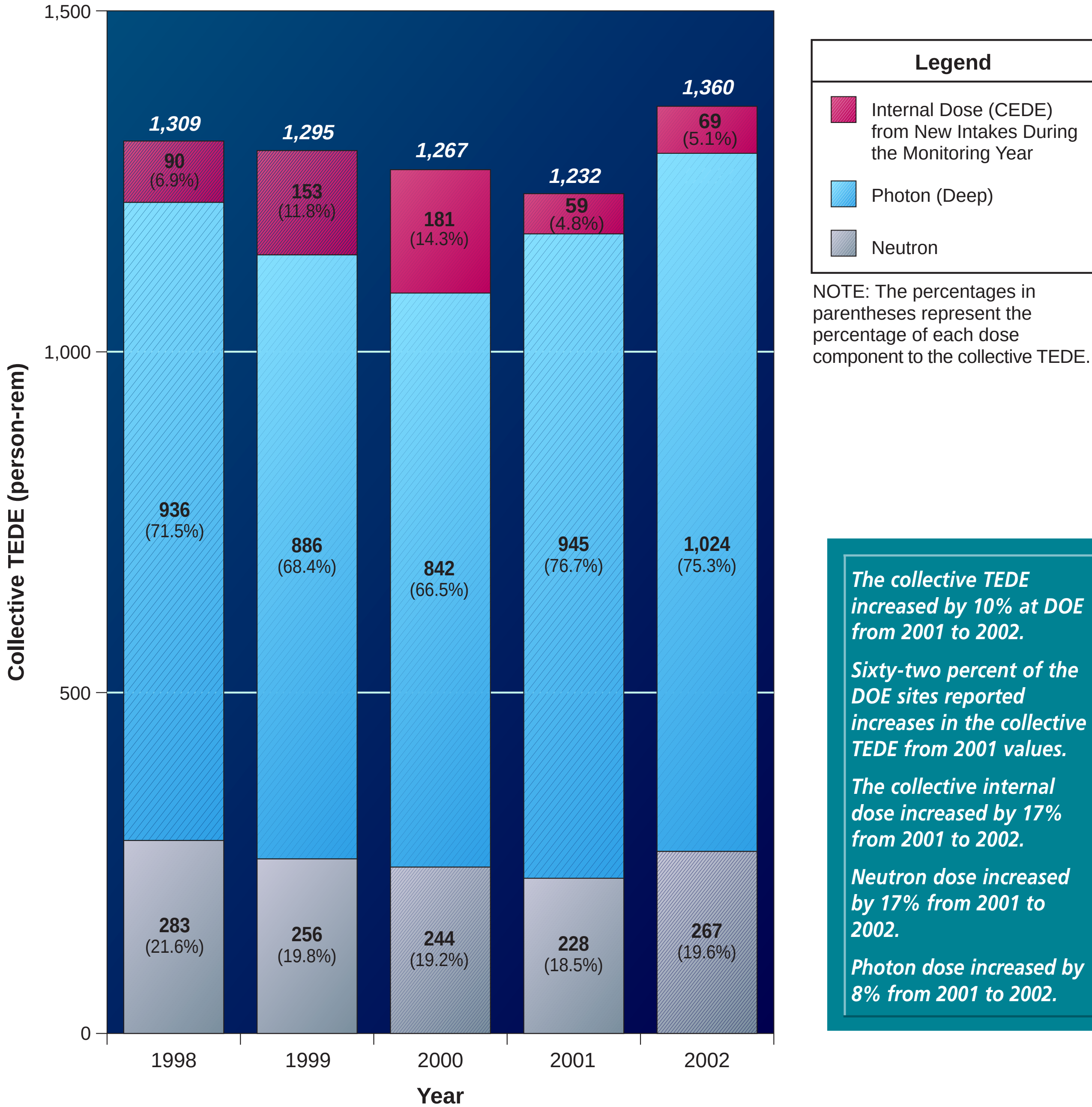
The percentage of monitored workers receiving measurable dose remained the same, at 17%, in 2002.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with measurable dose and is measured in units of person-rem (person-Sv). The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, subcontractors, and members of the public. 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 increased at DOE by 10% from 1,232 person-rem (12.32 person-Sv) in 2001 to 1,360 person-rem (13.60 person-Sv) in 2002. Sixty-two percent of the DOE sites (18 out of 29 sites) reported increases in the collective TEDE from the 2001 values. Three out of six of the highest dose sites reported increases in the collective TEDE. The six highest dose sites are (in descending order of collective dose for 2002) Hanford, Rocky Flats, Savannah River, Los Alamos, Oak Ridge, and Idaho. These sites attributed the increase in dose to an increase in the number of hours of radiological work performed (at Rocky Flats), increased processing

Exhibit 3-2:
Components of TEDE, 1998-2002.



NOTE: The percentages in parentheses represent the percentage of each dose component to the collective TEDE.

The collective TEDE increased by 10% at DOE from 2001 to 2002.

Sixty-two percent of the DOE sites reported increases in the collective TEDE from 2001 values.

The collective internal dose increased by 17% from 2001 to 2002.

Neutron dose increased by 17% from 2001 to 2002.

Photon dose increased by 8% from 2001 to 2002.

Photon dose (deep) - the component of external dose from gamma or x-ray electromagnetic radiation. (Also includes energetic betas.)

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.

of spent nuclear fuel in K-Basins (at Hanford), and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL). A discussion of the activities leading to this increase is included in Section 3.5.

A statistical analysis was performed to analyze the trend in collective dose over the past 5 years. For the collective TEDE, there were small but significant differences in all years, and the logarithmic mean TEDE per worker reached a 5-year peak of 0.030 rem (0.30 mSv) in 2002. The logarithmic mean TEDE increased from 0.028 rem (0.28 mSv) in 2001 to 0.030 (0.30 mSv) rem in 2002, reflecting both an increase in the dose to individual workers, and a larger number of individuals with measurable dose. The logarithmic mean TEDE per worker ranged from 0.026 rem to 0.029 rem (0.26 mSv to 0.29 mSv) for 1998-2001. However, the 2002 logarithmic mean TEDE remains significantly below the 1997 logarithmic mean TEDE of 0.035 rem (0.35 mSv) per worker. Note that the logarithmic mean used here is different from the average measurable dose discussed elsewhere in this report. See Section 3.2.6 for more information on the statistical analysis, Section 3.5 for more information on activities contributing to the collective dose, and Section 4 for a discussion of notable ALARA activities.

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. Internal dose, photon, and neutron components are shown.

It should be noted that the internal dose shown in *Exhibit 3-2* for 1998 through 2002 is based on the 50-year CEDE methodology. The internal dose component increased by 17% from 59 person-rem (590 person-mSv) in 2001 to 69 person-rem (690 person-mSv) in 2002, although it remains lower than the values for 1998 through 2000. There were no individuals receiving an internal dose above 2 rem (20 mSv) for the second year in a row. The collective internal dose can vary from year to year due to the relatively small number of uptakes of radioactive material and the fact that they often involve long-lived radionuclides, such as plutonium, which can result in relatively large committed doses. Due to the sporadic nature of these uptakes, care should be taken when attempting to identify trends from the internal dose records.

The external deep dose (comprised of photon, energetic beta, and neutron dose) is shown in *Exhibit 3-2* in order to see the contribution of external dose to the collective TEDE. The collective photon dose increased by 8% from 945 person-rem (9.45 person-Sv) in 2001 to 1,024 person-rem (10.24 person-Sv) in 2002. Two of the sites that reported the largest increases in the photon dose attributed the increase to activities involving the processing of spent nuclear fuel in K-Basins (at Hanford) and work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL). See Section 3.5 for more information on activities at these sites.

The neutron component of the TEDE increased by 17% from 228 person-rem (2.28 person-Sv) in 2001 to 267 person-rem (2.67 person-Sv) in 2002. This is primarily due to increases in the neutron dose at LANL. LANL contributed 29% of the neutron dose at the DOE during 2002. LANL and Rocky Flats work with plutonium in gloveboxes, which can result in a neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium. The collective neutron dose for 2002 by site is shown in Appendix Exhibit B-5. External deep dose (DDE) and TEDE for prior years (1974 through 2002) can be found in Appendix Exhibit B-3.

3.2.4 Average Measurable Dose

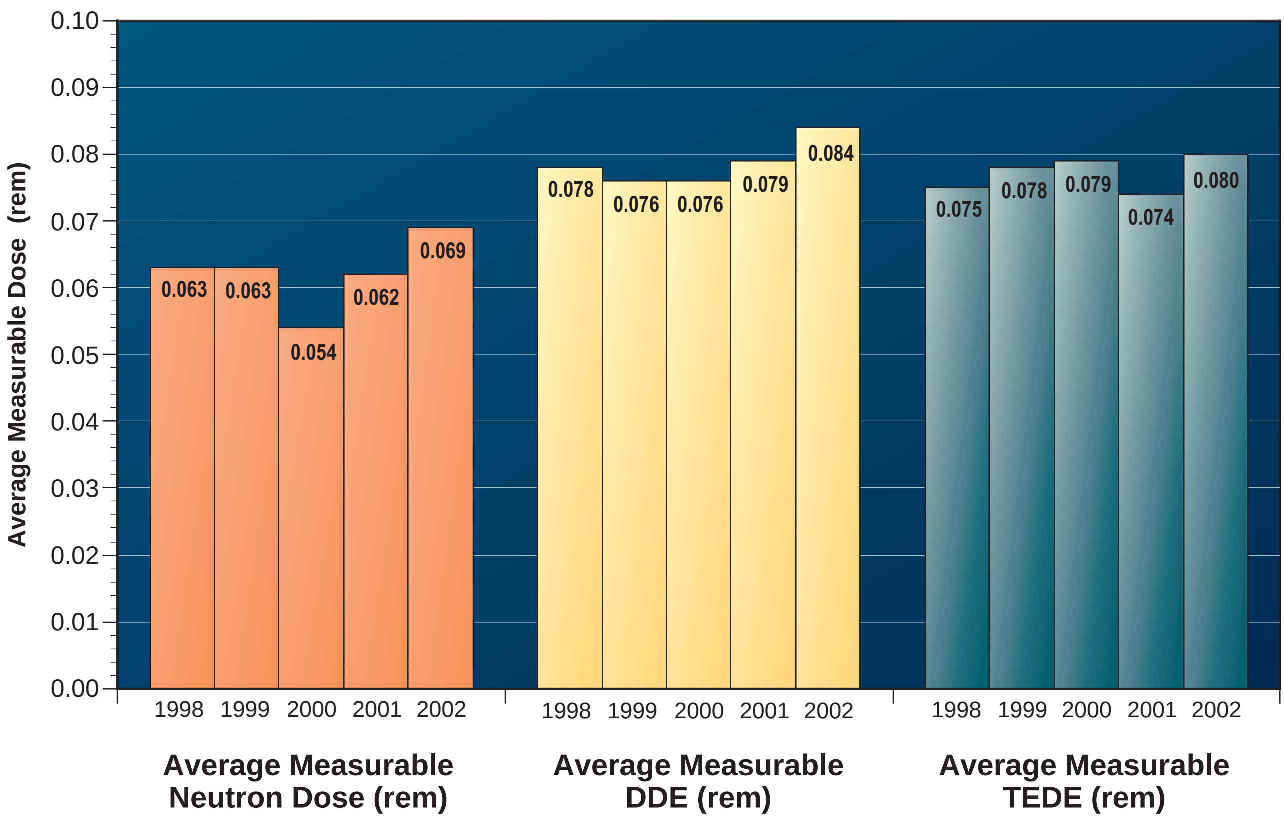
The average measurable dose to DOE workers presented in this report for TEDE, DDE, neutron, extremity, and CEDE is determined by dividing the collective dose for each dose type by the number of individuals with measurable dose for each dose type. This is one of the key indicators of the overall level of radiation dose received by DOE workers.

The average measurable neutron, DDE, and TEDE is shown in *Exhibit 3-3*. The average measurable neutron dose increased by 11% from 0.062 rem (0.62 mSv) in 2001 to 0.069 rem (0.69 mSv) in 2002, primarily due to increases in neutron dose at LANL. The average measurable neutron dose increased by 10% from 0.063 rem (0.63 mSv) in 1998 to 0.069 rem (0.69 mSv) in 2002. The average measurable DDE increased by 6% from 0.079 rem (0.79 mSv) in 2001 to 0.084 rem (0.84 mSv) in 2002 and increased by 8% from 0.078 rem (0.78 mSv) in 1998 to 0.084 rem (0.84 mSv) in 2002. The collective TEDE increased, as well as the number with measurable dose, resulting in an 8% increase in the average measurable TEDE from 0.074 rem (0.74 mSv) in 2001 to 0.080 rem (0.80 mSv) in 2002. The average measurable TEDE increased by 7% from 0.075 rem (0.75 mSv) in 1998 to 0.080 rem (0.80 mSv) in 2002. The average measurable neutron, DDE, and TEDE values are provided for trending purposes, not for comparison between them.

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 the distribution of doses among the worker population.

The average measurable neutron dose increased by 11% and the average measurable TEDE increased by 8%, while the average measurable DDE increased by 6% from 2001 to 2002.

Exhibit 3-3:
Average Measurable Neutron, DDE, and TEDE, 1998-2002.



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, and includes the photon and neutron 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, that the vast majority of doses are at low levels, and that the collective TEDE dose decreased each year from 1998 to 2001, but increased between 2001 and 2002. Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value as compared to the total collective dose.

The United Nations' *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes, Volume I* [16] recommends the calculation of a parameter "SR" (previously referred to as CR) to aid in the examination of the distribution of radiation exposure among workers. SR is defined to be the ratio of the annual collective dose incurred by workers whose annual doses exceed 1.5 rem (15 mSv) to the total annual collective dose. The UNSCEAR report notes that a dose level of 1.5 rem (15 mSv) may not be useful where doses are consistently lower than this level, and they recommend that research organizations

Exhibit 3-4:
Distribution of Dose by Dose Range, 1998-2002.

	Dose Ranges (rem)	1998		1999		2000		2001		2002	
		TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE
Number of Individuals in Each Dose Range*	Less than Measurable	90,964	92,803	96,396	98,125	86,898	88,621	81,131	82,950	83,170	84,874
	Measurable < 0.1	14,066	12,450	13,561	12,137	13,020	11,498	13,559	11,881	13,500	11,994
	0.10 - 0.25	2,253	2,120	1,898	1,763	1,873	1,722	1,891	1,782	2,202	2,042
	0.25 - 0.5	840	790	770	684	727	690	840	820	919	893
	0.5 - 0.75	268	245	238	206	211	203	259	250	269	259
	0.75 - 1.0	74	64	118	87	91	93	89	88	95	94
	1 - 2	41	36	80	62	58	54	48	47	65	64
	2 - 3	1		1				1		1	1
	3 - 4			1							
	4 - 5										
	5 - 6										
	6 - 7	1		1							
	7 - 8										
	8 - 9										
	9 - 10					1					
	10 - 11										
	11 - 12					1					
	> 12					1					
Total Number of Records for Monitored Individuals		108,508	108,508	113,064	113,064	102,881	102,881	97,818	97,818	100,221	100,221
Number with Measurable Dose		17,544	15,705	16,668	14,939	15,983	14,260	16,687	14,868	17,051	15,347
Number with Dose >0.1rem		3,478	3,255	3,107	2,802	2,963	2,762	3,128	2,987	3,551	3,353
% of Individuals with Measurable Dose		16%	14%	15%	13%	16%	14%	17%	15%	17%	15%
Collective Dose (person-rem)		1,309	1,219	1,295	1,142	1,267	1,086	1,232	1,173	1,360	1,291
Average Measurable Dose (rem)		0.075	0.078	0.078	0.076	0.079	0.076	0.074	0.079	0.080	0.084

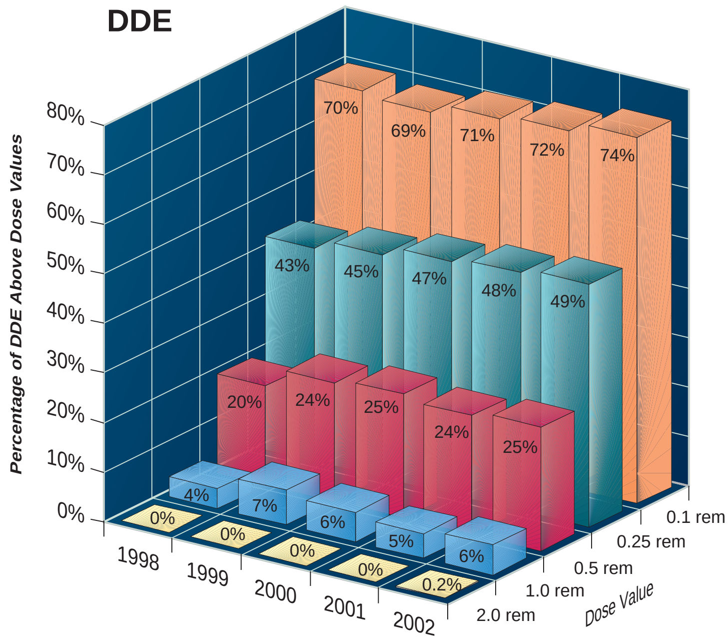
* Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.

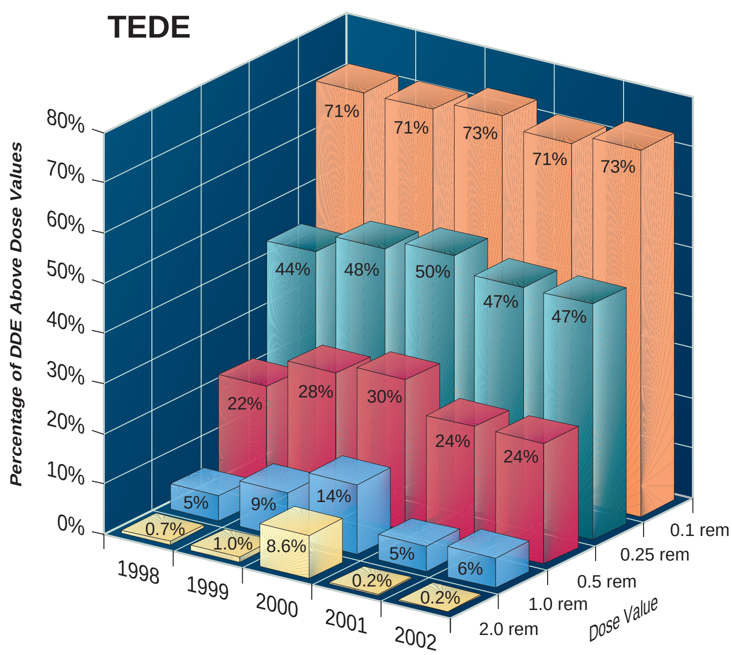
report SR values lower than 1.5 rem (15 mSv) where appropriate. For this reason, the DOE calculates and tracks the SR ratio at dose levels of 0.100 rem (1 mSv), 0.250 rem (2.5 mSv), 0.500 rem (5 mSv), 1.0 rem (10 mSv), and 2.0 rem (20 mSv). The SR values in this report were calculated by summing the TEDE to each individual who received a TEDE greater than, or equal to, the specified dose range divided by the total collective TEDE. This ratio is presented as a percentage rather than a decimal fraction.

Using this method of plotting the data, an ideal distribution would show only a small percentage of the collective dose delivered to individuals in the higher dose ranges. In addition, this method can be used to show the trend in the percentage of the collective dose above a certain dose range over time. For example, a significantly decreasing trend from year to year may indicate the effectiveness of ALARA programs to reduce doses to individuals or may indicate an overall reduction in activities involving radiation exposure over time. An increasing trend over time may indicate deficiencies in the implementation of ALARA practices or an increase in production or cleanup activities resulting in radiation exposure.

Exhibit 3-5 shows the dose distribution 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 facilitates the examination of 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* also shows that each successively higher dose range is responsible for a lower percentage of the collective dose. The values for the external dose (DDE) have fluctuated within a 5% margin for each dose range over the past 5 years. The values for TEDE in each dose range increased from 1998 to 2000, decreased significantly in 2001, and remained essentially the same between 2001 and 2002. The increases from 1998 to 2000 were due to the increase in internal doses that exceeded the DOE limits. In 2000, three individuals received a TEDE above 5.0 rem (50 mSv), which contributed to 8.6% of the collective TEDE for the year, the highest percentage above 2 rem (20 mSv)

Exhibit 3-5:
Percentage of Collective Dose above Dose Values During 1998-2002.





since 1990. See Section 3.3 for more information on exposures in excess of the DOE limit. In contrast, no individuals exceeded the DOE limits in 2001 and 2002.

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 2002, 3,878 individuals received measurable neutron dose, which is 23% of the individuals with measurable TEDE, and 4% of the total monitored individuals. The collective neutron dose in 2002 represents 20% of the collective TEDE. All neutron doses were below 2 rem (20 mSv) for the past 5 years. The collective neutron dose increased by 17% from 228 person-rem (2.28 person-Sv) in 2001 to 267 person-rem (2.67 person-Sv) in 2002, but has decreased by 6% since 1998. The average measurable neutron dose increased by 11% from 0.062 rem (0.62 mSv) in 2001 to 0.069 rem (0.69 mSv) in 2002. Statistical analysis of the neutron dose (see Section 3.2.6) reveals that the mean neutron dose rose significantly from 0.027 rem (0.27 mSv) in 2001 to 0.030 rem (0.30 mSv) in 2002. The 2002 value was not significantly different from the 5-year peak of 0.031 rem (0.31 mSv) that occurred in 1999.The rise reflects both an increase in the dose per worker, and a slight increase in the number of workers who received a measurable dose. The neutron dose distribution for 2002 by site is shown in Appendix Exhibit B-5.

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*, less than 1% of individuals with measurable extremity dose have received doses above the 5 rem (50 mSv) monitoring threshold over the past 5 years. All of the extremity exposures above 5 rem (50 mSv) in 2002 were for the upper extremities. Forty-eight percent of the extremity exposures above 5 rem (50 mSv) in 2002 occurred at Hanford, where operations involving the manipulation of radioactive materials are more common. Eighty-eight percent of individuals with measurable extremity dose were monitored at four sites: Savannah River, Hanford, Rocky Flats, and Los Alamos. The number of individuals receiving a measurable extremity dose decreased by 1% from 12,465 in 2001 to 12,300 in 2002, and the average extremity dose increased by 18% from 0.308 rem (3.08 mSv) in 2001 to 0.363 rem (3.63 mSv) in 2002. 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. One individual received a dose of 111 rem (1,111 mSv) to the upper extremities at Lawrence Livermore National Laboratory (LLNL) in 2002. See Section 3.3.1 for more information concerning this event.

Exhibit 3-6:
Neutron Dose Distribution, 1998-2002.

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. Neutron Dose	Collective Neutron DDE (person-rem)	Average Meas. Neutron DDE (rem)
1998	103,998	3,680	629	155	34	4	8		108,508	4,510	**283.078** ◄	0.063
1999	109,007	3,329	559	129	27	7	6		**113,064** ◄	4,057	256.075	0.063
2000	98,353	3,809	554	144	17	4			102,881	**4,528** ◄	243.802	0.054
2001	94,135	3,051	454	136	38	3	1		97,818	3,683	228.494	0.062
2002	96,343	3,082	607	122	50	11	6		100,221	3,878	267.029	**0.069** ◄

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

* Represents the total number of records reported. The number of individuals monitored for neutron radiation is not known because there is no distinction made between zero dose and not monitored.

Exhibit 3-7:
Extremity Dose Distribution, 1998-2002.

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)
1998	95,436	8,347	3,938	722	56	8	1			108,508	13,072	65	3,390.1	0.259
1999	99,776	8,759	3,649	750	95	30	2			**113,064** ◄	**13,285** ◄	127	3,988.6	0.300
2000	91,329	7,279	3,322	818	88	37	8			102,881	11,552	133	4,309.5	**0.373** ◄
2001	85,353	8,364	3,282	682	109	27		1		97,818	12,465	137	3,839.0	0.308
2002	87,921	7,902	3,461	777	115	39	5		1	100,221	12,300	**160** ◄	**4,466.1** ◄	0.363

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

* Represents the total number of records reported. The number of individuals monitored for extremity radiation is not known because there is no distinction made between zero dose and not monitored.

** 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 extremity of 5 rem or more in 1 year.

Statistical analysis indicates that the logarithmic mean measurable extremity dose rose significantly to 0.063 rem (0.63 mSv) in 2002 after a significant drop in 2001. The difference is due primarily to an increase in the dose per worker, although the total number of workers who received measurable dose decreased slightly. The extremity dose distribution by site for 2002 is shown in Appendix Exhibit B-22.

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 meaningful 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 because the number of records is too few.

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 use 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. Two nonparametric tests were used: (1) analysis of variance using ranks, and (2) the Kruskall-Wallis test.

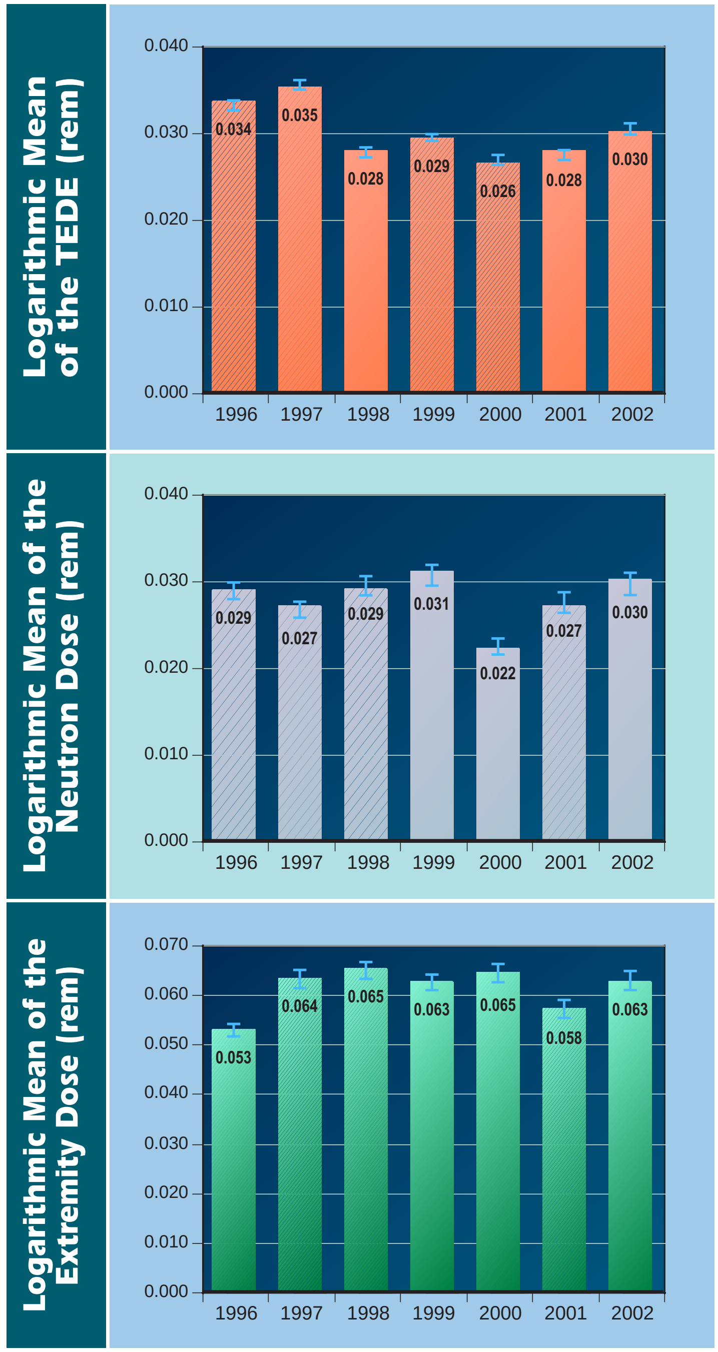
These statistical tests reveal trends that are not apparent when considering only the collective and average doses. In addition, the statistical analysis reveals that some of these trends are significant. *Exhibit 3-8* shows the results of pairwise T-tests for the collective TEDE, neutron, and extremity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

For the collective TEDE, there were small but significant differences in all years, and the logarithmic mean TEDE per worker reached a 5-year peak of 0.030 rem (0.30 mSv) in 2002. The logarithmic mean TEDE increased from 0.028 rem (0.28 mSv) in 2001 to 0.030 rem (0.30 mSv) rem in 2002, reflecting both an increase in the dose to individual workers, and a larger number of individuals with measurable dose. Nonparametric tests of the data confirmed this change. The logarithmic mean TEDE per worker ranged from 0.026 rem to 0.029 rem (0.26 mSv to 0.29 mSv) for 1998-2001. However, the 2002 logarithmic mean TEDE remains significantly below the 1997 logarithmic mean TEDE of 0.035 rem (0.35 mSv) per worker.

The mean neutron dose rose significantly from 0.027 rem (0.27 mSv) in 2001 to 0.030 rem (0.30 mSv) in 2002. The 2002 value was not significantly different from the 5-year peak of 0.031 rem (0.31 mSv), which occurred in 1999. The rise reflects both an increase in the dose per worker and a slight increase in the number of workers who received a measurable dose. Nonparametric tests confirmed this as a significant change from the 2001 distribution.

The logarithmic mean measurable extremity dose rose significantly from 0.058 rem (0.58 mSv) in 2001 to 0.063 rem (0.63 mSv) in 2002 after a significant drop in 2001. The difference is due primarily to an increase in the dose per worker, although the total number of workers who received measurable dose decreased slightly. Nonparametric tests confirmed this as a significant change from the 2001 distribution. Mean values since 1997 have been consistently and significantly higher than they were in 1996. The 1996 mean was itself an increase over 1995 and 1994 values[1]. The rise in mean dose therefore reconfirms the shift to higher individual doses that occurred between 1994 and 1997.

Exhibit 3-8:
DOE-wide Summary Results for Statistical Tests, 1996-2002.



[1] See DOE Occupational Radiation Exposure 1998 Report.

3.3 Analysis of Individual Dose Data

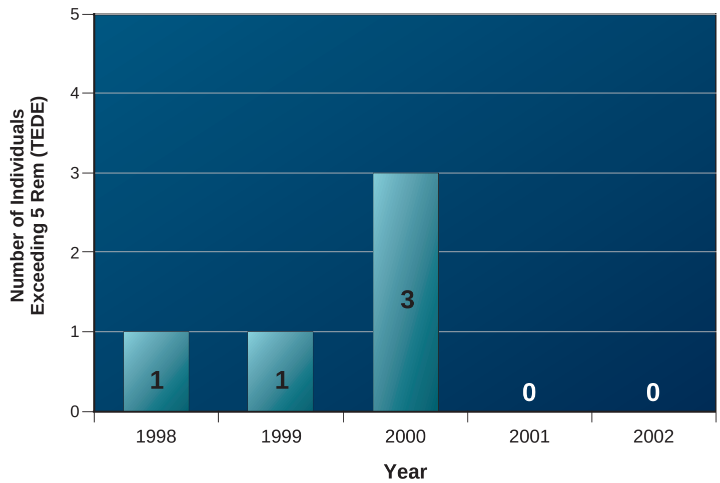
The above analysis is based on aggregate data for DOE. From an individual worker perspective, as well as a regulatory perspective, it is important to closely examine the doses received by individuals in the elevated dose ranges to thoroughly understand the circumstances leading to these doses in the workplace and to better manage and avoid these doses in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rem TEDE) or (50 mSv) and the DOE ACL (2 rem TEDE) or (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) or (50 mSv) from 1998 through 2002. Further information concerning the individual doses, radionuclides involved, and sites where the doses in excess of the 5 rem (50 mSv) TEDE limit have occurred during the past 5 years is shown in *Exhibit 3-10*.

In 2002, one individual received an extremity dose in excess of the 50 rem (0.5 Sv) extremity limit.

Exhibit 3-9:
Number of Individuals Exceeding 5 Rem (TEDE), 1998-2002.



In June 2002, an individual received an extremity dose in excess of the 50 rem (0.5 Sv) limit specified in 10 CFR 835.202(a)(4). An individual received 111 rem (1.11 Sv) to the upper extremity at LLNL where an experimenter had unpacked, chemically purified, assayed, and repacked a quantity of Cf-249 in preparation for shipping the radionuclide to collaborators for nuclear chemistry experiments. The quantity of Cf-249 involved in this activity was approximately 15 milligrams, or approximately 55 millicuries. The incident resulted in a DOE Type B Accident Investigation. For more information, see the occurrence report OAK-LLNL-LLNL-2002-0019.

Exhibit 3-10:
Doses in Excess of DOE Limits, 1998-2002.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	SDE Extremity (rem)	Intake Nuclides	Facility Types	Site
1998	6.292	0.282	6.010		Pu-238, Pu-239, Pu-240	Maintenance and Support	LANL
1999	6.964	0.245	6.719		Pu-238, Pu-239, Pu-241, Am-241	Weapons Fabrication and Testing	Savannah River
2000 *	9.692	0.322	9.370		Pu-238, Pu-239, Pu-240	Research, General	LANL
	11.745	0.245	11.500		Pu-238, Pu-239, Pu-240	Research, General	LANL
	87.156	0.156	87.000		Pu-238, Pu-239, Pu-240	Maintenance and Support	LANL
2001	None Reported						
2002	0.080	0.080	-	111		Research, General	LLNL

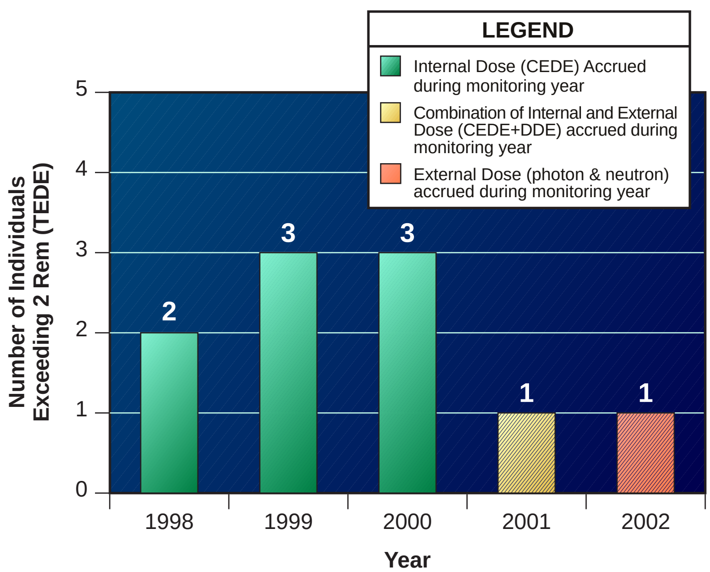
* *These three doses were all a result of the same occurrence.*

3.3.2 Doses in Excess of Administrative Control Level

The RCS [7] recommends a 2 rem (20 mSv) ACL for TEDE, which should not be exceeded without prior DOE approval. The RCS recommends that each DOE site establish its own, more restrictive ACL that would 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.

As shown in *Exhibit 3-11*, one individual received a TEDE above 2 rem (20 mSv) during 2002 at LANL. The individual was reported to have received 2.214 rem (22.14 mSv) TEDE, which included 1.731 rem (17.31 mSv) from neutrons. Neutron dose is more common at LANL due to the nature of the work involving plutonium at this facility. The dose was anticipated and formally approved by the LANL ALARA Steering Committee prior to incurring the dose; therefore, no occurrence report was required for this event.

Exhibit 3-11:
Number of Doses in Excess of the DOE 2 Rem ACL, 1998-2002.



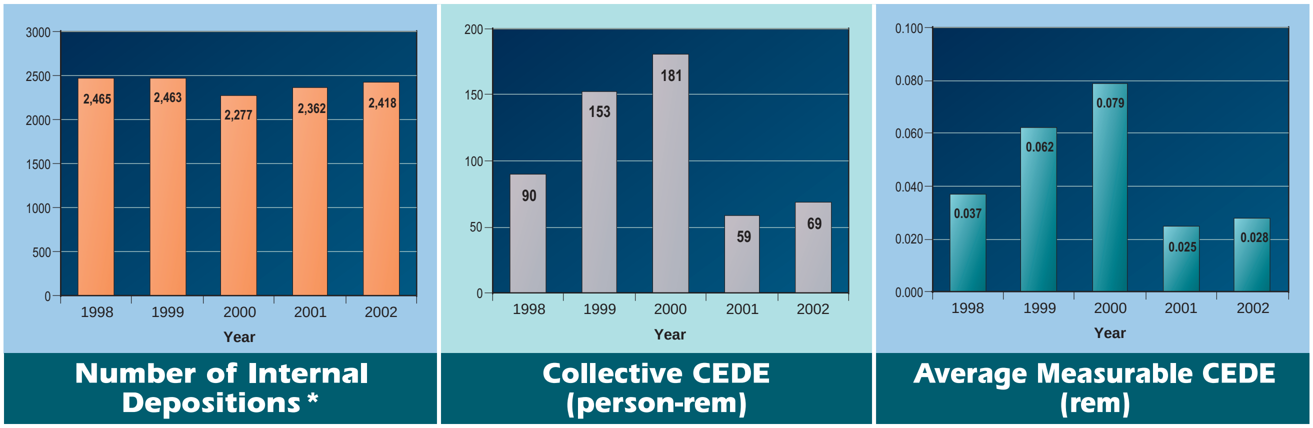
3.3.3 Internal Depositions of Radioactive Material

As shown in *Exhibit 3-10*, some of the highest 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), collective CEDE, and average measurable CEDE for 1998-2002 is shown in *Exhibit 3-12*. The number of internal depositions increased by 2% from 2,362 in 2001 to 2,418 in 2002, while the collective CEDE increased by 17%. Due to the increase in the collective CEDE and slight increase in the number of internal depositions, the average measurable CEDE increased by 12% from 0.025 rem (0.25 mSv) in 2001 to 0.028 rem (0.28 mSv) in 2002, which is the second lowest average measurable CEDE in the past 5 years.

The number of internal depositions of radioactive material for 2000 through 2002 is also shown in *Exhibit 3-13*. 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 each year over the 3-year period are 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.

Exhibit 3-12:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE (Graph), 1998-2002.



* The number of internal depositions represents the number of internal dose records reported for each individual. Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

The 17% increase in the collective CEDE from 59 person-rem (590 person-mSv) in 2001 to 69 person-rem (690 person-mSv) in 2002 was primarily due to a 20% increase in internal dose at the Oak Ridge Y-12 site. The Y-12 facility accounted for 77% of the collective CEDE for 2002. The increase was attributed to activities at the Enriched Uranium Operations (EUO) facilities.

During the past 5 years, there have been several intakes from plutonium or uranium in excess of 2 rem (20 mSv) each year, with some of the doses in excess of 5 rem (50 mSv) (see *Exhibit 3-10*). While the number of internal depositions above 2 rem (20 mSv) has been few, they have contributed significantly to the collective internal dose for the years 1998 through 2000. No such intakes were reported for 2001 and 2002, and the reduction in the collective CEDE reflects this fact.

Exhibit 3-13:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE by Nuclides (Data), 2000-2002.

Nuclide	**Number of Internal Depositions***			**Collective CEDE (person-rem)**			**Average Measurable CEDE (rem)**		
Year	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**
Hydrogen-3 (Tritium)	394	315	270	2.039	1.189	1.351	0.005	0.004	0.005
Radon-222	4	2	15	0.118	0.076	2.115	0.030	0.038	**0.141** ◄
Thorium	62	23	67	3.838	0.204	0.836	0.062	0.009	0.012
Uranium	**1,630** ◄	**1,838** ◄	**1,664** ◄	60.226	**47.078** ◄	**55.962** ◄	0.037	0.026	0.034
Plutonium	123	137	298	**113.020**** ◄	8.258	6.868	**0.919** ◄	0.060	0.023
Americium-241	34	28	65	0.989	1.777	1.226	0.029	**0.063** ◄	0.019
Other	27	13	26	0.145	0.146	0.091	0.005	0.011	0.004
Mixed	3	6	13	0.205	0.226	0.241	0.068	0.038	0.019
Totals	**2,277**	**2,362**	**2,418**	**180.580**	**58.954**	**68.690**	**0.079**	**0.025**	**0.028**

Note: Arrowed values indicate the greatest value in each column.
* The number of internal depositions represents the number of internal dose records reported for each individual.
** Primarily the result of an event resulting in three individuals receiving a total of 107.87 person-rem at LANL.

The highest collective CEDE and number of depositions in 2002 are due to uranium intakes. The majority of the collective dose from uranium (95%) occurred at the Oak Ridge Y-12 facility during the continued operation and management of EUO facilities at the site. The highest average measurable CEDE in 2002 is from Radon-222, although the collective dose and number of depositions from Radon-222 are relatively small. These intakes were received by individuals performing work at the former Grand Junction site and reported by the Idaho site. The number of intakes for tritium decreased for the sixth year in a row, with the decrease from 2001 to 2002 attributable to decreases in intakes at the Savannah River Site.

Because relatively few workers receive measurable internal dose, fluctuations in the number of workers and collective CEDE can occur from year to year.

Exhibit 3-14 shows the distribution of the internal dose from 1998 to 2002. The total number of individuals with intakes in each dose range is the sum of all records of intake in the subject dose range. 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 of the internal doses were below 2 rem (20 mSv) in 2002 for the second time in the past 5 years.

The internal dose records indicate that the majority of the intakes reported are at very low doses. In 2002, 63% of the internal dose records were for doses below 0.020 rem (0.20 mSv). Over the 5-year period, internal doses from new intakes accounted for only 9% of the collective TEDE, and only 6% of the individuals who received internal dose were above the monitoring threshold specified (100 mrem or 1 mSv) in 10 CFR 835.402(c).

Exhibit 3-14:
Internal Dose Distribution from Intakes, 1998-2002.

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)
1998	1,909	353	128	43	18	8	5	1			1	2,466	90.217
1999	1,726	443	137	78	32	26	19		1		1	2,463	152.868
2000	1,472	625	136	34	5	2					3	2,277	180.580
2001	1,673	574	90	19	4		2					2,362	58.954
2002	1,534	734	131	16	3							2,418	68.690

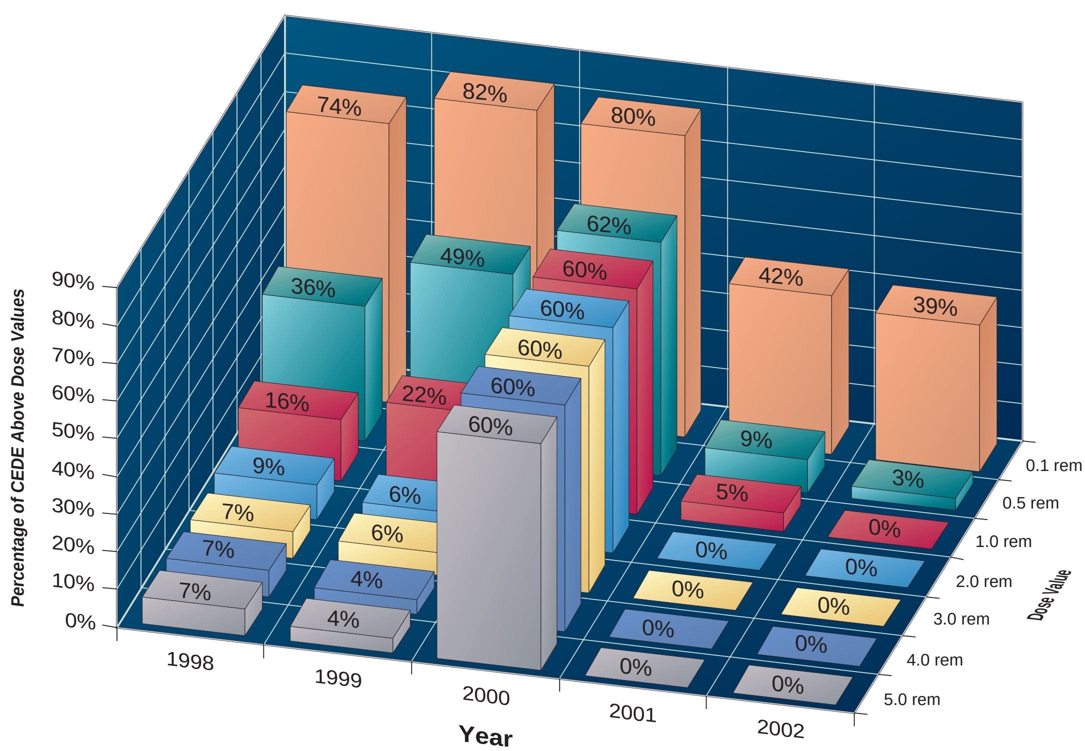
Note: Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
* Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

The internal dose distribution can also be shown in terms of the percentage of the collective dose delivered above certain dose levels. *Exhibit 3-15* shows this information for the CEDE for each year from 1998 to 2002. While the fluctuations in internal dose prohibit definitive trend analysis, it is evident from the graph that from 1998 to 2000, there was an increase in the percentages above 2 rem (20 mSv), which was due to the individuals who exceeded the DOE annual limits. In 2000, the percentages above 2 rem (20 mSv) were dominated by the three doses in excess of the DOE annual limit that occurred at LANL. For 2001 and 2002, the percentage of internal dose above each dose range decreased dramatically because of the lack of any internal doses above 2 rem (20 mSv). The distribution of internal dose by site and nuclide for 2002 is presented in Appendix Exhibit B-21.

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

Over the 5-year period, internal doses accounted for only 9% of the collective TEDE.

Exhibit 3-15:
Distribution of Collective CEDE vs. Dose Value, 1998-2002.



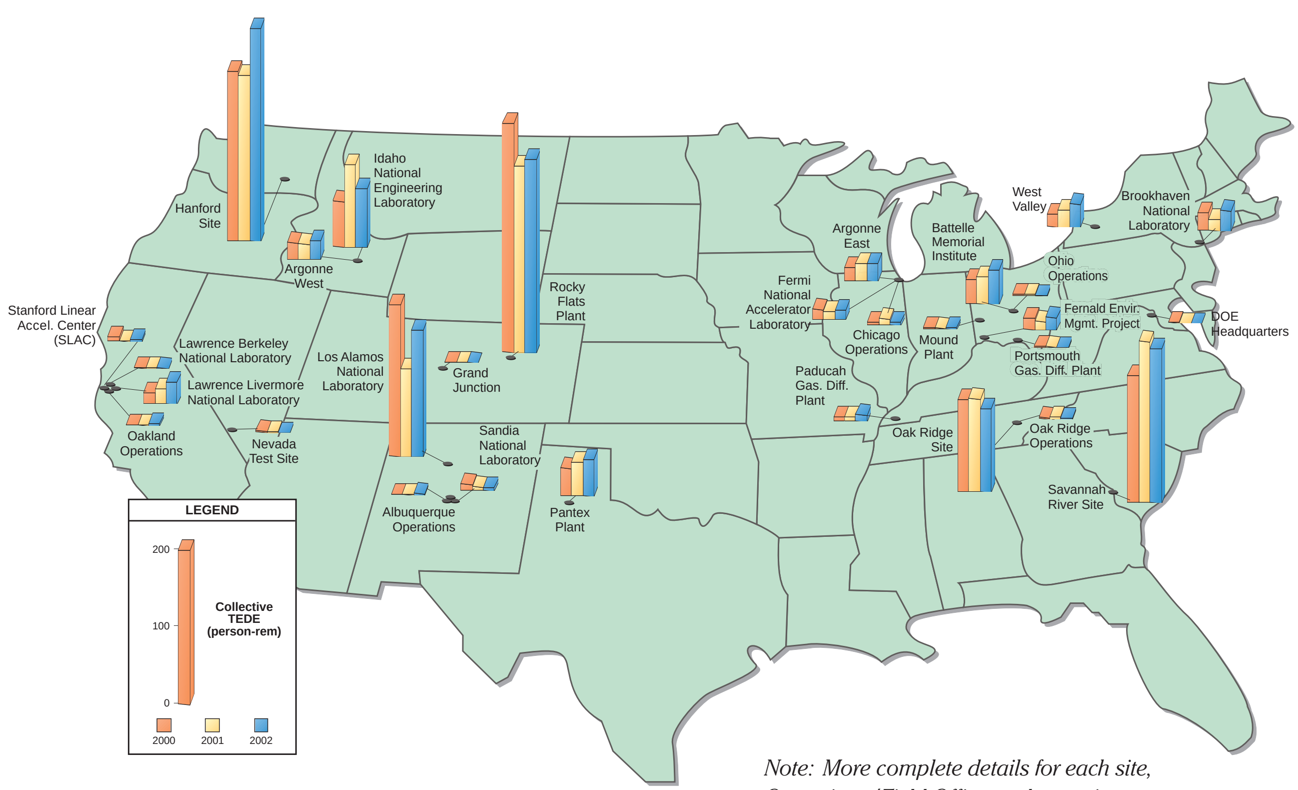
When examining trends involving internal dose, several factors should be considered. Some of the largest changes in the number of reported intakes over the years resulted from changes in internal dosimetry practices. Periodically, sites may implement new technology or change monitoring practices or procedures, 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 statistical variability of the internal dose data from year to year.

3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Operations/Field Offices

The collective TEDE for 2000 through 2002 for the major DOE sites and Operations/Field Offices is shown in *Exhibit 3-16*. A list of the collective TEDE and number of individuals with measurable TEDE for the DOE Sites and Operations/Field Offices is shown in *Exhibit 3-17*. Operations/Field Office dose is shown separately from the site dose wherever it is reported separately (see Appendix Exhibit A-2). Other small sites and facilities that do not contribute significantly to the collective dose are included within the numbers shown for "Ops. and Other Facilities." The collective TEDE increased by 10% from 1,232 person-rem (12.32 person-Sv) in 2001 to 1,360 person-rem (13.62 person-Sv) in 2002, with six of the highest dose sites (Hanford, Rocky Flats, Savannah River, Los Alamos, Oak Ridge, and Idaho) contributing 79% of the total DOE collective TEDE.

Exhibit 3-16:
Collective TEDE by Site for 2000-2002.



Note: More complete details for each site, Operations/Field Office, and reporting organization can be found in Appendix B.

Exhibit 3-17:
Collective TEDE and Number of Individuals with Measurable TEDE by Site, 2000-2002.

Operations/ Field Office	Site	2000 Collective TEDE (person-rem)	2000 Number with Meas. TEDE	2001 Collective TEDE (person-rem)	2001 Number with Meas. TEDE	2002 Collective TEDE (person-rem)	2002 Number with Meas. TEDE
Albuquerque	Ops. and Other Facilities	0.3	38	1.2	95	2.5	118
	Los Alamos National Lab. (LANL)	195.5	1,365	112.9	1,330	163.5	1,696
	Pantex Plant (PP)	35.0	277	43.6	293	47.3	292
	Sandia National Lab. (SNL)	7.6	105	4.7	99	4.5	109
	Grand Junction *	0.1	6	0.1	2		
Chicago	Ops. and Other Facilities	3.5	108	7.8	162	4.5	182
	Argonne Nat'l. Lab. - East (ANL-E)	17.2	183	23.0	187	23.6	233
	Argonne Nat'l. Lab. - West (ANL-W)	20.9	234	19.8	258	24.9	278
	Brookhaven Nat'l. Lab.(BNL)	22.4	430	14.6	387	26.2	439
	Fermi Nat'l. Accelerator Lab.(FERMI)	12.3	406	10.7	368	12.8	389
DOE HQ	DOE Headquarters	0.1	11	0.0	5	0.0	0
	DOE North Korea Project *			1.0	8		
	Russian Federation Project					0.0	0
Idaho	Idaho Site	58.8	795	106.6	1,088	76.0	1,089
Nevada	Nevada Test Site (NTS)	1.6	24	1.3	32	0.9	30
Oakland	Ops. and Other Facilities	0.9	133	1.6	134	3.2	81
	Lawrence Berkeley Nat'l. Lab. (LBNL)	1.1	44	0.7	21	0.9	33
	Lawrence Livermore Nat'l. Lab. (LLNL)	12.7	145	18.6	153	28.0	163
	Stanford Linear Accelerator Center (SLAC)	5.5	489	1.4	35	3.1	79
Oak Ridge	Ops. and Other Facilities	1.9	125	2.6	144	1.4	103
	Oak Ridge Site	118.1	2,276	120.0	2,576	107.8	2,304
	Paducah Gaseous Diff. Plant (PGDP)	5.0	63	5.0	122	8.8	232
	Portsmouth Gaseous Diff. Plant (PORTS)	1.5	44	1.2	35	1.0	37
Ohio	Ops. and Other Facilities	1.9	151	2.0	89	0.6	49
	Battelle Memorial Institute - Columbus	31.3	105	35.2	84	44.4	103
	Fernald Environmental Management Project	15.0	421	11.4	355	17.0	572
	Mound Plant	1.1	123	1.2	97	2.7	198
	West Valley	16.5	246	22.2	233	30.5	239
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**296.1** ◂	2,331	**240.7** ◂	2,436	250.0	2,175
Richland	Hanford Site	219.0	1,923	213.6	2,219	**274.4** ◂	2,611
Savannah River	Savannah River Site (SRS)	163.2	**3,382** ◂	207.6	**3,640** ◂	199.1	**3,217** ◂
Totals		**1,266.5**	**15,983**	**1,232.4**	**16,687**	**1,359.6**	**17,051**

* No longer in operation; therefore, not required to report.

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

Exhibit 3-18:
Number with Measurable Dose, Collective TEDE, and Average Measurable TEDE by Labor Category, 2000-2002.

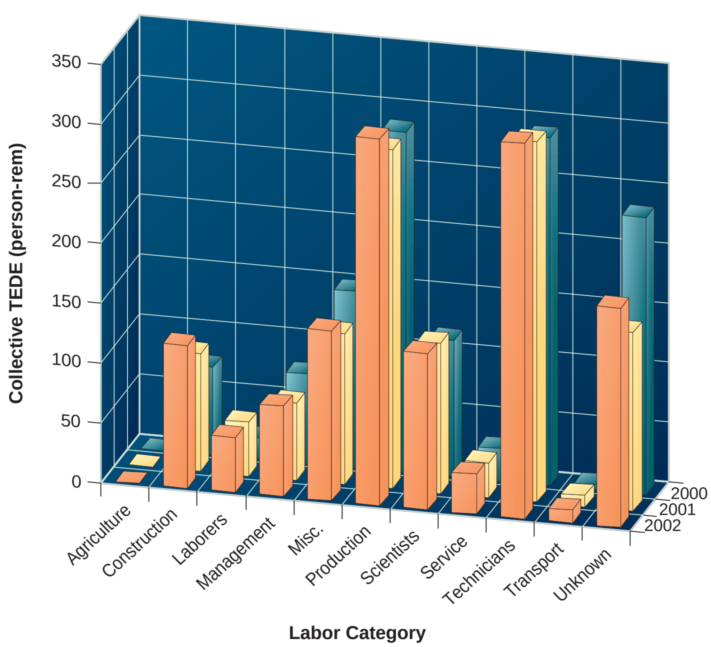
Labor Category	Number with Meas. Dose			Collective TEDE (person-rem)			Average Meas. TEDE (rem)		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
Agriculture	1	0	1	0.0	0.0	0.0	0.035	0.0	0.012
Construction	1,375	1,825	1,949	73.8	98.7	118.8	0.054	0.054	0.061
Laborers	281	434	605	17.8	44.6	45.8	0.063	0.103	0.076
Management	1,628	1,368	1,392	74.7	64.7	75.6	0.046	0.047	0.054
Misc.	1,563	1,667	1,527	147.4	125.9	142.2	0.094	0.076	0.093
Production	2,214	2,296	2,419	284.6	283.7	306.1	**0.129** ◄	**0.124** ◄	**0.127** ◄
Scientists	**3,001** ◄	**2,978** ◄	2,908	114.5	125.3	130.6	0.038	0.042	0.045
Service	658	710	631	27.1	29.2	33.4	0.041	0.041	0.053
Technicians	2,723	2,865	**2,956** ◄	**290.5** ◄	**301.5** ◄	**313.3** ◄	0.107	0.105	0.106
Transport	112	183	245	4.6	9.3	10.6	0.041	0.051	0.043
Unknown	2,427	2,361	2,418	231.4	149.6	183.2	0.095	0.063	0.076
Totals	**15,983**	**16,687**	**17,051**	**1,266.5**	**1,232.4**	**1,359.6**	**0.079**	**0.074**	**0.080**

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

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 assists 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 2000 through 2002 is shown in *Exhibits 3-18* and *3-19*. Technicians and production staff have the highest collective TEDE for the past 3 years because they generally handle more radioactive sources than individuals in the other labor categories. In 2002, 51% of the technician dose was attributed to radiation protection technicians, and 73% of the dose to production personnel is attributed to plant operators.

Exhibit 3-19:
Graph of Collective TEDE by Labor Category, 2000-2002.



The "unknown" and "miscellaneous" categories have the next highest collective TEDE totals. Eighty-nine percent of the dose in the "unknown" category for 2002 is attributed to LANL. Currently, the LANL computer system does not maintain the data necessary to report occupation codes in accordance with DOE M 231.1-1. Other sites also report 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 from 2000 to 2002 is presented in Appendix Exhibit B-19. In addition, Appendix Exhibit B-20 shows the TEDE distribution by labor category and occupation for 2002.

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. The contributions of certain facility types to the DOE collective TEDE is shown in *Exhibits 3-20* and *3-21*. The collective dose for each facility type at each major site of each DOE Operations/Field Office from 2000 to 2002 is shown in Appendix Exhibit B-7. An examination of internal dose from intake by facility type and nuclide for 2000 to 2002 is presented in Appendix Exhibit B-17.

The collective TEDE for 2000 through 2002 was highest at weapons fabrication and testing facilities. Fifty-seven percent of this dose was accrued at Rocky Flats in 2002, with 17% at Savannah River and 14% at the Oak Ridge Y-12 facility. 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. See Section 3.5 for information concerning the current activities at these sites.

Exhibit 3-20:
Graph of Collective TEDE by Facility Type, 2000-2002.

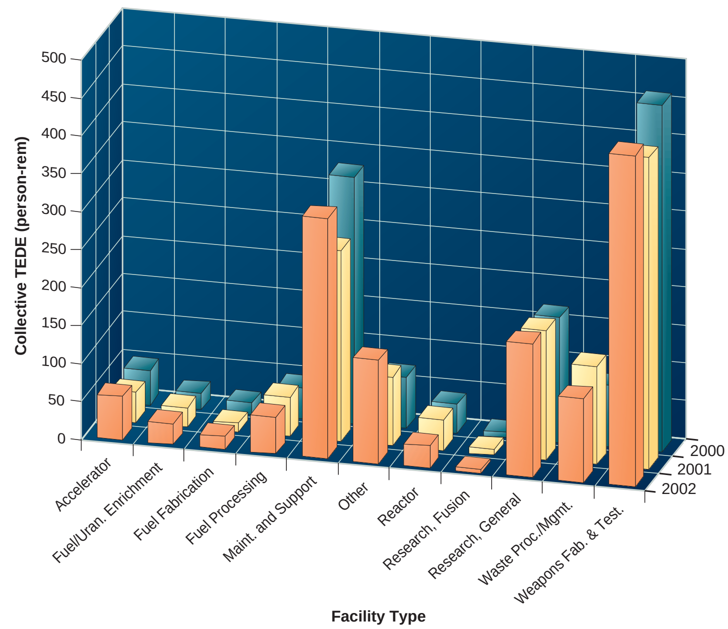


Exhibit 3-21:
Number with Measurable Dose, Collective TEDE, and Average Measurable TEDE by Facility Type, 2000-2002.

Facility Type	Number with Meas. Dose			Collective TEDE (person-rem)			Average Meas. TEDE (rem)		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
Accelerator	1,429	976	1,087	45.9	40.1	57.2	0.032	0.041	0.053
Fuel/Uranium Enrichment	679	846	744	21.6	25.8	27.7	0.032	0.031	0.037
Fuel Fabrication	424	355	572	15.1	11.4	17.0	0.036	0.032	0.030
Fuel Processing	1,115	1,155	1,137	41.6	52.5	48.9	0.037	0.045	0.043
Maintenance and Support	2,173	2,389	2,825	325.4	251.6	316.6	**0.150** ◀	**0.105** ◀	**0.112** ◀
Other	1,434	1,401	1,576	68.2	90.8	135.8	0.048	0.065	0.086
Reactor	600	560	470	38.1	40.9	29.3	0.064	0.073	0.062
Research, Fusion	78	116	153	7.1	7.8	4.3	0.092	0.067	0.028
Research, General	2,140	2,227	2,172	164.8	170.6	175.9	0.077	0.077	0.081
Waste Processing/Mgmt.	1,460	1,938	1,875	81.2	129.9	110.3	0.056	0.067	0.059
Weapons Fab. and Testing	**4,451** ◀	**4,724** ◀	**4,440** ◀	**457.5** ◀	**411.1** ◀	**436.6** ◀	0.103	0.087	0.098
Totals	**15,983**	**16,687**	**17,051**	**1,266.5**	**1,232.4**	**1,359.6**	**0.079**	**0.074**	**0.080**

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

3.4.4 Radiation Protection Occurrence Reports

In addition to the records of individual radiation exposure monitoring required by DOE M 231.1-1, sites are required to report certain unusual or off-normal occurrences involving radiation under DOE Order 232.1A . These reports are submitted to Occurrence Reporting and Processing System (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 *radiation exposure* occurrences, and Group 4B reports *personnel contamination* occurrences. The occurrence reporting requirements for DOE M 232.1-1A are summarized in *Exhibit 3-22*. These requirements became effective under DOE M 232.1-1 in September 1995 and have remained essentially unchanged under DOE M 232.1-1A, which became effective in July 1997. DOE Order 232.1A and DOE Manual 232.1-1A were in effect during the 2002 reporting year.

It should be noted that DOE Order 232.1A and Manual 232.1-1A have been cancelled as of August of 2003. The revised DOE Order 231.1A combines the requirements for occurrence reporting to ORPS and radiation exposure records to REMS. The revised DOE Manual 231.1-2 contains the detailed instructions on reporting information to ORPS. Subsequent annual reports on occupational exposure will reflect these changes in directives.

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. Significant increases or decreases in the number of occurrences reported may reflect trends in radiation exposures, the effectiveness of DOE radiation protection programs, or changes to the reporting procedure or thresholds. The reporting thresholds and processes have stabilized over the years, and the increase in the number of radiation exposure occurrences and decrease in the number of contamination occurrences reported in 2002 may reflect statistical variability rather than any performance trend.

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 report may involve the roll-up of similar or multiple occurrences. For the

Exhibit 3-22:
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 (1 mSv). ◆ Any single unplanned exposure onsite to a minor, student, or member of the public that exceeds 50 mrem (0.5 mSv). ◆ 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.

analysis included in this report, only the number of occurrences is considered. Also, it should be noted that some occurrences are reported based on an initial estimate of exposure but may be recategorized later pending the receipt of the final determined exposure.

The number of occurrences reported under Personnel Radiological Protection is broken into two subcategories: *Radiation Exposure*, and *Personnel Contamination*. Results for those two subcategories are presented in *Exhibits 3-23* and *3-25*.

3.4.4.1 Radiation Exposure Occurrences

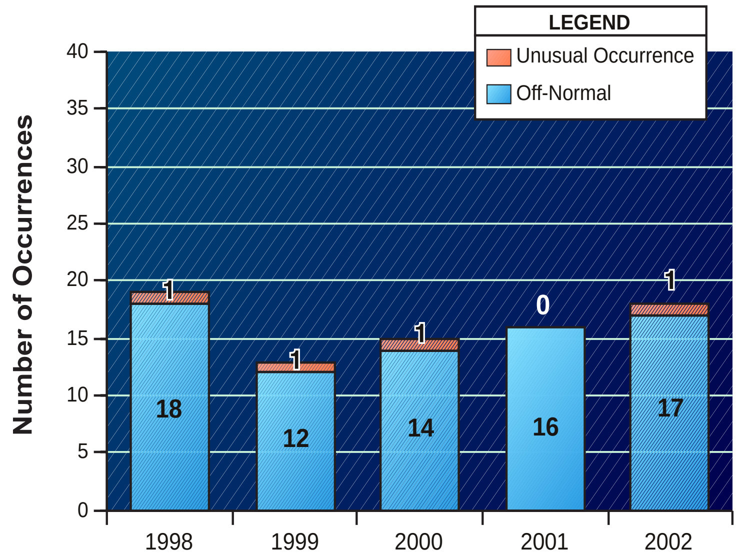
Radiation exposure occurrences are reported when individuals are exposed to radiation above anticipated levels, or when the resulting exposure exceeds 100 mrem (0.1 rem) (1 mSv) external (whole body, skin, or extremity) or internal. The number of *radiation exposure* occurrences increased by 13% from 16 in 2001 to 18 in 2002 as shown in *Exhibit 3-23.* The number of people involved in *radiation exposure* occurrences reported in 2002 (25 people) was 19% less than those in 2001 (31 people).

The number of radiation exposure occurrences increased by 13% from 2001 to 2002.

Four of the internal exposures reported in 2002 occurred in 2001, two occurred in 2000, and one in 1998 where a participant in the bioassay monitoring program began exhibiting what appeared to be elevated and widely varying concentrations of uranium isotopes in the urine (see Occurrence Report OH-MB-BWO-BWO04-2002-0002). Although there was no apparent occupational explanation for the elevated readings, an acute (one time) occupational dose of 939 mrem (9.39 mSv) CEDE was assigned to the worker.

One radiation exposure occurrence (see Occurrence Report OAK-LLNL-LLNL-2002-0019) was classified as an Unusual Event in 2002 compared to zero Unusual Events recorded in 2001. The Unusual Event occurred at LLNL and involved one individual whose finger ring

Exhibit 3-23:
Number of Radiation Exposure Occurrences, 1998-2002.



dosimeter indicated an excessive dose that exceeded the annual extremity dose limit. The worker was exposed to radiation as a result of 1-2 hours of directly handling unsealed radioactive material (Cf-249) over a period of approximately 10 days during unpacking, chemically purifying, and repacking in preparation for shipment. The excessive dose was discovered during routine dosimetry review approximately a month after the exposure occurred.

Another case (see Occurrence Report OH-MB-BWO-BWO06-2002-0001) involved two related occurrences in which one was classified as a *radiation exposure* and the other a *personnel contamination exposure* event. The first occurrence listed in this occurrence report was a *radiation exposure* that involved three individuals with elevated tritium bioassay results. The workers were in a contaminated area to sample and consolidate the contents of one drum and inventory a second drum. Upon completion of the tasks and after performing a whole body frisk, the workers exited the area. Three days later, internal monitoring results indicated that the three workers had elevated tritium bioassay results with dose estimates from 30 to 40 mrem (0.30 - 0.40 mSv) Additional bioassay samples for Pu/Am were tested and final results indicated that one worker received an exposure of 192 mrem (1.92 mSv) from Pu-238 and 15 mrem (0.15 mSv) from tritium.

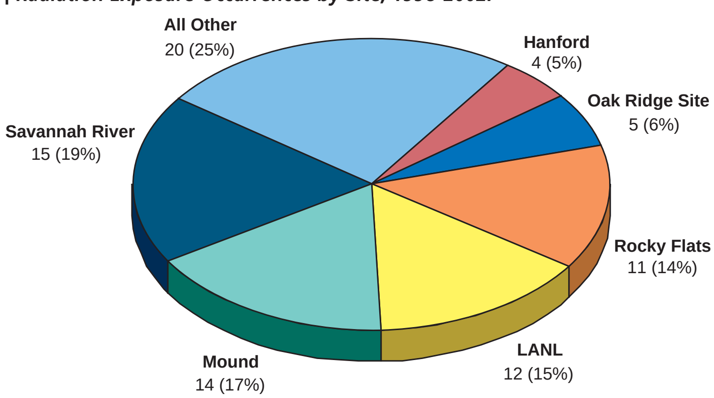
There was one *radiation exposure* occurrence for 2002 that was a "near miss" for internal exposure (see Occurrence Report ALO-LA-LANL-CMR-2002-0007). An employee dropped a sample container of plutonium oxide that resulted in area contamination and nearly resulted in an unanticipated internal exposure.

In another case (see Occurrence Report OH-WV-WVNS-FRS-2002-0004), routine annual whole body counts showed detectable Cs-137 for several individuals who had worked in the same area. As a result, whole body counts were given to 16 individuals who worked on common jobs in that area during the same time period. Eight of the 16 had detectable levels of Cs-137 due to inhalation of airborne contamination likely resulting from sediment and contamination in pool water as equipment was removed from the pool.

None of the 81 *radiation exposure* occurrence reports submitted to the ORPS between 1998 and 2002 involved exposure to minors, members of the public, or pregnant workers.

Exhibit 3-24 shows the breakdown of occurrences for radiation exposure by site for the 5-year period 1998 through 2002. Seventy-five percent of the 2002 *radiation exposure* occurrences were reported by six sites: Savannah River, Mound, Los Alamos, Rocky Flats, Oak Ridge, and Hanford. During 2002, Mound and Los Alamos had increases in reported occurrences, while Savannah River, Hanford, Rocky Flats, and Oak Ridge experienced decreases.

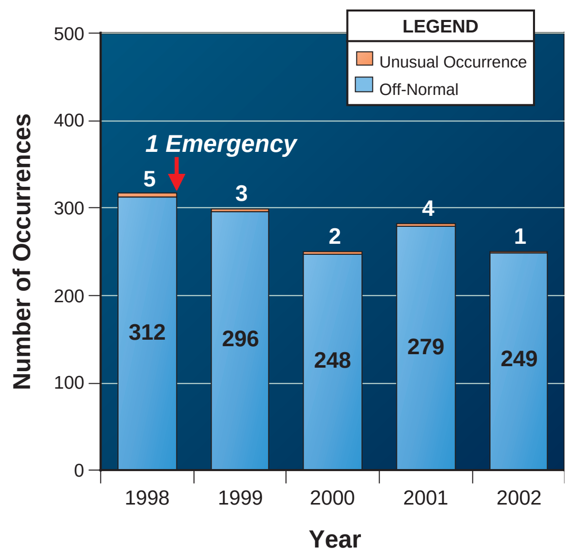
Exhibit 3-24:
Radiation Exposure Occurrences by Site, 1998-2002.



3.4.4.2 Personnel Contamination Occurrences

Personnel contamination occurrences are reported whenever personnel, clothing, or personal items are contaminated above threshold levels, generally five times the unconditional release limits. The number of *personnel contamination* occurrences reported decreased 12% from 283 in 2001 to 250 in 2002. The number of *personnel contamination* occurrences reported has decreased by 21% from 318 in 1998 to 250 in 2002 (see *Exhibit 3-25*). One *personnel contamination* occurrence in 2002 was classified as an Unusual Event, compared to four

Exhibit 3-25:
Number of Personnel Contamination Occurrences, 1998-2002.



in 2001. The case (see Occurrence Report RL-PHMC-SNF-2002-0031) involved three separate, but related, events resulting in seven individuals receiving contamination. The first event involved mostly shoe contamination for five individuals when contamination was identified outside the boundaries of a contaminated area. The second event occurred the following day when a worker who was supporting decontamination and recovery activities related to the original contamination event was discovered with shoe contamination. The next day, the third event involved a shoe contamination on a worker who had been conducting surveying activities outside the contaminated area boundaries.

Occurrence Report OH-MB-BWO-BWO06-2002-0001 recorded two occurrences: one *radiation exposure* occurrence and one *personnel contamination* occurrence. The *personnel contamination* occurrence was a shoe contamination, and it was determined that the radioactive particle detected on the sole of the worker's shoe had been picked up in the same contaminated area where the *radiation exposure* occurred (see section 3.4.4.1 for details).

The number of Personnel Contamination occurrences has decreased by 12% between 2001 and 2002.

It should be noted that the totals for *Exhibits 3-25, 3-26*, and *3-27* are not equivalent because some occurrences involve more than one affected area, and some occurrences involve more than one individual. *Exhibit 3-25* presents the total number of occurrences. *Exhibit 3-26* presents the number of personnel contaminations by affected area and may count occurrences more than once if there is more than one affected area involved in the occurrence. *Exhibit 3-27* shows the number of individuals by affected area. Individuals may be counted more than once if they have more than one affected area.

Exhibit 3-26 compares the *personnel contamination* occurrences by the affected area. Skin and shoe contamination incidents decreased from 2001 to 2002, while clothing contamination occurrences increased. Hand contaminations made up approximately 32% of the skin contamination incidents. In two cases, the hand contamination was due to puncture wounds received while wearing "cut resistant gloves." In one of those cases (see Occurrence Report RFO-KHLL-SOLIDWST-2002-0065), while wearing "cut resistant gloves," the index finger of an individual was punctured. After two unsuccessful attempts to excise the contamination, the wound was stitched. The individual was assigned a dose of 180 mrem (1.8 mSv) for 2002.

Although 250 *personnel contamination* occurrences were reported in 2002 (a 12% decline from 2001), 309 individuals were contaminated on the skin, clothing, and/or shoes, as shown in *Exhibit 3-27*, which represents a 5% decline from the 324 individuals in 2001.

Exhibit 3-26:
Personnel Contaminations by Affected Area, 1998-2002.

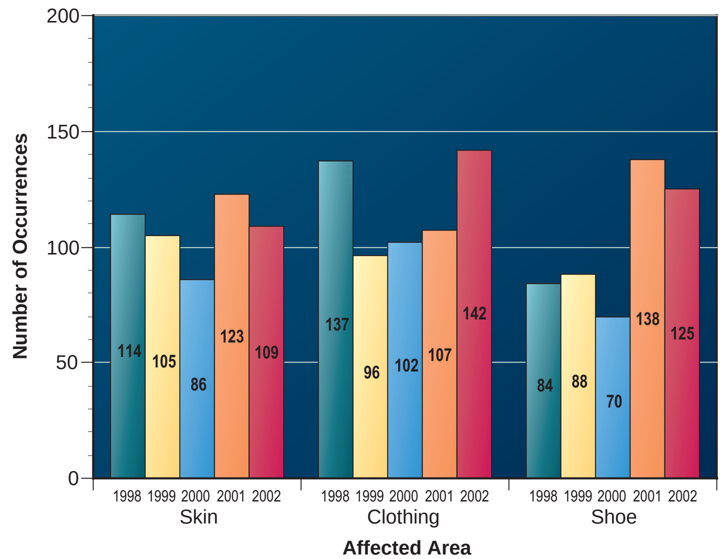


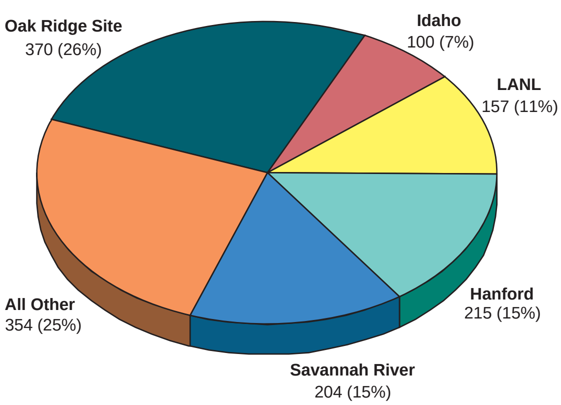
Exhibit 3-27:
Number of Individuals Contaminated by Affected Area in 2002.

Affected Area	Individuals Contaminated
Skin contamination only	59
Clothing (or other personal item) only	84
Shoes only	108
Skin and Clothing	42
Skin and Shoes	0
Clothing and Shoes	7
Skin, Clothing, and Shoes	9

The combination of skin and clothing (and many of the skin, clothing, and shoe) contamination usually involved situations where the contamination on the outer protective clothing was inadvertently transferred to the skin. Three modes of contamination are common among these occurrences. The first is personnel error in the removal of protective clothing that results in skin contamination. The second involves the transference or "wicking" of contaminated liquid through the protective clothing to the skin. This can occur as a result of kneeling in wet spots or from sweat-soaked clothing. The third common cause of skin contamination occurrences is from residual contamination remaining on the protective clothing after laundering. All of these problems have been reported in past years and the frequency of their occurrence has not changed significantly.

Exhibit 3-28 shows the *personnel contamination* occurrences by site for 1998 through 2002. The overall number of *personnel contamination* occurrences continued on a downward trend with three of the top five sites experiencing a slight decrease and the other two averaging the same number as the previous year.

Exhibit 3-28:
Personnel Contamination Occurrences by Site, 1998-2002.



3.4.4.3 Occurrence Cause

Exhibits 3-29 and *3-30* provide a breakdown of *radiation exposure* occurrences and *personnel contamination* occurrences by their root cause. For the ORPS, the "root cause" is defined as that which, if corrected, would prevent recurrences. Only four significant root causes are considered here (management problem, personnel error, equipment/material, and unknown source of radiation); other causes are included in the category entitled "All Other."

Exhibit 3-29:
Radiation Exposure Occurrences by Root Cause, 2000-2002.

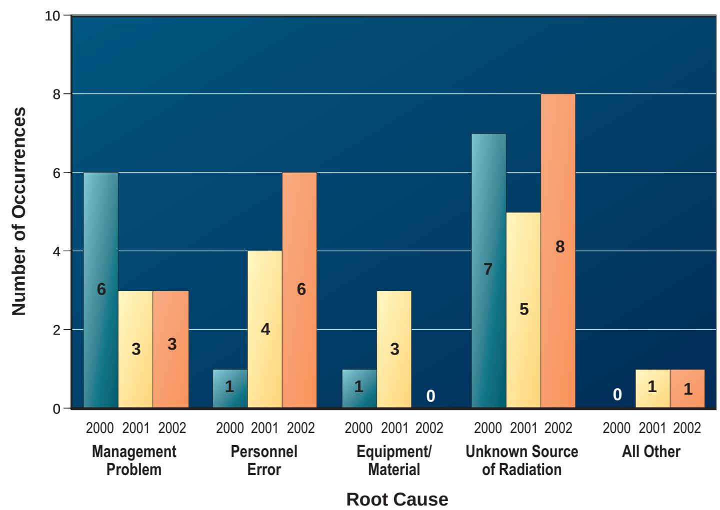
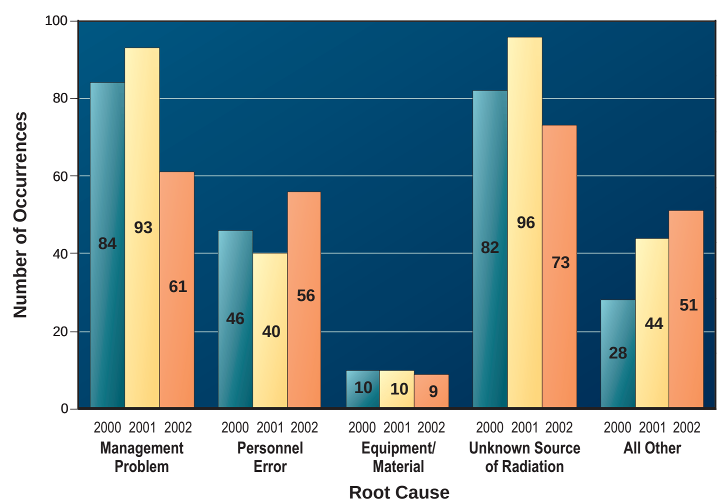


Exhibit 3-30:
Personnel Contamination Occurrences by Root Cause, 2000-2002.



In 2002, "Personnel Error" was cited as the root cause for six occurrences (33%) of the *radiation exposure* occurrences reported. "Unknown Source of Radiation" was the root cause of eight occurrences (44%) reported. The number of radiation occurrences of "Equipment or Material" failure decreased to zero in 2002. "Management Problems" made up approximately 17% of the cases in 2002. The "All Other" category had one occurrence, which was the same number as the previous year.

For *personnel contamination* occurrences, two categories reported increases in the root cause from 2001 to 2002. The largest increase occurred in "Personnel Error" with an increase of 40% over 2001. The only other area that saw an increase was "All Other" with a 16% increase over the previous year. "All Other" includes these subcategories: Design Problems, Procedure Inadequacy, Training Deficiency, and None (no root cause reported). The remaining root cause categories declined. "Management Problem" had the largest decrease of 34% less than 2001. "Unknown Source of Radiation" decreased 24% from 2001 to 2002 and includes unknown sources, as well as known sources from "legacy" contamination. Finally, the number of occurrences that were attributed to "Equipment/Material" decreased by 10% over last year's statistics.

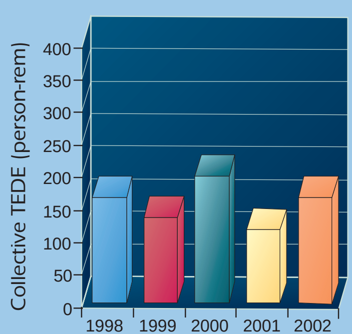
Further information concerning ORPS can be obtained by contacting Eugenia Boyle of EH-33 or the ORPS web page at:

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

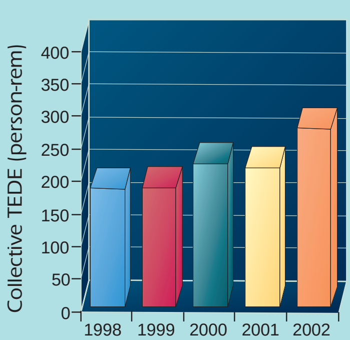
3.5 Activities Contributing to Collective Dose in 2002

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 2002. These sites (Hanford, Rocky Flats, Savannah River, Los Alamos, Oak Ridge, and Idaho) were the top six sites in their contribution to the collective TEDE for 2002 and comprised 79% of the total DOE dose. Three of the six sites reported increases in the collective TEDE, which resulted in a 10% increase in the DOE collective dose from 1,232 person-rem (12.32 person-Sv) in 2001 to 1,360 person-rem (13.60 person-Sv) in 2002. The six sites are shown in *Exhibit 3-31*, including a description of activities that contributed to the collective TEDE for 2002.

Exhibit 3-31:
Activities Contributing to Collective TEDE in 2002 for Six Sites.



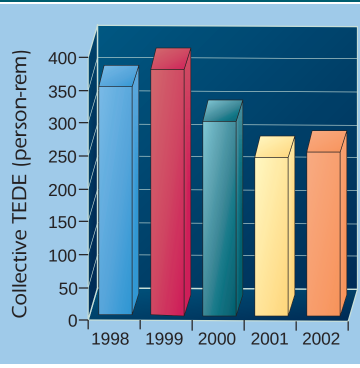
Los Alamos National Lab.	Percent Change 2001-2002 (last yr.)	Percent Change 2000-2002 (3 yr.)	Percent Change Since 1998 (5 yr.)	Description of Activities at the Site
	↑ 45%	16% ↓	↑ 1%	The collective TEDE at LANL increased by 45% from 2001 to 2002. Of the total TEDE in 2002, 3.2 person-rem is from internal dose, and 160 person-rem is attributable to external dose. In terms of external dose, there was a 46% increase in dose from 2001 to 2002, which is attributable to increased workload. Work at the TA-55 Plutonium Facility accounts for the majority of occupational dose incurred at Los Alamos. Programmatic work at TA-55 increased from 2001 resulting in corresponding, anticipated, increased dose to workers, and was reflected in increased ALARA goals across the NMT Division programmatic and infrastructure groups. Increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support such as nuclear material control and accountability, shipping, and waste management all contributed to an increase in associated occupational dose. Plutonium-238 work and pit manufacturing contributed an increment of 10 rem and 6 rem, respectively, from 2001 to 2002. One individual received a dose of 2.2 rem TEDE in 2002 – one of three individuals performing work with Pu-238 fuels approved to exceed 2 rem per formal justification and approval through the Laboratory's ALARA Steering Committee. All other occupational doses at LANL in 2002 were below 2 rem (TEDE).



Hanford	Percent Change 2001-2002 (last yr.)	Percent Change 2000-2002 (3 yr.)	Percent Change Since 1998 (5 yr.)	Description of Activities at the Site
	↑ 28%	↑ 25%	↑ 52%	The collective TEDE at Hanford increased by 28% from 2001 to 2002. The largest contributors to the collective TEDE at Hanford were thermal stabilization and repackaging of plutonium-bearing materials at the Plutonium Finishing Plant (32.7%), processing of spent nuclear fuel in K-Basins for interim dry storage at the Canister Storage Building (26.4%), and activities of the central plateau project (predominantly 324 Facility B-cell clean-out) (11.1%). Other contributors to the dose included tank farm activities (9.2%) and Pacific Northwest National Laboratory (PNNL) activities (6.4%). The largest increase in collective TEDE at Hanford was from increased processing of spent nuclear fuel in K-Basins. Hanford processed 3.7 times more fuel in 2002, compared to 2001, constructed a fuel transfer system in KE-Basin, and significantly increased the number of fuel canisters cleaned and removed from KW-Basin. The extremity dose increased 21.6%, consistent with the increase in TEDE. Neutron dose in 2002 did not change significantly from 2001, consistent with work operations at PFP at the Hanford Site. CEDE in 2002 was 249 mrem, a decrease of 73% from the 919 mrem reported in 2001.

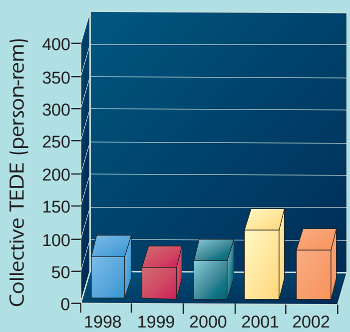
Exhibit 3-31:
Activities Contributing to Collective TEDE in 2002 for Six Sites (continued).

Rocky Flats



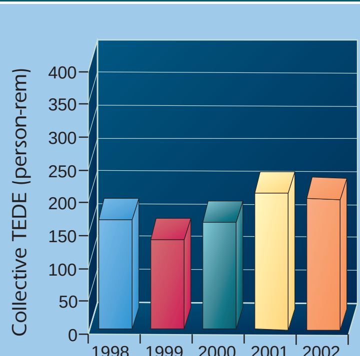
Percent Change: 2001 - 2002 (last yr.)	Percent Change: 2000 - 2002 (3 yr.)	Percent Change: Since 1998 (5 yr.)	Description of Activities at the Site
↑ 4%	15% ↓	28% ↓	The collective TEDE at Rocky Flats increased by 4% from 2001 to 2002. The activities for calendar year 2002 included processing and shipment of plutonium residues, packaging and shipment of low-level waste, and the Decontamination and Decommissioning (D&D) of the four major plutonium facilities on Site, as well as D&D of numerous uranium and administrative facilities. The increase in collective dose was primarily due to a 53% increase in the number of hours of radiological work performed (1,005,537 hours to 1,542,059 hours) over CY 2001. The CEDE decreased 30% (3.3 rem to 2.3 rem) over CY 2001, partly attributable to reductions in risk by shipping highly contaminated gloveboxes as Surface Contaminated Objects, rather than size-reducing them for packaging.

Idaho



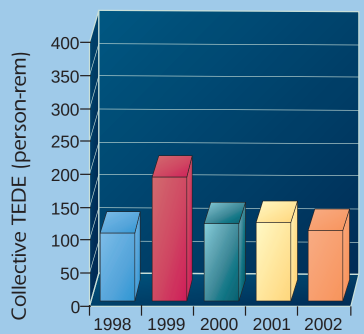
Percent Change: 2001 - 2002 (last yr.)	Percent Change: 2000 - 2002 (3 yr.)	Percent Change: Since 1998 (5 yr.)	Description of Activities at the Site
29% ↓	↑ 29%	↑ 17%	The collective TEDE at the Idaho National Engineering and Environmental Laboratory (INEEL) decreased by 29% from 2001 to 2002. Radiation exposure to INEEL employees (excluding ANL-W and BNFL employees) is primarily the result of radiological work conducted in support of four major activities: (1) preparation of waste shipments to Waste Isolation Pilot Plant from the Radioactive Waste Management Complex, (2) spent nuclear fuel operations at Test Area North and Idaho Nuclear Technology and Engineering Center (INTEC), (3) operation of the Advanced Test Reactor at the Test Reactor Area (TRA), and (4) extensive inspections of the tank farms at INTEC. The collective dose decreased in 2002 from that of the previous year. The decrease was due to the completion of milestone work preparing shipments of waste to WIPP midway through the year so that this exposure-intensive work no longer contributed to the total exposure and a general reduction in the amount of fuel transfer work was performed during 2002 compared to 2001. The completion of the decontamination at one of the remotely operated hot cells at TRA during 2001 eliminated this as a source of exposure for 2002.

Savannah River Site



Percent Change: 2001 - 2002 (last yr.)	Percent Change: 2000 - 2002 (3 yr.)	Percent Change: Since 1998 (5 yr.)	Description of Activities at the Site
4% ↓	↑ 22%	↑ 20%	The collective TEDE at Savannah River decreased by 4% from 2001 to 2002. Radiation exposures increased in 2001 due to resumption in processing of radioactive material, such as legacy reactor fuels and targets, as well as special programs. These activities continued in 2002 resulting in the comparable exposure totals. Examples of the work performed in 2002 include the receipt and storage of excess plutonium from RFETS, movement of spent nuclear fuel from the Receiving Basin for Off-site Fuels to the L-Area fuel storage facility, movement of excess Americium/Curium solutions from F-Canyon to the H-Area high-level liquid waste storage facility, accelerated retrieval and preparation of transuranic waste for shipment to WIPP, remediation of contaminated environmental sites and facilities, and stabilization and packaging of excess plutonium materials.

Exhibit 3-31:
Activities Contributing to Collective TEDE in 2002 for Six Sites (continued).

Oak Ridge Site	**Percent Change**			**Description of Activities at the Site**
	2001 - 2002 (last yr.)	**2000 - 2002 (3 yr.)**	**Since 1998 (5 yr.)**	
	10% ↓	8% ↓	5% ↑	Exposures at the Oak Ridge Site decreased 10% from 2001 to 2002. The Oak Ridge Site includes the Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12 Plant), and East Tennessee Technology Park (ETTP), formerly known as K-25). **Bechtel Jacobs:** Bechtel Jacobs Company, LLC, monitored and conducted activities at the ETTP, ORNL, Y-12, and the Portsmouth and Paducah Gaseous Diffusion Plants. Projects that contributed to exposure in 2002 include: (1) environmental restoration, decontamination and decommissioning, and waste handling of legacy, solid, and liquid materials at ORNL, Y-12, and the ETTP and (2) uranium fluoride cylinder maintenance and operations at Portsmouth, Paducah, and ETTP. Environmental restoration, decontamination and decommissioning, and waste-handling activities at ORNL contributed 54% of the dose, and cylinder operations at Paducah accounted for 27%. The reported TEDE for Bechtel Jacobs decreased 20%, with corresponding decreases in deep, shallow, and lens dose below that reported in 2001. This decrease is largely due to a decrease in activities performed in support of operations at the ORNL. Major projects contributing to the dose at ORNL in 2002 included: replacement and testing for fuel salt removal and depleted uranium testing at the Molten Salt Reactor Experiment, waste removal from Federal Facilities Agreement tanks, decontamination and decommissioning of the Old Hydrofracture Facility, cleanup of Waste Tank 1A, and decontamination and decommissioning of the Metal Recovery Facility and sludge removal and waste operations associated with SIOU. **Y-12:** During 2002, continued operation and management of EUO facilities at the Y-12 Nuclear Security Complex were the primary activities that resulted in the total collective radiation exposure at Y-12. EUO facilities were the major source of TEDE at Y-12, while activities involving depleted uranium contributed to the shallow dose and dose to the extremities. Collective TEDE increased by 18% from 53.2 person-rem in 2001 to 62.8 person-rem in 2002, while the total persons monitored increased by 7% from 4592 to 4906. The average TEDE increased from 0.012 to 0.013 rem. Maximum TEDE increased by 3% from 0.519 rem to 0.535 rem. Collective CEDE increased 20% from 44.3 person-rem in 2001 to 53.0 person-rem in 2002, while the average CEDE remained the same at 0.019 rem for both years. Collective external doses (based on DDE) increased by 9% from 9.0 person-rem to 9.8 person-rem in 2002. Average DDE remained essentially the same at 0.002 rem for both years.

3.6 Transient Individuals

Transient individuals are defined as individuals who are monitored at more than one DOE site during the calendar year. For the purposes of this report, a DOE site is defined as a geographic location. The DOE sites are listed in Appendix Exhibit A-2 by operations office. During the year, some individuals perform work at multiple sites and, therefore, have more than one monitoring record reported to the repository. In addition, some individuals transfer from one site to another during the year. This section presents information on transient individuals to determine the extent to which individuals travel from site to site and to examine the dose received by these individuals.

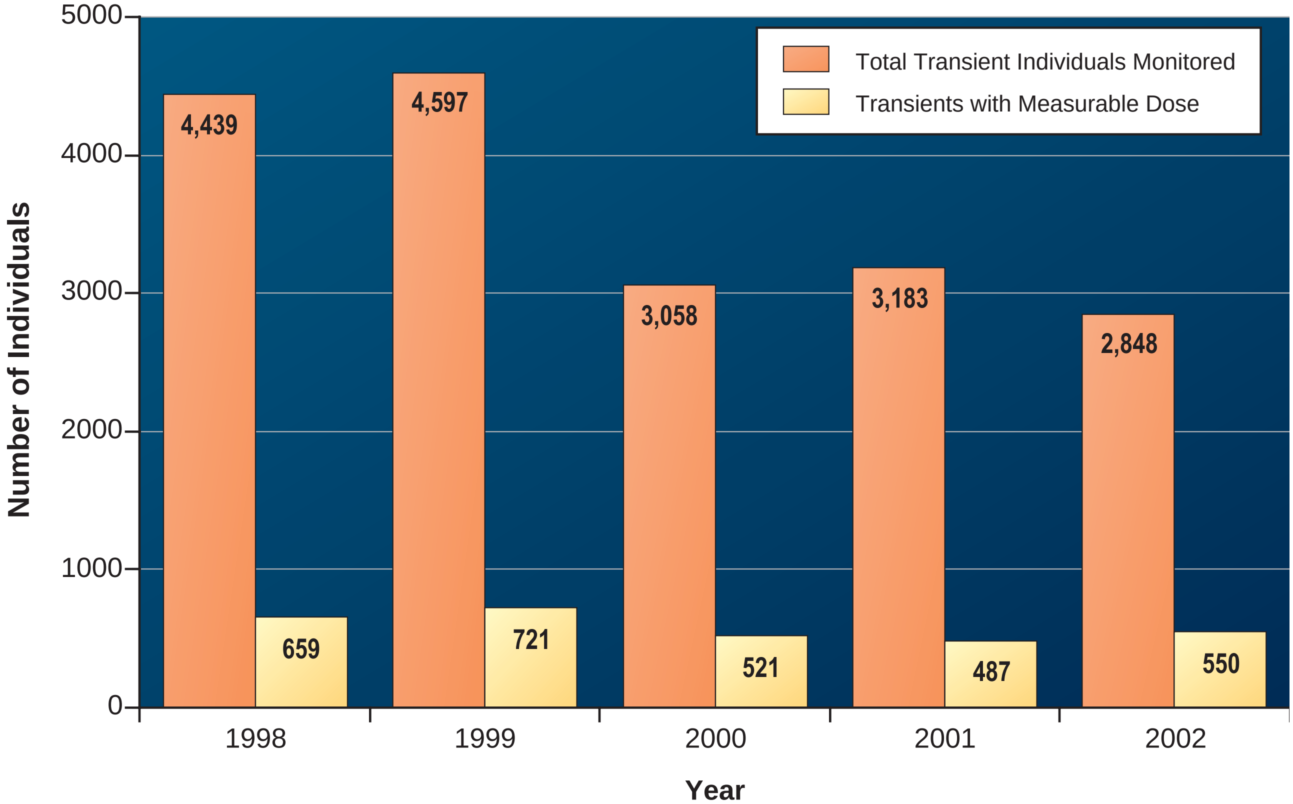
Exhibit 3-32 shows the distribution and total number of transient individuals from 1998 to 2002. Over the past 5 years, on an average, transient individuals have accounted for 3.5% of the total number of records for monitored individuals at DOE and received, on an average, 2.5% of the collective dose. As shown in *Exhibits 3-33* and *3-34*, the number of transients with measurable dose increased by 13% from 487 in 2001 to 550 in 2002. The collective dose for transients increased by 45% from 25.1 person-rem (251 person-mSv) in 2001 to 36.5 person-rem (365 person-mSv) in 2002. The average measurable TEDE increased by 27% from 0.052 rem (0.52 mSv) in 2001 to 0.066 rem (0.66 mSv) in 2002. The average measurable TEDE for transients in 2002 was 18% less than the average measurable TEDE (0.080 rem) for all monitored DOE workers. As shown in *Exhibit 3-35*, LANL was the site with the largest collective dose to transient workers from 1998 to 2002. LANL has the largest percentage of dose to transients because workers at TA-55 (who generally receive elevated doses) tend to perform temporary work at sites such as Nevada Test Site (NTS), Rocky Flats, and Pantex, as part of their routine duties.

Exhibit 3-32:
Dose Distribution of Transient Workers, 1998-2002.

	Dose Ranges (TEDE in rem)	1998	1999	2000	2001	2002
Transients	Less than Measurable Dose	3,780	3,876	2,537	2,696	2,298
	Measurable < 0.1	585	638	466	439	470
	0.10 - 0.25	49	50	37	31	50
	0.25 - 0.5	14	21	14	13	12
	0.5 - 0.75	8	6	4	1	11
	0.75 - 1.0	2	6		1	5
	1.0 - 2.0	1			2	2
	Total Number of Individuals Monitored *	4,439	4,597	3,058	3,183	2,848
	Number with Measurable Dose	659	721	521	487	550
	% with Measurable Dose	15%	16%	17%	15%	19%
	Collective TEDE (person rem)	34.742	39.521	23.632	25.138	36.477
	Average Measurable TEDE (rem)	0.053	0.055	0.045	0.052	0.066
All DOE	Total Number of Records for Monitored Individuals	108,508	113,064	102,881	97,818	100,221
	Number with Meas. Dose	17,544	16,668	15,983	16,687	17,051
	% of Total Monitored who are Transient	4.1%	4.1%	3.0%	3.2%	2.8%
	% of the Number with Measurable Dose Who are Transient	3.8%	4.3%	3.3%	2.9%	3.2%

* Total number of individuals represents the number of individuals monitored and not the number of records.

Exhibit 3-33:
Individuals Monitored at More Than One Site (Transients) During the Year, 1998-2002.



One group of individuals who routinely travel from site to site is DOE employees from Headquarters or the Field Offices who visit or inspect multiple sites during the year. For 2002, this group accounts for 15% of the monitored transient individuals but only 2% of the collective dose to transients.

In 2002, 14% of the transient individuals were monitored at three or more sites. DOE Headquarters and Field Office personnel make up a large percentage of these individuals. In 2002, 28% of the individuals monitored at three or more sites were DOE Headquarters or Field Office employees, and 34% of the individuals monitored at four or more facilities were DOE Headquarters or Field Office employees. The maximum number of sites visited by one monitored individual during 2002 was eight, and this individual was a DOE Headquarters employee (involved in health and safety evaluations) who received no dose during these visits.

Exhibit 3-34:
Collective and Average Measurable Dose to Transient Individuals, 1998-2002.

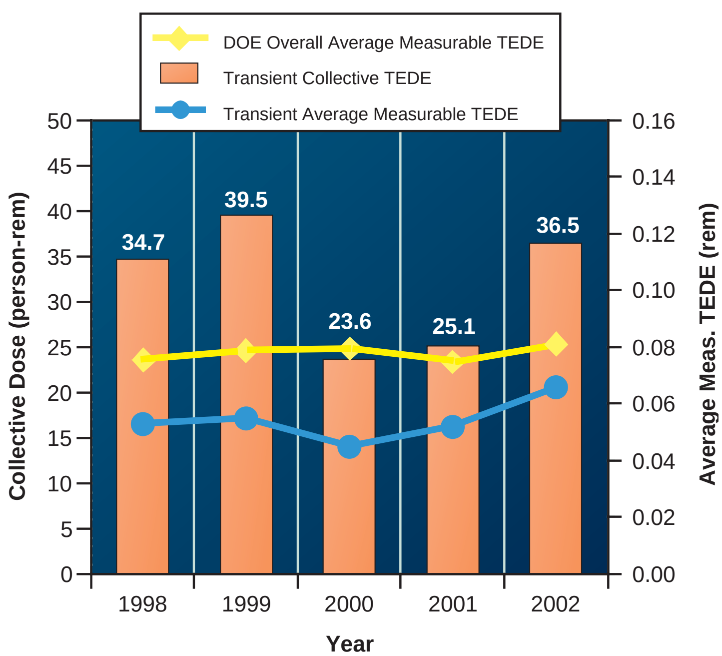
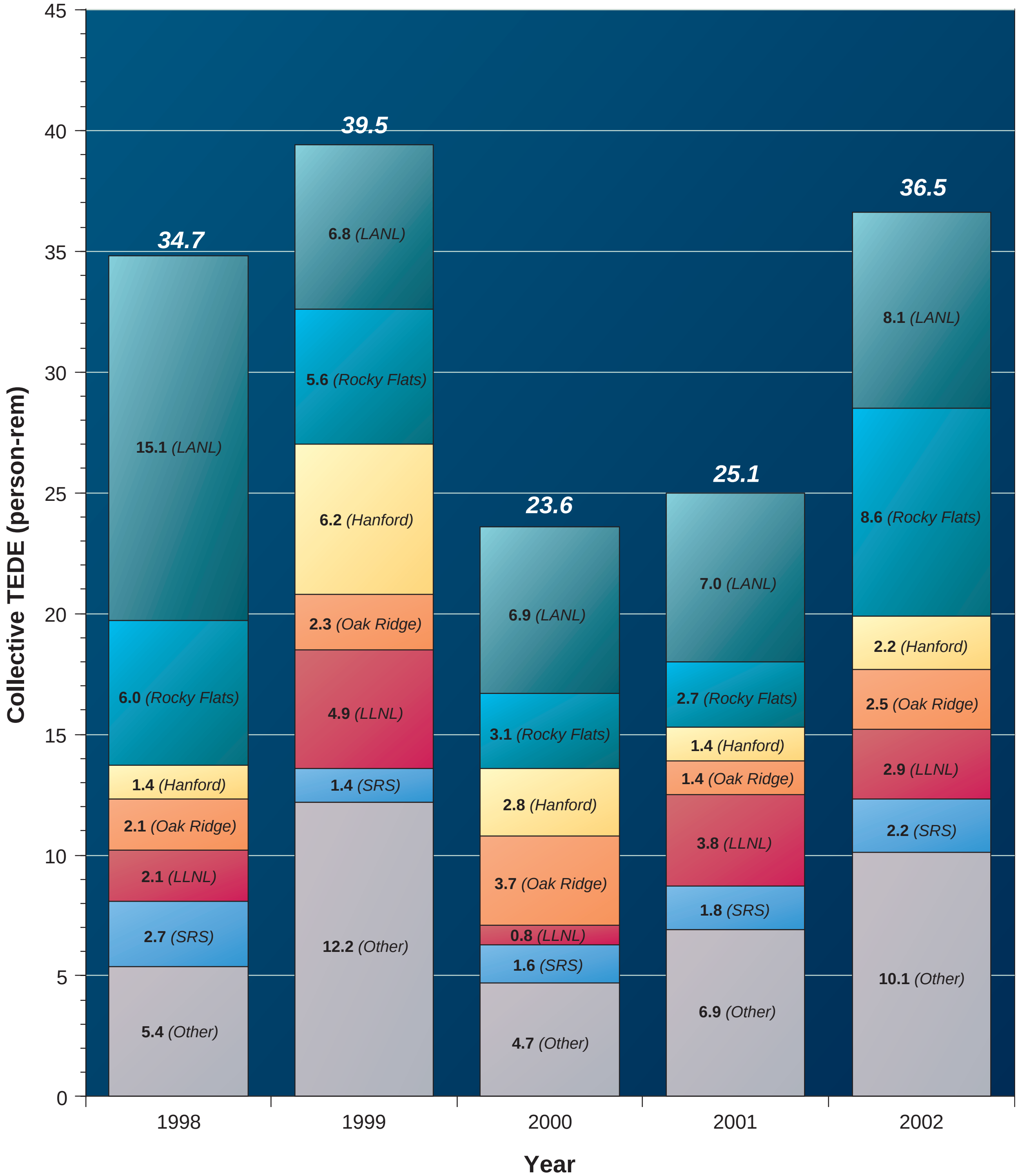


Exhibit 3-35:
Collective TEDE to Transient Workers by Site, 1998-2002.



LANL has a larger percentage of dose to transients because workers at TA-55 (who generally receive elevated doses) tend to perform temporary work at sites such as NTS, Rocky Flats, and Pantex, as part of their routine duties.

Section 3.7 Historical Data Collection

In Section 3.7 of the 2000 and 2001 annual reports on occupational exposure, information was presented on historical data that have been collected to date from a request by the DOE Office of Environment, Safety and Health to the DOE sites to voluntarily provide historical exposure records. No additional sites have reported historical data during the year 2002.

Sites that have not yet reported historical dose records are encouraged to contact Ms. Nirmala Rao at DOE to obtain further information on reporting these records. This is a voluntary request to report historical data (records prior to 1987) that are available in electronic form in whatever format that is most convenient for the site to report. The data will be stored as reported in the REMS and wherever possible, data will be extracted and loaded into the REMS database for analysis and retrieval. For detailed analysis, read Section 3.7 of the 2000 report.

Sites that have voluntarily reported historical data are:

- Fernald
- Hanford
- Idaho
- Kansas City Plant
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Nevada Test Site
- Oak Ridge K-25 Site
- Pantex
- Portsmouth
- Rocky Flats
- Sandia National Laboratory
- Savannah River Site

Section Four

ALARA Activities at DOE

4

This section on ALARA activities is a vehicle to document successes and to point all DOE sites to those programs whose managers have confronted radiation protection issues and used innovative techniques to solve problems common to most DOE sites. DOE program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of Integrated Safety Management and quality are encouraged to provide input to be included in future reports.

4.1 ALARA Activities at the Hanford Site

4.1.1 Hanford Contractors Use Variety of Mock-ups to Reduce Worker Dose

Mock-ups are invaluable in maintaining worker radiation exposure ALARA. Mock-ups are used not only to provide training for workers but also are often used to develop and proof test methods of accomplishing work. Examples of mock-ups used at Hanford are discussed in the following pages.

4.1.1.1 Mock-up Waste Tank Will Reduce Dose and Speed Cleanup

The Hanford Cold Test Facility, a simulated waste tank, completed construction in May 2002 (see *Exhibit 4-1*). The Cold Test Facility is a key player in the effort to clean up millions of gallons of highly radioactive and hazardous waste stored in 177 large underground tanks, within a few miles of the Columbia River. With this facility, equipment needed to retrieve tank waste and send it to a planned treatment plant will be demonstrated and developed.

The centerpiece of the facility is an open-top steel tank that is 75 feet in diameter — the same width as a real million-gallon Hanford tank. A superstructure spans the tank, with platforms at 35 feet and 55 feet, simulating the heights of single-shell and double-shell tanks. The tank holds up to 800,000 gallons of reusable, non-hazardous, and non-radioactive simulated waste. The Hanford Cold Test Facility Mock-up is estimated to have saved 6.0 rem (60 mSv) during its first year of operation. The facility is managed by CH2M Hill Hanford Group.

Exhibit 4-1:
Hanford Cold Test Facility.

Photo Courtesy of Hanford.

4.1.1.2 Pacific Northwest National Laboratory Coordinates the First Test at Hanford's Newly Constructed Cold Test Facility

Pacific Northwest National Laboratory (PNNL) launched the Hanford Cold Test Facility into full operation with completion of its first test. The test demonstrated a full-scale mock-up of the water distribution system process aimed at dissolution of existing saltcake waste forms from single shell tank 241-S-112 as part of the S-112 Saltcake Waste Retrieval Technology Demonstration Project. Testing of the S-112 prototype water distribution system was performed to verify system design and operation, characterize the hydraulic performance of individual system components, evaluate ergonomics of the operator interface with the Manual Water Distribution Device, and evaluate operator interface with the in-tank camera video feed. Testing was performed by an integrated team of personnel from PNNL, CH2M Hill Hanford Group, DMJMH&N (Daniel, Mann, Johnson and Mendenhall, Holmes and Narver), and Babcock Services.

The testing results identified need for improvement in ergonomics and one individual component design. Testing the system outside of a radiological area saves both dose to workers and prevents delays during actual work operations.

4.1.1.3 Hanford Cold Test Facility Used to Demonstrate Tank Crawler

Most of the liquid waste has been removed from Hanford's older tanks to newer, safer double-shell tanks. Methods are being developed to remove the remaining solid waste — more than 31 million gallons by volume. That waste consists of saltcake, which is somewhat like wet beach sand, and sludge that looks like fine mud and dries very hard.

A tank crawler arrived at Hanford in August 2002 to undergo demonstrations prior to cleaning up sludge waste inside a tank. The crawler is a remote-controlled, 1,300-pound in-tank vehicle that is sturdy and agile. It looks like a small bulldozer with treads and a blade (see *Exhibit 4-2*). With the push of a button, hydraulics fold the crawler to just 27 inches wide, narrow enough to enter a tank through a 36-inch-wide riser that has been fitted with a protective sleeve. Once inside, the crawler will push its way through thick sludge, moving the waste toward a central pump that will transfer the contents of the tank. A pump and spray mechanism on the crawler helps the in-tank vehicle move through waste.

Exhibit 4-2: Tank crawler.

Photo Courtesy of Hanford.

Preliminary demonstrations of the tank crawler were performed at the Hanford Cold Test Facility using mud that is similar in particle size and viscosity to sludge tank waste (see *Exhibit 4-3*). Using simulated waste in the tank, the crawler was put through its paces in preparation for real tank cleanup work. Single-shell Tank C-104 is currently scheduled for the first deployment of the crawler by 2005.

4.1.1.4 Fluor Hanford, Inc. Uses Spare Equipment to Mock-up Televator Repair Operations at 324 Building Radiochemical Engineering Cell Airlock, Saving 1.7 Person-rem (17 Person-mSv)

The Radiochemical Engineering Cell (REC) airlock is a high hazard work area with dose rates from 75 to 450 mrem/hr (.75 to 4.5 mSv/hr) and contamination levels in the rad-per-hour magnitude. Personnel enter the airlock in bubble suits wearing headsets to communicate with staff members in the adjacent Cask Handling Area.

Exhibit 4-3:
Picture of Crawler in Tank.

Photo Courtesy of Hanford.

A Reynolds Televator Corporation's Model 30A televator located inside the REC airlock is used extensively, enabling staff members to work in the overhead areas. Recently, the televator was used for the replacement of the B-cell crane jib hoist and for the installation of the A-cell bridge hoist structure, two components critical to the movement and loading of the spent nuclear fuel stored in B cell. During performance of routine preventive maintenance on the televator, workers discovered that the cables used to raise and lower the televator deck were twisted and frayed, requiring the cables to be replaced prior to continued use.

Two options were investigated. The first option was to replace the televator. This option would have cost approximately $80,000, would have generated 225 cubic feet of radioactive waste, and would have resulted in work schedule delays while the new equipment was procured, installed, and modified for the work environment and while personnel were trained on the new equipment. The second option was to replace the cables.

The four worn lifting cables, measuring 60 feet long, each supporting a leg of the televator deck, would need to be removed and new cables inserted. Personnel could not access the cables directly because of the internal scissor lifting extensions of the unit (see *Exhibit 4-4*). Workers planned to pull the new cables through the cable pathway by attaching the new cables to the end of the old cables with a nylon rope. The method of attachment was crucial. Each leg of the televator had 12 pulleys. The critical element of this process was being able to pull the new wire cables through the complex turns and pulleys without losing the connection point. If the connection point were lost while the rope was being pulled, the workers would have no way of threading the new cables into place without disassembling the televator.

Exhibit 4-4:
Televator Deck Internal Scissor Lifting Extensions.

Photo Courtesy of Hanford.

Fluor Hanford, Inc. (FHI) located a duplicate televator in a non-controlled area. This duplicate televator was used to mock-up the replacement of the cables. In the initial mock-up, staff members used the existing cable without modification. With the pulleys about 180 degrees apart and very little tolerance between the cable and the pulleys, they initially found the threading impossible. They modified the new cable with a tapered end, and the nylon rope was woven through that tapered end for a secure connection point. Shrink tubing was used over the connection point to make the transition smooth (see *Exhibit 4-5*).

Exhibit 4-5:
Cable Connection Process.

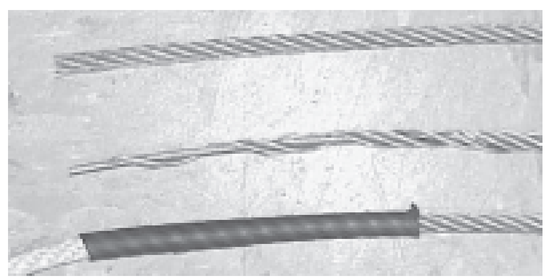


Photo Courtesy of Hanford.

Each of the four cables would need to be the same length and secured at the same tension. During operation, this would enable the televator deck to be lifted and lowered in a balanced fashion. The cables were cut longer than needed and were cut to the proper length, discarding the tapered end after installation.

The development and testing of a successful method of replacing the cables took approximately five shifts. Based on the high dose rates inside the REC airlock, use of the duplicate televator, located in a non-controlled area as a mock-up for the development and testing of cable replacement, saved an estimated 1.715 person-rem (17.15 person-mSv).

4.1.1.5 FHI Builds Transuranic Retrieval Mock-up Trench

FHI Waste Management Project completed construction of a full size replica of a typical transuranic (TRU) waste burial trench July 1, 2002. The mock-up (shown in *Exhibit 4-6*) is used for hands-on training, emergency response exercises, training on use of new equipment, procedural walk downs, and equipment suitability trials. The mock-up removes the need for personnel and equipment entry into a radiological area for hands-on training and equipment trials. The mock-up allows members of the TRU-retrieval team to try out new procedures and work out problems they encounter without radiation exposure. New and innovative techniques, such as new forms of temporary or permanent shielding, use of special or non-standard personal protective clothing and equipment, and use of over packs and new air monitoring devices, can be proved or disproved outside a radiological area. FHI estimates the mock-up TRU-retrieval trench will save 2.8 rem (28 mSv) annually.

Exhibit 4-6:
TRU-Retrieval Mock-up Trench.

Photo Courtesy of Hanford.

4.1.2 Bechtel Hanford, Inc. Used Skilled Workers and Innovative Technology to Reduce Dose During F Reactor Fuel Basin Cleanout

Hanford production reactors were configured with adjacent 6,400-square-foot water basins that served as collection areas for discharged fuel elements, transfer facilities, and shielding from radiation. The F Reactor fuel storage basin was used to house irradiated uranium fuel from 1945 until 1965, when the facility was permanently shut down.

In 1970, during the F Reactor deactivation, water inside the 20-foot-deep basin was drained until only 2 feet of water remained. The water-covered floor contained some spent nuclear fuel elements, fuel baskets, reactor hardware, the fuel basin's wooden deck, overhead rail structures, and miscellaneous debris. The remaining 17 feet of the basin was then filled with sand, covering the underlying radioactive sludge and debris for nearly 30 years.

In 1998, Bechtel Hanford, Inc. (BHI) began "cocooning" F Reactor to safely isolate its core for as long as 75 years. Cocooning requires demolition of the surrounding ancillary structures and cleaning out the highly radioactive fuel storage basin prior to its demolition. BHI used a phased approach to the basin cleanout. In November 2000, BHI began the first phase, removing the fuel basin's upper 17 feet of sand (low hazard). The second phase, removing the remaining soil and debris began in July 2001, and was completed by November 2002. BHI incorporated proven construction techniques and several technologies to protect the workers, public, and environment.

State-of-the-art radiological monitoring equipment was used to survey the last 30 inches of basin fill to identify locations of spent nuclear fuel before it was uncovered. A Laser-Assisted Ranging and Data System (LARADS) radiological survey was performed remotely to provide a map of the radiological conditions of the basin. The instrument documents radiological conditions, records geographic locations, and provides photos stored in accessible computer files. The higher dose areas (hot spots) were then remotely monitored with the Universal Radiation Spectrum Analyzer to distinguish spent nuclear fuel from other high dose rate hardware. This monitoring was effective in identifying locations of spent nuclear fuel within the top 15 inches of fill. The process was performed twice, once at 30 inches and once at 15 inches.

LARADS, suspended from a crane, (see *Exhibit 4-7)* was used to remotely perform radiological surveys of the F Reactor spent nuclear fuel basin.

Exhibit 4-7:
LARADS Suspended from a Crane.

Photo Courtesy of Hanford.

Electronic dosimeters and remote monitoring systems are additional technologies that were used for F Reactor basin cleanout. The remotely read devices were worn by workers and placed in strategic areas to promptly detect any high radiation levels during excavation activities.

Fuel elements were found within the last 15 inches of the basin floor. The fuel elements had high dose rates ranging from 5 to 120 rem/hr (50 to 1,200 mSv/hr) on contact. To reduce the dose to workers, the fuel elements were removed using a remotely operated excavator manufactured in Sweden by Brokk, Inc. The scaled-down excavator shown in *Exhibit 4-8* is remotely controlled by an operator in a nearby trailer, out of sight and at a safe distance from any potential hazards. The excavator has four cameras to transmit pictures to monitoring screens inside the control station (see *Exhibit 4-9)*. Operators navigate the device using a pair of joy-sticks and images provided by the Brokk cameras. The 270-degree turning radius of the Brokk's three-jointed arm was used in tandem with several attachments capable of demolition, excavation, cutting, and grappling objects as small as 1-1/8 inches in length. Brokk attachments can be independently changed without worker assistance. Workers received extensive training on the operation of Brokk by company representatives before using the equipment in the basin. Workers indicated the extensive training they received and exercises they participated in made the transition from operating conventional excavation equipment to the Brokk very easy.

Exhibit 4-8:
Brokk Unit Excavating Materials Inside F Reactor Fuel Basin.

Photo Courtesy of Hanford.

Exhibit 4-9:
Brokk Remote Control Station in Nearby Trailer.

Photo Courtesy of Hanford.

BHI estimates that use of the Brokk alone saved 1.8 person-rem (18 person-mSv). Lessons learned from the F Reactor spent fuel basin cleanout are being applied to other decontamination and demolition activities at Hanford. The progress at F Reactor is one step in the larger task of removing contaminants away from the Columbia River to protect the public and the environment.

4.1.3 FHI Removes Highly Radioactive Piping at 105KE Fuel Storage Basin, Saving More Than 20 Person-rem (200 Person-mSv) of Dose

FHI is removing spent nuclear fuel from the 105KE and 105KW Fuel Storage Basins and processing the fuel for interim dry storage in the Canister Storage Building at Hanford. To reduce costs, FHI decided to transfer KE spent nuclear fuel to the KW Fuel Storage Basin for processing instead of building duplicate processing equipment at the KE Fuel Storage Basin. To transfer KE spent fuel, a Fuel Transfer System (FTS) was built.

The construction of the FTS in the 105KE Fuel Storage Basin required demolition of portions of a 50-year-old basin water cooling and recirculation pipe system (see *Exhibit 4-10*), an associated pump, and valves to make room for the new equipment. The pipe sizes varied from 4 inches to 8 inches in diameter. The pipes had several hot spots that exceeded 100 mrem/hr (1 mSv/hr) and averaged 20 to 40 mrem/hr (.2 to .4 mSv/hr) on contact, contributing significantly to the overall general area radiation levels.

Exhibit 4-10:
Basin Water Cooling and Recirculation Pipe System.

Photo Courtesy of Hanford.

An ALARA review recommended removal of all of the pipe and installation of new piping before construction of the FTS rather than just removing the piping needed to make room for the system. Engineering and construction plans were changed to incorporate the ALARA team's recommendation. The pipe cuts were planned by the workforce using Integrated Safety Management System principles. Construction crafts assembled rigging at key locations to prevent the heavy pieces of pipe from falling and installed glove bags over the cut locations and the flanges that could be disassembled. The piping cuts were made with a reciprocating hack saw (German saw). The saw was installed so the saw blade was clamped to the pipe inside the glove bag, while the saw motor was suspended outside the glove bag. This type of saw enables the worker to stand several feet away from the pipe during cutting operations. When a cut was complete, the blade was disconnected from the saw and was disposed of as radioactive waste with the piping, and the saw was moved to the next location. The glove bag was used to seal both ends of the cut for movement of the pipe to the waste container.

A total of ten cuts were made, as well as several flange disconnections. There was no loss of control of contamination and the work was performed without the need for respiratory protection. Dose rates in the area were reduced an average of 8 mrem/hr (.08 mSv/hr). The added work scope cost approximately 2 person-rem (20 person-mSv), but is estimated to have saved more than 20 person-rem (200 person-mSv) to construction forces that built the FTS and to workers during operation of the FTS.

4.2 ALARA Activities at the Savannah River Site

4.2.1 Build-up of Material within the 2H Evaporator Pot at Savannah River Site

The 2H Evaporator located in the H-Tank Farm is designed to reduce the volume of liquid radioactive waste. Over time it had become increasingly difficult to operate the Evaporator at its optimum level. After numerous possible causes had been investigated and eliminated, it was determined that an inspection of the interior of the Evaporator Pot (see *Exhibit 4-11*) was required to visually look for problems. It is important to note that the Evaporator Pot is the physical location where the radioactive liquid reduction actually occurs. Thus, even when empty, the pot is still a significant source of radiation and is highly contaminated.

A camera was used to perform inspections within the Evaporator Pot. The camera was installed through a glovebag that was open at the top. After the camera was in place, the glovebag was sealed. The camera was removed using the glovebag and sleeving for total containment.

Exhibit 4-11:
View of Evaporator Pot.

Photo Courtesy of Savannah River Site.

The initial camera inspection revealed a considerable amount of build-up or plaque within the pot. This finding led to numerous additional camera inspections and sampling activities (see *Exhibit 4-12*). During camera inspections, workers stayed in low-dose areas when possible. Ultimately, this led to a plan to perform chemical cleaning of the pot. Prior to cleaning, it was necessary to remove cell covers (see *Exhibit 4-13*) so that the process jumpers could be properly configured.

Exhibit 4-12:
Sampling of Evaporator Pot.

Photo Courtesy of Savannah River Site.

Exhibit 4-13:
Removal of Cell Cover.

Photo Courtesy of Savannah River Site.

The jumper work required numerous entries. Personnel stayed away from the open cell and remained in low-dose areas, when possible, to keep exposure ALARA. A remote gasket installation tool was used to increase personnel efficiency and maintain exposure ALARA. Workers' hands were in a radiation field of 2,900 mrem/hr (29 mSv/hr) instead of a radiation field of 27,400 mrem/hr (274 mSv/hr). Maximum contamination levels encountered were as follows: 40,000 dpm/100 cm2 alpha and 10 mrad/hr/100 cm2 beta-gamma. Total containment was used for much of the work activities; therefore, the contamination levels indicated above do not reflect maximum contamination on the equipment. Connector head regasketing activities took place within a glovebag to control contamination at the source.

This proved to be a success and did not increase exposure (see *Exhibit 4-14*). Temporary shielding was available to shield connector heads when more than one was in the work area. This reduced exposure to workers by reducing the number of radiation sources. It should be noted that the gasket installation tool was designed, developed, and patented by personnel from H-Tank Farm at SRS.

Exhibit 4-14:
Dose Rates With and Without ALARA Methods.

Dose Rates (Without ALARA Methods)
140 mrem/hr extremities 80 mrem/hr whole body and skin
Dose Rates (With ALARA Methods)
8 mrem/hr extremities ND whole body 3 mrem/hr skin

In summary, remote/extended tools, temporary shielding, and cameras were used to maintain exposure ALARA. When total containment was not used, several additional controls (e.g., ventilation, misting, flushing, and wind speed work restrictions) were used to reduce the potential for the spread of contamination.

For additional information about this project contact: Athena D. Freeman, Site ALARA Coordinator: (803)725-5030, e-mail: athena.freeman@srs.gov

4.2.2 Failure Back-flush Valves at the Savannah River Site

During operation of the 3H Evaporator it is necessary to vent the Evaporator Pot and drop concentrated waste into Tank 20 and Tank 30, respectively, through their Back-flush Valves (BFV). These new valves (shown in *Exhibit 4-15*) failed to function properly and often failed to function at all. Numerous possible causes were investigated to include the digital control system, the pneumatic actuator, and thermal expansion. These investigations failed to correct the problem. As a result, both valves were removed to perform testing and repairs. They were reinstalled and still did not function properly. This remove, repair, reinstall cycle would be repeated numerous times. Personnel became experienced in working with the BFV, which increased their ability to improve methods in keeping dose ALARA and in controlling contamination. Often, personnel were forced to adapt to difficulties to be successful, (e.g., using the riser plug for shielding during wrapping and unwrapping activities).

Exhibit 4-15:
Back-flush Valve.

Photo Courtesy of Savannah River Site.

During BFV removal and installation activities, cameras were used to guide the BFV into and out of the riser. This allowed workers to remain in fields of approximately 100 mrem/hr (1 mSv/hr) instead of entering the 18,000 mrem/hr (180 mSv/hr) field, which radiated from the tank opening. Cameras were also used to perform inspections of the BFV in an effort to determine the cause of equipment failure. Camera personnel positioned themselves behind temporary shielding to maintain exposure ALARA. A crane was used to pull the plug from the riser up into a containment bag. Once the plug was out of the riser, it was placed in a low-dose area where workers sealed the containment bag. The containment bag was sealed by rotating the plug as it was held by the crane instead of walking around the plug. The plug was used as shielding by keeping the 5-feet x 5-feet plug between them and the open riser (see *Exhibit 4-16*). This effort allowed the riser plug to swivel to access the

Exhibit 4-16:
Back-flush Valve Riser with Shielded Plug in Place.

Photo Courtesy of Savannah River Site.

required work points, while personnel would stand behind the plug using shielding and distance to maintain ALARA (see *Exhibit 4-17*). Once the BFV was removed from the riser, extended tools were employed to limit hands-on contact with the BFV. This resulted in workers exposed to a field of 5,000 mrem/hr (50 mSv/hr) whole body instead of 140,000 mrem/hr (1,400 mSv/hr) extremity, which was measured on contact with the plastic BFV containment.

Exhibit 4-17:
Dose Rates With and Without Shielding.

Dose Rates Without Shielding
100 mrem/hr whole body at open riser 30 mrem/hr general area at hut
Dose Rates With Shielding
4 mrem/hr whole body at open riser 2 mrem/hr whole body at hut

Maximum dose rates and contamination levels encountered were as follows: 140,000 mrem/hr (1,400 mSv/hr) extremity, 44,900 mrem/hr (449 mSv/hr) skin, 2,000 dpm/100 cm2 alpha and 10 mrad/hr/100 cm2 beta-gamma.

In summary, remote/extended tools, temporary shielding, and cameras were used to maintain exposure ALARA. Total containment was used when possible. When total containment was not used, several additional controls (e.g., ventilation, misting, flushing, and wind speed work restrictions) were used to reduce the potential for the spread of contamination.

For additional information about this project contact: Athena D. Freeman, Site ALARA Coordinator: (803) 725-5030, e-mail: athena.freeman@srs.gov

4.3 ALARA Activities at the West Valley Demonstration Project

The West Valley Demonstration Project (WVDP) is the site of a former commercial nuclear fuel reprocessing plant. The WVDP Act passed by Congress in 1980 directed DOE to solidify the liquid waste left from reprocessing activities, clean and close the facilities used, and dispose of low-level and TRU wastes left from project operations. The New York State Energy Research and Development Authority owns the site property.

Cleanup efforts at the WVDP have shifted from high-level radioactive waste processing, which was completed in 2002, to decontamination and dismantlement of some of the cells in the former nuclear fuel reprocessing plant. A portion of these decontamination and dismantlement efforts is being focused on the cleanup of the Head End Cells (HECs), which were used to mechanically process and store spent nuclear fuel before chemical processing to recover uranium and plutonium. The HECs are heavily shielded hot cells where in-cell equipment sheared spent nuclear fuel, stored the sheared spent nuclear fuel prior to chemical dissolution, and received the leached spent nuclear fuel hulls for eventual transfer to an on-site disposal area. Decontaminating these facilities includes the repair and replacement of some failed equipment, as well as retrieving, characterizing, processing, packaging, and storing loose debris.

4.3.1 Cleanup of the HECs

The HECs consist of two main cells: the Process Mechanical Cell (PMC) and the General Purpose Cell (GPC). The HECs are heavily contaminated with spent fuel, mixed fission, and activation products. Radiation levels in the cells range from general area dose rates of 100 R/hr to hot spots of 2,000R/hr. Both alpha and beta/gamma removable contamination levels are on the order of billions of disintegrations per minute.

Much of the remote operations equipment in these cells, including the shielded viewing windows, the GPC shield door that shielded an adjacent Crane Maintenance Room, and all of the remote handling equipment, was deteriorated beyond use and required either repair or replacement.

4.3.1.1 Shield Window Refurbishment

Each shield window assembly consists of leaded shield glass in a concrete/cast-iron, shot-filled window frame. The spaces between the shield glass panes were filled with mineral oil. In the PMC, the total window assembly weighed approximately 15 tons, with each piece of shield glass weighing between 800 to 1,500 pounds. The windows needed to be pulled from the window cavity into the operating aisle to allow for removal and replacement of the glass and fluid, but the floor in the operating aisle could not support the weight of the window assembly. To help distribute the 15-ton weight of the window assembly and to facilitate its removal, a structural steel extraction table was installed in the aisle (see *Exhibit 4-18*).

Exhibit 4-18: Replacement of Shield Window.

Photo Courtesy of WVDP.

To control the spread of contamination during the window removal process, a containment tent was erected in the operating aisle. Work to refurbish the window took place inside the tent. Instead of ventilating the tent with a portable ventilation system, airborne radioactive contamination was managed by ventilating the containment tent back to the PMC through an empty manipulator port. Radiation exposure to personnel was reduced by installing temporary steel shielding around the window opening, while a temporary shield door was slid into place in front of the window cavity. Lessons learned from refurbishment of the first windows were incorporated by the project team into the field work for subsequent windows, resulting in a reduction of the time needed for refurbishment of the later windows by almost 75%. These radiological protection measures allowed personnel to perform the refurbishment work in radiation fields of less than 5 mR/hr and resulted in no personnel contaminations.

4.3.1.2 GPC Shield Door Repair

The GPC shield door required repair to allow personnel entry in the GPC Crane Room (GCR) to support removal of failed equipment. The 50-ton shield door between the GPC and GCR had been left in a half-open position and the drive mechanism located in the GCR had failed. The drive mechanism was damaged further from periodic flooding of the GCR from surface water infiltration. General area dose rates in the GCR were 30 to 150 mR/hr, with hot spots greater than 300 mR/hr gamma. There was also a large amount of dirt and debris covering the floor. Removable contamination levels exceeded 1 million dpm beta/gamma.

It was determined that replacement of the failed components, rather than a new design and equipment fabrication, would best ensure the maximum degree of radiological protection and cost-effectiveness (see *Exhibit 4-19*). A means to safely secure the shield door during the repair process was also devised, using standard trailer jacks and a base plate grouted to the floor. Due to the complexity of the repair work, the project team decided to construct a full-scale mock-up of the GCR. This full-scale mock-up then allowed Operations and Maintenance personnel to review each step of the repair process and develop the necessary tools and techniques to accomplish the repair. Prior to the start of repair work, one-half-inch-thick steel shield plates were placed on the floor of the GCR to cover the contaminated dirt and debris. General area exposure rates were reduced by more than 20% and airborne contamination levels were reduced by 99%. The drive mechanism repair and replacement was then conducted over a 4-month period. The refinement and execution of the repair approach resulted in a personnel exposure reduction of greater than 65% from the original 2,980 person-mrem (29.8 person-mSv) estimate to 1,037 person-mrem (10.37 person-mSv). A contamination fixative was also applied to the old equipment to ensure that airborne contamination levels remained low and to facilitate its future packaging for disposal.

Exhibit 4-19:
GPC Shield Door Repair.

Photo Courtesy of WVDP.

4.3.1.3 Remote Handling Equipment Replacement

Removal of the failed bridge-mounted cranes and power manipulators posed a significant contamination control challenge. New hard-walled enclosures were constructed over the existing PMC Crane Room (PMCR) and GCR to serve as buffer areas during removal and replacement of the crane bridges. Concrete roof hatches weighing up to 25 tons were removed or relocated from the ceiling of each crane room to provide ready access to the cranes during the removal process, and lighter steel covers were installed in their place.

The crane bridges were constructed of carbon steel, measured 16 feet rail-to-rail and were 9 feet wide; each weighed approximately 7 tons. Initial radiological data on the crane bridges showed high contamination levels and dose rates of 30 to 80 mR/hr, with hot spots of up to 650 mR/hr. The initial dose estimate, based on hands-on mechanical size-reduction, was 1,600 person-mrem (16 person-mSv). Due to the high potential personnel exposure, the project team conducted an evaluation of alternative cutting methods. An oxy-gasoline cutting technology was found through a technology sharing program with the Fernald Environmental Management Project. The oxy-gasoline technology offered the advantages of cutting much faster and providing several safety features not found with oxy-acetylene torch cutting. Working directly with the torch vendor, a first-of-its-kind, 13-foot-long cutting tool was fabricated. This specially designed torch allowed operations personnel to size-reduce the PMC crane bridges (see *Exhibit 4-20*) while standing in the enclosure located above the PMCR.

Before using the oxy-gasoline torch, a full-scale mock-up of the bridge girder was fabricated and constructed. The mock-up provided a means to train operations personnel in the use of the torch and refine the tools and techniques to be used. As an added measure, to control the spread of contamination during cutting, a strippable coating was sprayed on the bridges and other miscellaneous pieces of equipment. The entire evolution, from setup to crane bridge removal, lasted 7 weeks for the first of two PMC crane bridges. The project team reviewed the work done on the first crane bridge and implemented improvements for removal of the second bridge. By factoring in the lessons learned, the time to complete the removal of the second crane bridge was reduced to 2 weeks.

Exhibit 4-20:
Size Reduction of PMC Crane Bridge.

Photo Courtesy of WVDP.

A new single bridge, having both the crane and the power manipulator, was installed through the PMCR enclosure onto the rails in the PMCR. Because the GPC crane bridge was of lighter construction and due to the airborne hazards associated with thermal cutting, mechanical cutting was used instead. The crane bridge and power manipulator bridge were moved to the GCR. Personnel performed hands-on, size reduction of the bridges using a special large-capacity band saw. Similar to work done in the PMC, the new GPC crane bridge was installed through the GCR enclosure onto the crane rails in the GCR, and moved into the GPC.

For more information on this project, contact Scott Chase at (716) 942-2184.

4.3.2 Decontamination of the Fuel Receiving and Storage Facility

The Fuel Receiving and Storage (FRS) building houses all the facilities previously used to receive, store, and ship spent nuclear fuel. In 2001, 125 remaining spent fuel assemblies were removed from the pool and loaded into shipping casks. Activities conducted following that effort included the removal of 149 empty fuel canisters, racks, and other miscellaneous equipment by nuclear divers. The final phase of the project involved removing and processing all the water from both pools, packaging the high-dose filters generated from the water processing and pool vacuuming efforts, removing all remaining debris from the Cask Unloading Pool (CUP) and packaging it, grouting the floor of both pools, and applying a fixative to contain any remaining contamination.

The FRS consists of a Fuel Storage Pool (FSP) and CUP. The FSP is made of reinforced concrete, measures 40 feet wide by 75 feet long by 29 feet deep, and holds approximately 800,000 gallons of water. It was used to store spent fuel assemblies prior to processing. The CUP is a stainless steel-lined, reinforced concrete pool connected to the east end of the FSP and measures 24 feet wide by 26 feet long by 45 feet deep. It was designed as an unloading and holding area for fuel assemblies during transfer operations from shipping casks to the FSP.

4.3.2.1 Pool Water Draining and Treatment

Initial pool water draining was conducted between August and September 2002, during which approximately 180,000 gallons or 6 feet of water was treated and discharged to the on-site water treatment facility. The pool walls were manually scrubbed prior to draining and rinsed with demineralized water after draining. Strippable coating was applied to sections of the original water level around the pool. Also, a fixative called Polymeric Barrier System™ (PBS) was applied to the pool walls after draining the water and was effective in fixing the remaining contamination below DOE limits for high contamination. The PBS was tinted with blue dye/paint, making it easy to distinguish between treated and untreated surfaces. Pool draining resumed in March 2003 and was completed the following month. Nearly 800,000 gallons of water were removed and treated during this activity.

The pool water was treated through 1-micron cartridges, then sent through an ion exchange column to remove cesium. A second ion exchange column removed plutonium from the water before it was sent to the on-site water treatment system.

4.3.2.2 Pool Vacuuming

A vacuum system was used to clean the floor of the pools (see *Exhibit 4-21*). Two test vacuums were conducted first, then the entire FSP floor was cleaned of up to 3 inches of sediment in nine shifts. The CUP, although smaller in area than the FSP, contained up to 1 foot of sediment and took approximately eight shifts to vacuum. The solids removed from the pool floors during the vacuuming process were captured by filters, which had dose rates of <400 mR/hr to 2 R/hr. These filters were drained, removed, and packaged in lead-lined or shielded boxes.

Exhibit 4-21:
A Portion of the Pool Vacuumed (light side).

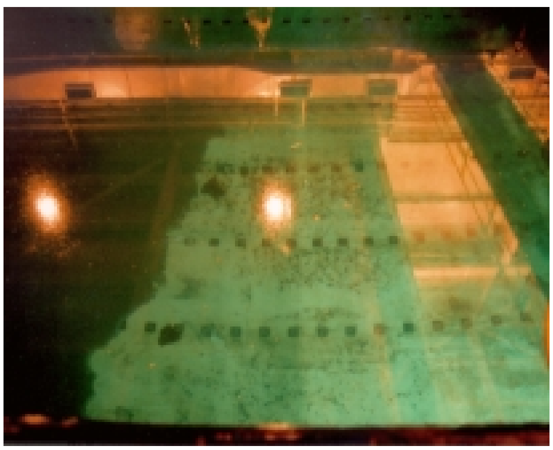


Photo Courtesy of WVDP.

4.3.2.3 Debris Removal and Packaging

A host of equipment and debris from more than 30 years of pool operation remained in the pools at the start of the FRS decontamination project. Removal of this equipment presented several challenges due to the high levels of contamination associated with the material. Eight cask liners, four empty debris barrels, and the cask liner rack were removed from the CUP in February 2003. The liners had high levels of removable contamination and were a potential source of airborne contamination. Prior to removal, the liners were sprayed with high-pressure water below the water surface and rinsed with demineralized water as they were being removed. The liners were then sprayed with a fixative and wrapped with herculite before placing them in a waste box.

Three cask liners had radiation levels too high to be boxed as waste; two of the liners had fixed hot spots greater than 1.5 R/hr on the bottom and were shielded with 1-inch-thick steel. The final liner had fixed hot spots of 12.5 R/hr and 20 R/hr on the bottom and was temporarily shielded while 32 inches of its length were removed from the bottom. The top portion of the last liner was wrapped and boxed; the bottom portion was packaged with activated metal hardware in a specially designed, steel liner.

The WVDP installed a sorting table and barrel holder to facilitate sorting and segregating of solid debris in the CUP. Also, special tooling was fabricated to unbolt the lid to the debris containers. An In-Situ Object Counting System was used to evaluate the predominant gamma emitting isotopes in selected pieces of debris. Sorting of four, 10-foot-long debris barrels in the CUP was completed in February 2003. D&D operators reduced the time required to sort the third and fourth barrels by two-thirds, using lessons learned from sorting the first two barrels.

4.3.2.4 FRS Weir Decontamination

The FRS weir is a concrete trough in the wall between the CUP and FSP. It was decontaminated by manually scrubbing with long-handled brushes, draining, and then spraying on its sides and bottom with a fixative. Radiological surveys taken after applying the fixative confirmed that surface contamination levels were below targeted limits. The weir was then covered with plywood to provide a working surface for safely changing out pool filters.

As part of the specially funded Large-Scale Demonstration and Deployment Project, the WVDP demonstrated the use of a special decontamination solution in the FRS Decontamination Stall trough. The trough is a stainless steel-lined trough running from the Decontamination Stall to a floor drain. The proprietary chemical process used was developed by Environmental Alternatives, Inc. and proved to be effective in removing loose contamination and in decontaminating a section of the cask liner storage rack.

4.3.2.5 Sealing the PMC Hatch

Another portion of this project involved sealing the PMC hatch, which is located in the fuel transfer tunnel that connects the PMC to the FRS. The tunnel is 3 feet wide and 30 feet long. As the water was drained from the pool, the water seal between the FRS and the roof of the transfer tunnel was lost and allowed air to flow from the FRS into the PMC. A nuclear diving company was contracted to seal the hatch and remove sludge and debris that had accumulated inside the tunnel. The divers conducted a full-scale mock-up of the foaming project (see *Exhibit 4-22*), which significantly reduced worker time and radiation exposure. Fifteen dives were planned but because of extensive preparation and planning, all work was completed after only five dives with one-third of the personnel radiation exposure planned for the project.

Exhibit 4-22:
Mock-up of PMS Hatch Foaming.

Photo Courtesy of WVDP.

4.3.2.6 Grouting of Pool Floors

To fix any remaining contamination in the pools after being emptied of all water (see *Exhibit 4-23*), a grout mat was placed in the FSP and CUP. An average of 4 inches were placed in the FSP and 6 inches were placed in the CUP. The WVDP conducted grout mock-ups at the vendor's batch plant to ensure that the grout would spread the full width of the pool and to test creation of a slope from one side of the FSP to the other (to aid in channeling any water inflow to the pool into the CUP). The grout placement in the FSP was successfully completed in a few hours and allowed to cure for several days. Grouting of the CUP was completed immediately afterward. Final radiological surveys confirmed that smearable contamination levels were less than 20,000 dpm/100cm^2 beta-gamma and 2,000 dpm/100cm^2 alpha.

The FRS decontamination project was completed approximately 2 months ahead of schedule. For more information on this project, contact Dave Ploetz at (716) 942-4276.

Exhibit 4-23:
Pool Storage Pool Emptied of Water.

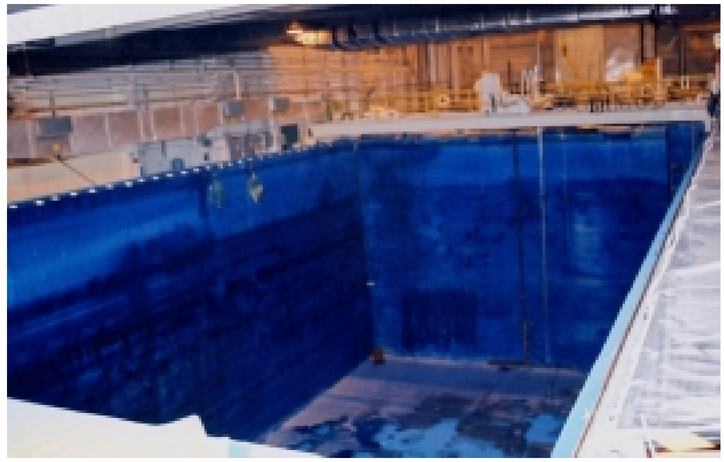


Photo Courtesy of WVDP.

4.4 ALARA Activities at Fermi National Accelerator Laboratory

4.4.1 NM2 Target Station Upgrade Project at Fermilab

At the Fermi National Accelerator Laboratory (Fermilab), a policy consistent with integrated safety management is to conduct activities in such a manner that worker and public safety, and protection of the environment are given the highest priority. Fermilab management is committed, in all its activities, to maintain any safety, health, or environmental risks associated with ionizing radiation or radioactive materials at levels that are ALARA.

Several years ago, a high energy physics experiment called KTEV was conducted to study particles called kaons. This resulted in significant levels of radioactivation of a target station (see *Exhibit 4-24*) in an enclosure called NM2. In order to utilize experimental apparatus from KTEV for a planned future experiment called KAMI, components of this activated target station needed to be reconfigured so that beam studies related to the planned KAMI experiment could be performed. To accomplish this work, the modification of the KTEV target station was conducted in January 2000.

Exhibit 4-24:
Downstream End of the KTEV Target Station, Showing the Proton Beam Pipe Near the Target.

Photo Courtesy of Fermilab.

This job required Radiological Control Technician coverage, the development of an ALARA plan, the preparation of a job-specific Radiological Work Permit, and the conduct of ALARA planning meetings involving both radiation safety personnel and the individuals who would carry out the actual work. Radiological hold points were set at 50 mrem (.5 mSv) per individual and 306 mrem (3.06 mSv) for the entire job. The general area dose rate in front of the target station was approximately 250 mrem/hr (2.5 mSv/hr) at 1 foot. The task involving adjustment of a particular collimator was of concern because it required an individual to reach into the interior of the target station. There, the general area dose rates were much higher, approximately 600 mrem/hr (6 mSv/hr) at 1 foot. Additionally, the necessary raising of another collimator downstream of the target required an individual to work near the target. The dose rate of the target was approximately 750 mrem/hr (7.5 mSv/hr) at 1 foot. These dose rates are almost completely due to gamma rays from the volume-activated target station components.

Careful ALARA planning and ALARA techniques implemented by the use of ratcheting wrenches to raise mechanical devices helped greatly to control exposures.

Workers were conscientious in observing good radiological work practices (see *Exhibit 4-25*) and following the instructions of the Radiological Control Technicians monitoring the job. ALARA preplanning and detailed discussion of the tasks involved in this job were also credited with keeping doses ALARA. Finally, allowance of a 1-week cool-off time prior to the beginning of work significantly reduced radiation doses to personnel performing this work.

A total of 14 people were involved in this target station changeover. The total dose for the job was 306 person-mrem (3.06 person-mSv). The actual dose received was 277 person-mrem, (2.77 person-mSv) approximately 10% lower than the estimated dose. Thus, the planning efforts were quite accurate and the dose control measures were judged to be very effective. The planning efforts involved are typical for ALARA planning activities at Fermilab.

Exhibit 4-25:
Downstream End of the Target Station, Showing Proton Beamline for Secondary Kaons.

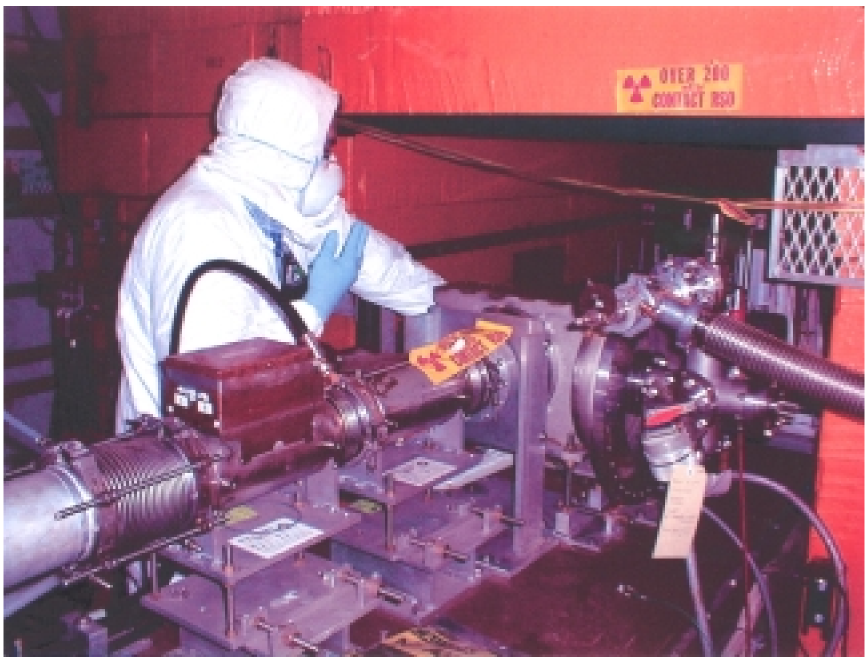


Photo Courtesy of Fermilab.

4.5 ALARA Activities at the Rocky Flats Site

4.5.1 Innovative Waste Packaging and Shipping Method Used at Rocky Flats to Reduce the Risk of Contamination and Intakes

One of the major challenges involved in closing the Rocky Flats Environmental Technology Site (RFETS) is the disposal of extremely large pieces of contaminated production equipment and building debris. Past practice has been to size-reduce the equipment into pieces small enough to fit into approved, standard waste containers. Size-reducing this equipment is extremely expensive and exposes workers to high-risk tasks, including significant industrial, chemical, and radiological hazards. RFETS has developed a waste package using a Polyurea coating for shipping large contaminated objects.

With the removal of almost all of the plutonium residues at RFETS, D&D and shipment of low-level radioactive waste is becoming the major focus of the site. Gloveboxes, tanks, and other equipment are routinely decontaminated on the internal surfaces by the use of a cerium nitrate solution (see DOE *Occupational Radiation Exposure 2001 Report*, Section 4.3.1) to reduce the internal levels to at least SCO-II limits (surface contaminated object) limits (49 CFR 173.403). The smaller items are then loaded into a suitable shipping container. Items that are too large or heavy for a cargo container previously had to be cut up for packaging. This size reduction has been the cause of several worker intakes in the past. Rocky Flats has developed a method to apply a coating on the outside of large items that will meet industrial Packaging Type 1 requirements. This coating system has been used for tanks, furnaces, a 90,900-pound Supercompactor and Repackaging Facility, and other miscellaneous waste. The following description and photographs show the packaging of the 45-ton supercompactor, which was shipped to the Nevada Test Site in late September 2002.

The supercompactor had high levels of removable contamination on its inside surfaces. This contamination was rendered inaccessible by blanking off the ends with sheet metal, thus meeting the much higher contamination levels allowed under SCO-I limits. The supercompactor was wrapped in plastic and moved outside of the building where it was loaded and chained onto a specially-prepared shipping skid on a low-boy trailer. The supercompactor and skid were then covered in a shrink-wrap plastic (*Exhibit 4-26*), then heat was applied to shrink the plastic (*Exhibit 4-27*). Adhesive metal depth-gauge buttons (*Exhibit 4-28*) and a vent filter were applied to the shrink-wrap. A polyurea coating (InstaCote™ SE) was sprayed on the outside surface to a depth of 0.25 inch (*Exhibit 4-29*). The process typically requires four to six passes with the sprayer, in a cross-hatch pattern. The thickness can be checked at any time by pressing a calibrated Elcometer Electronic Thickness Gauge™ to the metal depth-gauge buttons. The quick-curing coating was soon ready for quality inspections (*Exhibit 4-30*) and then shipment. This process saved $202,000 over the cost to size-reduce and ship the supercompactor using existing technologies.

For more information, contact Mr. Kent Dorr at 303-966-6034, Mr. Richard S. (Dick) Hogue at 303-966-2586, or Radiological Engineer, Mr. Rock Neveau at 303-966-3461.

Exhibit 4-26:
Applying Shrink-wrap Plastic to the 45-ton Supercompactor.

Photo Courtesy of Rocky Flats.

Exhibit 4-27:
Applying Heat to Shrink the Plastic.

Photo Courtesy of Rocky Flats.

Exhibit 4-28:
Applying Metal Depth-gauge Buttons.

Photo Courtesy of Rocky Flats.

Exhibit 4-29:
Spraying the Polyurea Coating.

Photo Courtesy of Rocky Flats.

Exhibit 4-30:
Quality Inspection of the Polyurea Coating.

Photo Courtesy of Rocky Flats.

4.6 Hanford ALARA Center of Excellence

The Hanford ALARA Center of Excellence is committed to providing a centralized resource for others to gain insight into practical applications of the ALARA approach and to serve as a clearinghouse of ALARA information.

DOE's Hanford Site (586 square miles located in southeastern Washington State) was established during World War II as part of the Manhattan Project and played a pivotal role in the nation's defense for more than 50 years.

Currently, the Hanford Site is engaged in the world's largest environmental cleanup effort with many challenges to be resolved in the face of overlapping technical, regulatory, and cultural interests. The cleanup effort focuses on three outcomes: restoring the Columbia River corridor for other uses, transitioning the central plateau to long-term waste treatment and storage, and preparing for the future.

Over the years, the center has gathered a great deal of information in the application of the ALARA approach to daily operations. In 1996, DOE established the ALARA Center of Technology to provide a common resource for Hanford workers in the practical aspects of ALARA.

The Hanford ALARA Center is centrally located on the Hanford site to provide an informational resource to workers in the application of the ALARA approach in daily operations. While the focus of the ALARA Center has been at the Hanford site, ALARA Center staff routinely exchange information and ideas with others throughout the DOE complex for the benefit of all. Access the Center's web site for more information:

http://www.hanford.gov/alara/index.cfm

4.7 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Corporate Performance Assessment. 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)
- Figures and/or photos of the project or equipment (electronic images if available)
- Point-of-contact for follow-up by interested professionals.

4.8 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 web site as part of the Environmental Safety & Health (ES&H) Information Portal. 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 also 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.eh.doe.gov/ll

The specific web site address may be subject to change. ES&H information services can be accessed through the main ES&H Information Portal at:

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

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Section Five

Conclusions

5

Conclusions

5.1 Conclusions

The collective dose at DOE facilities has experienced a dramatic (84%) decrease since 1986. 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. 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. As facilities are shut down or undergo transition from operation to stabilization or D&D, there are significant changes in the opportunities for worker radiation exposure.

The collective TEDE increased 10% from 1,232 person-rem (12.32 person-Sv) in 2001 to 1,360 person-rem (13.60 person-Sv) in 2002 due to increases in the collective dose at three of the six highest dose sites. These six sites accounted for 79% of the collective dose at DOE in 2002. Three of these sites attributed the increase in dose to an increase in the number of hours of radiological work performed (at Rocky Flats), increased processing of spent nuclear fuel in K-Basins (at Hanford), and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL). Statistical analysis reveals that there were small but significant differences in all years, and the logarithmic mean TEDE per worker reached a 5-year peak of 0.030 rem (0.30 mSv) in 2002. The logarithmic mean TEDE increased from 0.028 rem (0.28 mSv) in 2001 to 0.030 (0.30 mSv) rem in 2002, reflecting both an increase in the dose to individual workers, and a larger number of individuals with measurable dose. The logarithmic mean TEDE per worker ranged from 0.026 rem to 0.029 rem (0.26 mSv to 0.29 mSv) for 1998-2001. However, the 2002 logarithmic mean TEDE remains significantly below the 1997 logarithmic mean TEDE of 0.035 rem (0.35 mSv) per worker.

The collective internal dose (CEDE) increased by 17% from 59 person-rem (590 person-mSv) in 2001 to 69 person-rem (690 person-mSv) in 2002. The increase was primarily due to a 20% increase in internal dose at the Oak Ridge Y-12 site. The Y-12 facility accounted for 77% of the collective CEDE for 2002. The increase was attributed to activities at the EUO facilities. During the past 5 years, there have been several intakes from plutonium or uranium in excess of 2 rem (20 mSv) each year, with some of the doses in excess of 5 rem (50 mSv), as noted in Section 3.3.1. While the number of internal depositions above 2 rem (20 mSv) over the past 5 years has been few, it has contributed significantly to the collective internal dose each year. With no such intakes reported for 2001 and 2002, the collective CEDE has decreased significantly compared to prior years. The number of internal depositions increased by 2% from 2,362 in 2001 to 2,418 in 2002, while the collective CEDE increased by 17%. The average measurable CEDE increased by 12% from 0.025 rem (0.25 mSv) in 2001 to 0.028 rem (0.28 mSv) in 2002 and is the second lowest average measurable CEDE in the past 5 years. Due to several factors, such as changes in internal dosimetry practices, monitoring and reporting procedures, changes in the dosimetry equipment, and the relatively small number of internal doses, care should be taken in examining trends in internal dose.

An analysis was performed on the transient workforce at DOE. A transient worker is defined as an individual monitored at more than one DOE site in a year. The results of this analysis show that the number of transient workers monitored decreased from 3,183 in 2001 to 2,848 in 2002. The collective dose for these transients increased by 45% from 25.1 person-rem (251 person-mSv) in 2001 to 36.5 person-rem (365 person-mSv) in 2002, resulting in a 27% increase in the average measurable dose to transients.

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. A summary of the findings for 2002 is shown in *Exhibit 5-1*.

Exhibit 5-1:
2002 Radiation Exposure Fact Sheet.

- The collective TEDE increased by 10% (from 1,232 person-rem to 1,360 person-rem) (12,320 person-mSv to 13,600 person-mSv) from 2001 to 2002. Statistical analysis reveals that the logarithmic mean TEDE per worker reached a 5-year peak of 0.030 rem (0.30 mSv) in 2002.The logarithmic mean TEDE increased from 0.028 rem (0.28 mSv) in 2001 to 0.030 (0.30 mSv) rem in 2002, reflecting both an increase in the dose to individual workers, and a larger number of individuals with measurable dose. The logarithmic mean TEDE per worker ranged from 0.026 rem to 0.029 rem (0.26 mSv to 0.29 mSv) for 1998-2001. However, the 2002 logarithmic mean TEDE remains significantly below the 1997 logarithmic mean TEDE of 0.035 rem (0.35 mSv) per worker.

- The six highest dose sites (in descending order of collective dose: Hanford, Rocky Flats, Savannah River, Los Alamos, Oak Ridge, and Idaho) accounted for 79% of the collective dose at DOE in 2002.

- Increases in collective dose at three of the top six sites indicate that increases were due to an increase in the number of hours of radiological work performed (at Rocky Flats), increased processing of spent nuclear fuel in K-Basins (at Hanford), and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support (at LANL).

- The collective internal dose (CEDE) increased by 17% from 2001 to 2002. The increase was primarily due to a 20% increase in internal dose from uranium at the Oak Ridge Y-12 site attributed to activities at the Enriched Uranium Operations facilities.

- The number of transient workers monitored at DOE decreased from 3,183 in 2001 to 2,848 in 2002. The average measurable dose to transient workers was 17% lower than the average measurable dose for the overall DOE workforce in 2002.

Glossary

Administrative Control Level (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 (UNSCEAR) as the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem (15 mSv) to the collective dose. UNSCEAR now uses SR_{15} to denote this ratio where the subscript indicates the dose value (in mSv) used to calculate the ratio.

Deep Dose Equivalent (DDE)
The dose equivalent derived from external radiation at a depth of 1 cm in tissue.

DOE Site
A geographic location operated under the authority of the Department of Energy (DOE). The DOE sites considered in this report are listed in Appendix A by Operations Office.

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.

Exposure

As used in this report, *exposure* refers to individuals subjected to, or in the presence of, radioactive materials which may or may not result in occupational radiation dose.

Kruskall-Wallis Test

Uses a test statistic based on rank sums to determine whether two populations are significantly different.

Lens of the Eye Dose Equivalent (LDE)

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

Logarithmic Mean

The mean calculated from log-transformed values.

Members of the Public

Individuals who are not occupationally exposed to radiation or radioactive material. This includes visitors and visiting dignitaries.

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 or lower limit of detection.

Non-parametric Procedures

Statistical tests that do not depend on a specific parent distribution.

Normal Log-transformed Data

Data that fit a normal distribution after being transformed to logarithms.

Number of Individuals with Measurable Dose

The subset of all monitored individuals who receive a measurable dose (greater than limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable dose. For this reason, the number of individuals with measurable dose is presented in this report as a more accurate indicator of the exposed workforce. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

Occupational Dose

An individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

Pairwise T-tests

This test compares all possible pairs of means and uses a T-test to determine whether differences are significant.

Shallow Dose Equivalent (SDE)

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

SR

SR is defined by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as the ratio of the annual collective dose delivered at individual doses exceeding a specified dose value to the collective dose. UNSCEAR uses a subscript to denote the dose value (in mSv) used in the calculation of the ratio. Therefore SR_{15} would be the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem (15 mSv) to the collective dose.

Statistical Normal Distribution

A distribution that is symmetric and can be described completely by the mean and variance. This property is required for many statistical tests.

Total Effective Dose Equivalent (TEDE)

The sum of the effective dose equivalent for external exposures and the committed 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 Number of Records for Monitored Individuals

All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, subcontractors, and members of the public monitored during a visit to a DOE site. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

Transient Individual

An individual who is monitored at more than one DOE site during the calendar year.

T-test

A statistical test for comparing means from two populations based on the value of t, where

$t = \dfrac{\overline{y}_1 - \overline{y}_2}{S_{\overline{y}_1 - \overline{y}_2}}$ and $\overline{y}_1$ = sample mean, population 1

$\overline{y}_2$ = sample mean, population 2

$S_{\overline{y}_1 - \overline{y}_2}$ = standard deviation appropriate to the difference between the two means.

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Appendix A

DOE Reporting Sites and Reporting Codes

A

DOE Reporting Sites and Reporting Codes

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 M 231.1-1 [13]. Occupation Codes are grouped into Labor Categories for the purposes of analysis and summary in this report. The occupation codes are listed in DOE M 231.1-1, Appendix G, Table 2, and represent a subset of the occupations listed in the Department of Commerce's Standard Occupational Classification (SOC) Manual (1980).

Exhibit A-1.
Labor Categories and Occupation Codes.

Labor Category	Occupation Code	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, 1998-2002

Twenty-nine sites reported occupational exposure data in 2002. The following is a list of all organizations reporting to the DOE REMS from 1998 to 2002. The list provides the Operations Field Office and Site groupings used in this report as well as the organization reporting code and name.

Exhibit A-2.
Organizations Reporting to DOE REMS, 1998-2002.

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported*				
				'98	'99	'00	'01	'02
Albuquerque	Ops. and Other Facilities	501001	Albuquerque Operations Office	●	●	●	●	●
		502009	Albuquerque Transportation Division	●	●	●	●	
		530001	Kansas City Area Office	●	●	●	●	●
		531002	Honeywell Federal Manufacturing Tech.	●	●	●	●	●
		590001	Waste Isolation Pilot Project (WIPP)	●	●	●	●	●
		593004	Carlsbad Area Miscellaneous Contractors	●	●	●	●	●
		2806003	National Renewable Energy Lab (NREL) - GO	●	●	●	●	●
	Grand Junction	560605	MACTEC - ERS	●	●	●	●	
		560704	WASTREN		●	●	●	
	Los Alamos National Lab. (LANL)	540001	Los Alamos Area Office	●	●	●	●	●
		544003	Los Alamos National Laboratory	●	●	●	●	●
		544809	Protection Technologies Los Alamos	●	●	●	●	●
		544904	Johnson Controls, Inc.	●	●	●	●	●
	Pantex Plant (PP)	510001	Amarillo Area Office	●	●	●	●	●
		514004	Battelle - Pantex	●	●			
		515002	BWXT - Amarillo	●	●	●	●	●
		515006	BWXT - Amarillo - Subcontractors				●	●
		515009	BWXT - Amarillo - Security Forces	●	●	●	●	●
	Sandia National Lab. (SNL)	570001	Kirtland Area Office	●		●	●	●
		578003	Sandia National Laboratory	●	●	●	●	●
Chicago	Ops. and Other Facilities	1000503	Ames Laboratory (Iowa State)	●	●	●	●	●
		1001501	Chicago Operations Office	●	●	●	●	●
		1001606	Chicago Office Subs		●	●		●
		1002001	Environmental Meas. Lab. - Research	●	●	●	●	●
		1004031	New Brunswick Laboratory - Research	●	●	●	●	●
		1005003	Princeton Plasma Physics Laboratory	●	●	●	●	●
	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	●	●	●	●	●
	N. Korea Project	8009001	DOE North Korea Project	●			●	
	Russia	8011001	Russian Federation Project					●
	Kazakhstan	8010001	DOE Kazakhstan Project		●		●	
Idaho	Idaho Site	3003402	Babcock & Wilcox Idaho, Inc.	●				
		3004001	Idaho Field Office	●	●	●	●	●
		3004402	BNFL - Idaho					●
		3005004	Bechtel BWXT Idaho, LLC - Services	●	●	●	●	●
		3005016	Bechtel BWXT Idaho, LLC - Subs - Construction	●	●	●	●	●
		3005024	LMITCO Subcontractor - Coleman	●				
		3005034	LMITCO Subcontractor - Parsons	●				
		3060634	Stoller Service Subcontractors - Grand Junction					●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1998-2002 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported *				
				'98	'99	'00	'01	'02
Nevada	Nevada Test Site (NTS)	3500000	Nevada Operations	●	●	●	●	●
		3501104	Bechtel Nevada - Amador Valley	●				
		3501304	Bechtel Nevada - Los Alamos	●				
		3501405	Bechtel Nevada - NTS	●	●	●	●	●
		3501416	Bechtel Nevada - NTS Subcontractors	●	●	●	●	●
		3501503	Bechtel Nevada - Special Technologies Labs	●	●	●		
		3502004	Computer Sciences Corporation	●				
		3501604	Bechtel Nevada - Washington Aerial Meas.	●			●	●
		3504504	EG&G Santa Barbara	●				
		3506004	Raytheon Services - Nevada	●				
		3507501	Nevada Field Office	●	●			
		3507514	Nevada Miscellaneous Contractors	●	●	●	●	●
		3507521	Air Resources Laboratory	●				
		3507531	Defense Nuclear Agency - Kirtland AFB	●	●			
		3507551	Environmental Protection Agency (NERC)	●				
		3508004	Nye County Sheriff	●	●	●	●	●
		3508505	Bechtel Nevada - NTS	●				
		3508703	Science Applications Int'l. Corp. - NV	●	●	●	●	●
		3509009	Wackenhut Services, Inc. - NV	●	●	●	●	●
		3509504	Westinghouse Electric Corp. - NV	●				
Oak Ridge	Ops. and Other Facilities	4004203	Oak Ridge Inst. for Science & Educ. (ORISE)	●	●	●	●	●
		4004501	Oak Ridge Field Office	●	●	●	●	●
		4009006	Morrison-Knudsen (WSSRAP)	●	●	●	●	
		4009503	Thomas Jefferson National Accel. Facility	●	●	●	●	●
		4542005	RMI Company	●	●			
	Oak Ridge Site	4005505	LMES/MK - Ferguson Subcontractors	●	●			
		4006002	Bechtel-Jacobs Co., LLC – ETTP	●	●	●	●	●
		4006007	Decontam. & Recovery Services (DRS) (K-25)	●				
		4006302	British Nuclear Fuels Limited (BNFL) (ETTP)	●	●	●	●	●
		4006406	Decontamination & Recovery Services - ETTP		●	●	●	
		4006503	UT-Battelle - ORNL	●	●	●	●	●
		4006510	Bechtel Jacobs - ORNL			●	●	●
		4007509	Wackenhut Services			●	●	●
		4008002	BWXT Y-12, LLC	●	●	●	●	
		4008010	Bechtel-Jacobs - Y-12			●	●	●
		4018102	BWXT, Y-12				●	●
	Paducah Gas. Diff. Plant (PGDP)	4007002	Bechtel-Jacobs Co., LLC – Paducah	●	●	●	●	●
	Portsmouth Gas. Diff. Plant (PORTS)	4002502	Bechtel-Jacobs (Portsmouth)	●	●	●	●	●

Exhibit A-2.
Organizations Reporting to DOE REMS, 1998-2002 (continued).

Operations/ Field Office		Organization Code	Organization Name	Year Reported *				
				'98	'99	'00	'01	'02
Oakland	Ops. and Other Facilities	8001003	Boeing, Rocketdyne - ETEC	●	●	●	●	●
		8006103	U. of Cal./Davis, Radiobiology Lab. - LEHR	●	●	●	●	●
	Lawrence Berkeley Nat'l. Lab. (LBNL)	8003003	Lawrence Berkeley National Laboratory	●	●	●	●	●
	Lawrence Livermore Nat'l. Lab. (LLNL)	8004003	Lawrence Livermore National Laboratory	●	●	●	●	●
		8004004	LLNL Subcontractors	●			●	●
		8004009	LLNL Security	●				
		8005003	LLNL - Nevada					●
	Stanford Linear Acc. Center (SLAC)	8008003	Stanford Linear Accelerator Center	●	●	●	●	●
		8009005	Separation Process Research Unit				●	
Ohio	Ops. and Other Facilities	4500001	Ohio Field Office	●	●	●	●	●
		4510001	Miamisburg Envir. Mgmt. Project Office	●	●	●	●	●
		4510006	MEMP Office Subs	●	●	●	●	●
		4517003	Battelle Memorial Institute - Columbus	●	●	●	●	●
	Fernald Environmental	4521001	Fernald Envir. Mgmt. Project Office	●	●	●	●	●
		4521004	FEMP Office Service Subcontractors	●	●	●	●	●
		4523702	Fluor Fernald - FEMP	●	●	●	●	●
		4523704	Fluor Fernald Service Vendors		●	●	●	●
		4523706	Fluor Fernald Subcontractors	●	●	●	●	●
	Mound Plant	4516002	BWX Technologies, Inc.	●	●	●	●	●
		4516004	BWX Technologies, Inc. - Subcontractors	●	●	●	●	●
		4516009	BWX Technologies, Inc. - Security Forces	●	●	●	●	●
	West Valley Project	4530001	West Valley Area Office				●	
		4539004	West Valley Nuclear Services, Inc. (WVNS)	●	●	●	●	●
		4542005	RMI Environmental Services			●	●	●
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	7700001	Rocky Flats Office	●	●	●	●	●
		7700007	Rocky Flats Office Subs	●				
		7707002	Rocky Flats Prime Contractors	●	●	●	●	●
		7707004	Rocky Flats Subcontractors	●	●	●	●	●
Richland	Hanford Site	4700805	Bechtel National, Inc. - WTP				●	●
		4707104	CH2M Hill Hanford Group			●	●	●
		7500503	Battelle Memorial Institute (PNL)	●	●	●	●	●
		7500605	Environmental Restoration Contr. (ERC)					●
		7500705	Bechtel Power Co.	●	●	●	●	
		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, 1998-2002 (continued).

Operations/ Field Office	Site	Organization Code	Organization Name	Year Reported *				
				'98	'99	'00	'01	'02
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 Info Tech (LMIT)	●	●	●	●	●
		7505064	Dyncorp Hanford	●	●	●	●	
		7505075	SGN Eurisys Services Corp.		●	●	●	●
		7505099	Hanford Security		●	●	●	●
		7506001	Richland Field Office		●	●	●	●
		7509104	Verizon/Qwest	●	●	●	●	●
Savannah River	Savannah River Site (SRS)	8500505	Bechtel Construction - SR	●	●	●	●	●
		8501002	Westinghouse Savannah River Co.	●	●	●	●	●
		8501014	Westinghouse S.R. Subcontractors	●	●	●	●	●
		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	Bechtel 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					

* 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 M 231.1-1 [13]. A facility type code is reported with each individual's dose record and indicates 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.

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Appendix B

Additional Data

B

Additional Data

Exhibit	Title	Page

Exhibit B-1a: Operations Office/Site Dose Data - 2000

Operations/ Field Office	Site	2000: Collective TEDE (person-rem)	Percent Change from 1999	Number with Meas. Dose	Percent Change from 1999	Avg. Meas. TEDE (rem)	Percent Change from 1999	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1999
Albuquerque	Ops. and Other Facilities	0.3	-35% ▼	38	46% ▲	0.007	-55% ▼	0%	0%
	Los Alamos National Lab. (LANL)	195.5	49% ▲	1,365	-8% ▼	0.143	62% ▲	64%	**25%** ▲
	Pantex Plant (PP)	35.0	19% ▲	277	-22% ▼	0.126	52% ▲	30%	19% ▲
	Sandia National Lab. (SNL)	7.6	19% ▲	105	-13% ▼	0.072	36% ▲	9%	-9% ▼
	Grand Junction	0.1	-97% ▼	6	-88% ▼	0.012	-78% ▼	0%	0%
Chicago	Ops. and Other Facilities	3.5	141% ▲	108	32% ▲	0.033	**83%** ▲	0%	0%
	Argonne National Lab. - East (ANL-E)	17.2	-30% ▼	183	-2% ▼	0.094	-28% ▼	37%	-5% ▼
	Argonne National Lab. - West (ANL-W)	20.9	-22% ▼	234	-22% ▼	0.089	0%	5%	2% ▲
	Brookhaven National Lab. (BNL)	22.4	-4% ▼	430	-17% ▼	0.052	16% ▲	5%	-1% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.3	41% ▲	406	79% ▲	0.030	-21% ▼	4%	-10% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	0.1	187% ▲	11	175% ▲	0.006	4% ▲	0%	0%
	North Korea Project								
	Kazakhstan								
Idaho	Idaho Site	58.8	22% ▲	795	9% ▲	0.074	12% ▲	21%	17% ▲
Nevada	Nevada Test Site (NTS)	1.6	**257%** ▲	24	300% ▲	0.067	-11% ▼	0%	0%
Oakland	Ops. and Other Facilities	0.9	-10% ▼	133	56% ▲	0.007	-42% ▼	0%	0%
	Lawrence Berkeley National Lab. (LBNL)	1.1	-39% ▼	44	-4% ▼	0.025	-36% ▼	0%	0%
	Lawrence Livermore National Lab. (LLNL)	12.7	-15% ▼	145	6% ▲	0.088	-19% ▼	30%	-7% ▼
	Stanford Linear Accelerator Center (SLAC)	5.5	-46% ▼	489	**370%** ▲	0.011	-89% ▼	0%	-11% ▼
Oak Ridge	Ops. and Other Facilities	1.9	-20% ▼	125	15% ▲	0.015	-30% ▼	0%	0%
	Oak Ridge Site	118.1	-42% ▼	2,276	-9% ▼	0.052	-36% ▼	8%	-30% ▼
	Paducah Gaseous Diff. Plant (PGDP)	5.0	14% ▲	63	9% ▲	0.079	5% ▲	0%	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	1.5	198% ▲	44	76% ▲	0.035	69% ▲	0%	0%
Ohio	Ops. and Other Facilities	1.9		151		0.013			
	Battelle Memorial Institute - Columbus	31.3	-1% ▼	105	1% ▲	**0.298**	-2% ▼	**67%**	-5% ▼
	Fernald Environmental Mgmt. Project	15.0	0%	421	-8% ▼	0.036	8% ▲	0%	0%
	Mound Plant	1.1	-59% ▼	123	-38% ▼	0.009	-34% ▼	0%	0%
	West Valley Project	16.5	32% ▲	246	1% ▲	0.067	30% ▲	0%	0%
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**296.1**	-21% ▼	2,331	-34% ▼	0.127	19% ▲	35%	7% ▲
Richland	Hanford Site	219.0	20% ▲	1,923	-4% ▼	0.114	26% ▲	36%	1% ▲
Savannah River	Savannah River Site (SRS)	163.2	20% ▲	**3,382**	13% ▲	0.048	6% ▲	5%	-5% ▼
Totals		**1,266.5**	**-2%** ▼	**15,983**	**-4%** ▼	**0.079**	**2%** ▲	**30%**	**3%** ▲

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

Exhibit B-1b: Operations Office/Site Dose Data - 2001

Operations/ Field Office	Site	2001 Collective TEDE (person-rem)	Percent Change from 2000	Number with Meas. Dose	Percent Change from 2000	Avg. Meas. TEDE (rem)	Percent Change from 2000	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 2000
Albuquerque	Ops. and Other Facilities	1.2	**347%** ▲	95	**150%** ▲	0.013	79% ▲	0%	0%
	Los Alamos National Lab. (LANL)	112.9	-42% ▼	1,330	-3% ▼	0.085	-41% ▼	31%	-34% ▼
	Pantex Plant (PP)	43.6	25% ▲	293	6% ▲	0.149	18% ▲	32%	2% ▲
	Sandia National Lab. (SNL)	4.7	-38% ▼	99	-6% ▼	0.048	-34% ▼	0%	-9% ▼
	Grand Junction	0.1	9% ▲	2	-67% ▼	0.038	226% ▲	0%	0%
Chicago	Ops. and Other Facilities	7.8	119% ▲	162	50% ▲	0.048	46% ▲	0%	0%
	Argonne National Lab. - East (ANL-E)	23.0	34% ▲	187	2% ▲	0.123	31% ▲	47%	10% ▲
	Argonne National Lab. - West (ANL-W)	19.8	-5% ▼	258	10% ▲	0.077	-14% ▼	0%	-5% ▼
	Brookhaven National Lab. (BNL)	14.6	-35% ▼	387	-10% ▼	0.038	-27% ▼	0%	-5% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	10.7	-14% ▼	368	-9% ▼	0.029	-5% ▼	0%	-4% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	0.0	-56% ▼	5	-55% ▼	0.006	-3% ▼	0%	0%
	North Korea Project	1.0		8		0.130			
	Kazakhstan								
Idaho	Idaho Site	106.6	81% ▲	1,088	37% ▲	0.098	32% ▲	19%	-2% ▼
Nevada	Nevada Test Site (NTS)	1.3	-18% ▼	32	33% ▲	0.041	-39% ▼	0%	0%
Oakland	Ops. and Other Facilities	1.6	72% ▲	134	1% ▲	0.012	70% ▲	0%	0%
	Lawrence Berkeley National Lab. (LBNL)	0.7	-39% ▼	21	-52% ▼	0.032	28% ▲	0%	0%
	Lawrence Livermore National Lab. (LLNL)	18.6	46% ▲	153	6% ▲	0.121	38% ▲	50%	**20%** ▲
	Stanford Linear Accelerator Center (SLAC)	1.4	-75% ▼	35	-93% ▼	0.039	**250%** ▲	0%	0%
Oak Ridge	Ops. and Other Facilities	2.6	38% ▲	144	15% ▲	0.018	20% ▲	0%	0%
	Oak Ridge Site	120.0	2% ▲	2,576	13% ▲	0.047	-10% ▼	11%	3% ▲
	Paducah Gaseous Diff. Plant (PGDP)	5.0	2% ▲	122	94% ▲	0.041	-48% ▼	0%	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	1.2	-23% ▼	35	-20% ▼	0.034	-3% ▼	0%	0%
Ohio	Ops. and Other Facilities	2.0	6% ▲	89	-41% ▼	0.023	79% ▲	0%	0%
	Battelle Memorial Institute - Columbus	35.2	12% ▲	84	-20% ▼	**0.419**	40% ▲	**82%**	15% ▲
	Fernald Environmental Mgmt. Project	11.4	-24% ▼	355	-16% ▼	0.032	-10% ▼	0%	0%
	Mound Plant	1.2	11% ▲	97	-21% ▼	0.013	41% ▲	0%	0%
	West Valley Project	22.2	34% ▲	233	-5% ▼	0.095	42% ▲	2%	2% ▲
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	**240.7**	-19% ▼	2,436	5% ▲	0.099	-22% ▼	23%	-12% ▼
Richland	Hanford Site	213.6	-2% ▼	2,219	15% ▲	0.096	-15% ▼	32%	-4% ▼
Savannah River	Savannah River Site (SRS)	207.6	27% ▲	**3,640**	8% ▲	0.057	18% ▲	16%	11% ▲
Totals		**1,232.4**	**-3%** ▼	**16,687**	**4%** ▲	**0.074**	**-7%** ▼	**0%**	**-30%** ▼

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

Exhibit B-1c: Operations Office/Site Dose Data - 2002

Operations/ Field Office	Site	2002 Collective TEDE (person-rem)	Percent Change from 2001	Number with Meas. Dose	Percent Change from 2001	Avg. Meas. TEDE (rem)	Percent Change from 2001	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 2001
Albuquerque	Ops. and Other Facilities	2.5	101% ▲	118	24% ▲	0.021	62% ▲	0%	0%
	Los Alamos National Lab. (LANL)	163.5	45% ▲	1,696	28% ▲	0.096	14% ▲	35%	4% ▲
	Pantex Plant (PP)	47.3	9% ▲	292	0%	0.162	9% ▲	32%	0%
	Sandia National Lab. (SNL)	4.5	-4% ▼	109	10% ▲	0.042	-13% ▼	0%	0%
	Grand Junction*								
Chicago	Ops. and Other Facilities	4.5	-42% ▼	182	12% ▲	0.025	-48% ▼	12%	12% ▲
	Argonne National Lab. - East (ANL-E)	23.6	2% ▲	233	25% ▲	0.101	-18% ▼	39%	-8% ▼
	Argonne National Lab. - West (ANL-W)	24.9	26% ▲	278	8% ▲	0.090	17% ▲	8%	8% ▲
	Brookhaven National Lab. (BNL)	26.2	79% ▲	439	13% ▲	0.060	58% ▲	20%	20% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.8	20% ▲	389	6% ▲	0.033	14% ▲	0%	0%
DOE HQ	DOE Headquarters (includes DNFSB)	0.0		0		0.0		0%	0%
	Russian Federation Project	0.0		0		0.0		0%	0%
Idaho	Idaho Site	76.0	-29% ▼	1,089	0%	0.070	-29% ▼	4%	-15% ▼
Nevada	Nevada Test Site (NTS)	0.9	-30% ▼	30	-6% ▼	0.031	-25% ▼	0%	0%
Oakland	Ops. and Other Facilities	3.2	103% ▲	81	-40% ▼	0.040	**236%** ▲	19%	19% ▲
	Lawrence Berkeley National Lab. (LBNL)	0.9	31% ▲	33	57% ▲	0.027	-16% ▼	0%	0%
	Lawrence Livermore National Lab. (LLNL)	28.0	51% ▲	163	7% ▲	0.172	41% ▲	60%	11% ▲
	Stanford Linear Accelerator Center (SLAC)	3.1	**125%** ▲	79	**126%** ▲	0.039	0%	0%	0%
Oak Ridge	Ops. and Other Facilities	1.4	-48% ▼	103	-28% ▼	0.013	-27% ▼	0%	0%
	Oak Ridge Site	107.8	-10% ▼	2,304	-11% ▼	0.047	0%	4%	-7% ▼
	Paducah Gaseous Diff. Plant (PGDP)	8.8	75% ▲	232	90% ▲	0.038	-8% ▼	0%	0%
	Portsmouth Gaseous Diff. Plant (PORTS)	1.0	-18% ▼	37	6% ▲	0.026	-23% ▼	0%	0%
Ohio	Ops. and Other Facilities	0.6	-71% ▼	49	-45% ▼	0.012	-48% ▼	0%	0%
	Battelle Memorial Institute - Columbus	44.4	26% ▲	103	23% ▲	**0.431**	3% ▲	**80%**	-3% ▼
	Fernald Environmental Mgmt. Project	17.0	50% ▲	572	61% ▲	0.030	-7% ▼	0%	0%
	Mound Plant	2.7	120% ▲	198	104% ▲	0.014	8% ▲	0%	0%
	West Valley Project	30.5	38% ▲	239	3% ▲	0.128	34% ▲	24%	**21%** ▲
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	250.0	4% ▲	2,175	-11% ▼	0.115	16% ▲	24%	1% ▲
Richland	Hanford Site	**274.4**	28% ▲	2,611	18% ▲	0.105	9% ▲	29%	-3% ▼
Savannah River	Savannah River Site (SRS)	199.1	-4% ▼	**3,217**	-12% ▼	0.062	9% ▲	15%	-1% ▼
Totals		**1,359.6**	**10%** ▲	**17,051**	**2%** ▲	**0.080**	**8%** ▲	**24%**	**24%** ▲

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

*No longer in operation, therefore not required to report.

The collective dose increased by 10% from 2001 to 2002. Primary contributors to the increase include LANL (up 45%) and Hanford (up 28%). Increases at these sites were attributed to increased processing of spent nuclear fuel in K-Basins at Hanford and increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support at LANL.

Exhibit B-2a: Collective TEDE and Average Measurable Dose 1974-2002

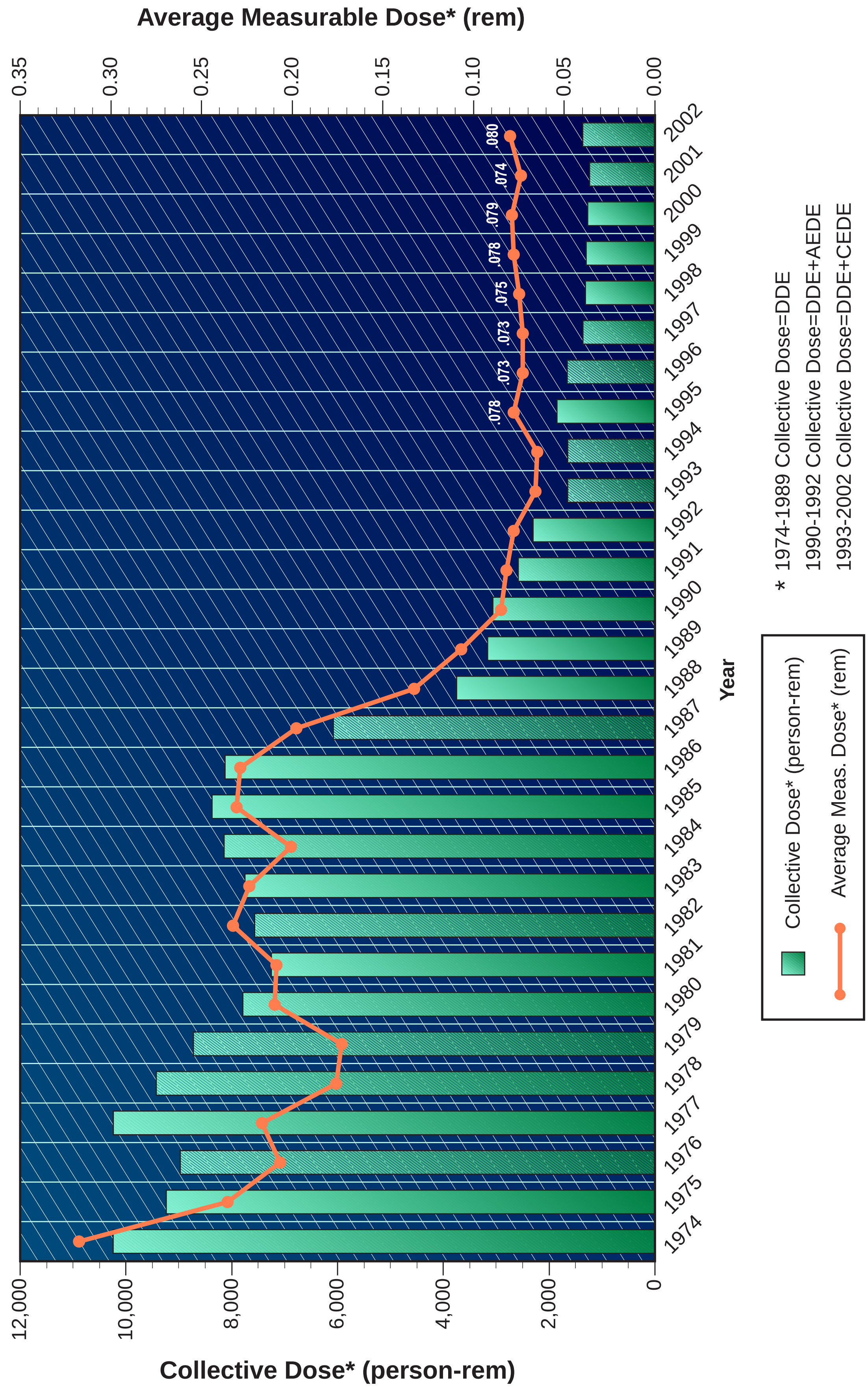
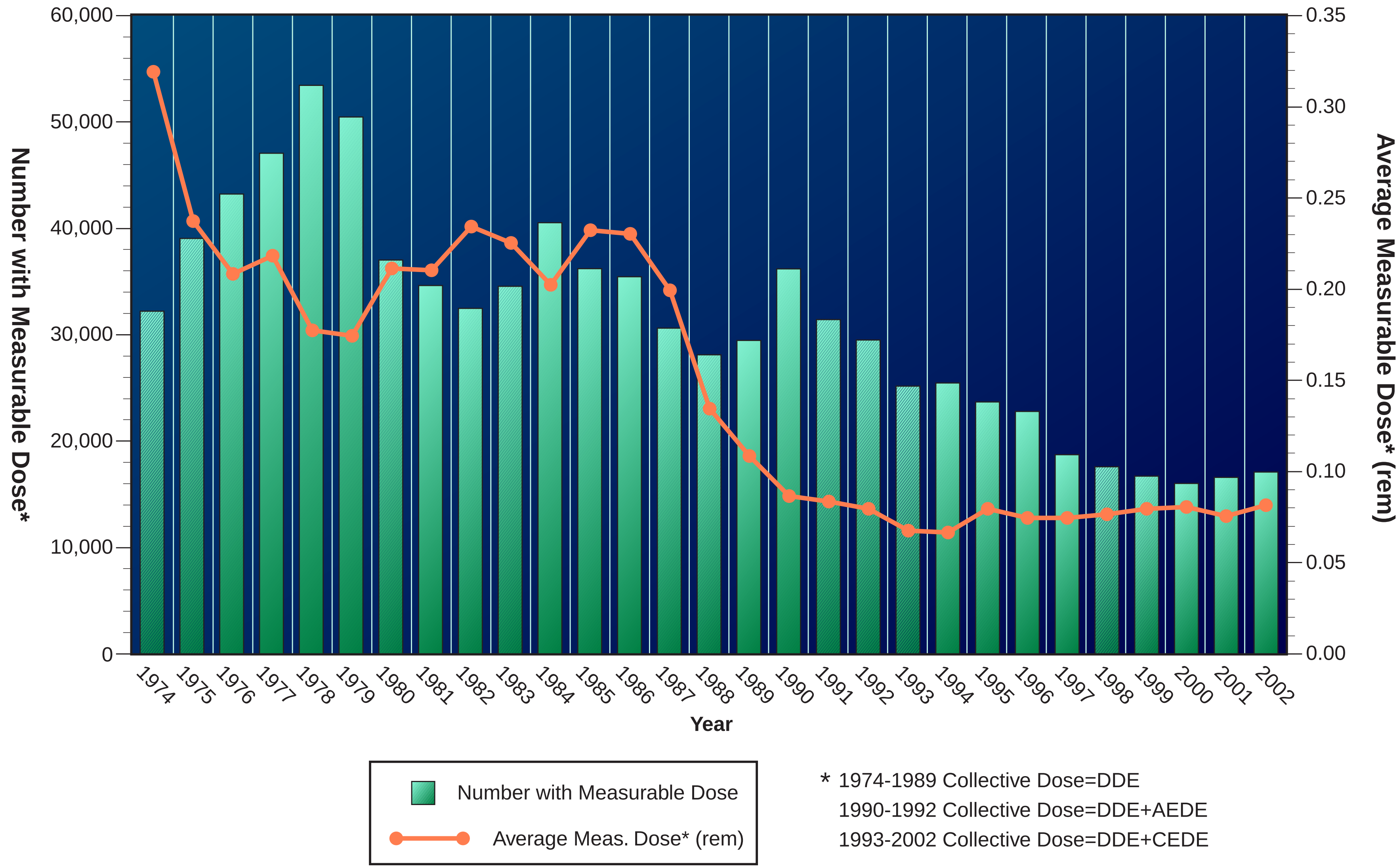


Exhibit B-2b: Number with Measurable Dose and Average Measurable Dose 1974-2002



* 1974-1989 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-2002 Collective Dose=DDE+CEDE

Exhibit B-3: Distribution of Deep Dose Equivalent (DDE) 1974-2002 and Total Effective Dose Equivalent (TEDE) 1990-2002

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
1998	92,803	15,669	36												108,508	15,705	1,219	0.078
1999	98,125	14,877	62												113,064	14,939	1,142	0.076
2000	88,621	14,206	54												102,881	14,260	1,086	0.076
2001	82,950	14,821	47												97,818	14,868	1,173	0.079
2002	84,874	15,282	64	1											100,221	15,347	1,291	0.084

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	88,502	18,627	48	1	2	1									107,181	18,675	1,356	0.073
1998	90,964	17,501	41	1				1							108,508	17,544	1,309	0.075
1999	96,396	16,585	80	1	1			1							113,064	16,668	1,295	0.078
2000	86,898	15,922	58								1		1	1	102,881	15,983	1,267	0.079
2001	81,131	16,638	48	2											97,818	16,687	1,232	0.074
2002	83,170	16,985	65	1											100,221	17,051	1,360	0.080

* 1990-1992 TEDE=DDE+AEDE 1993-2002 TEDE=DDE+CEDE Note: Arrowed values indicate the greatest value in each column.

Exhibit B-4: Internal Dose by Operations/Site, 2000-2002

Operations/ Field Office	Site	No. of Individuals with New Intakes*			Collective CEDE Dose from Intake (person-rem)			Average CEDE (rem)		
		2000	2001	2002	2000	2001	2002	2000	2001	2002
Albuquerque	LANL	90	97	111	**109.816** ◄	2.948	3.200	**1.220** ◄	0.030	0.029
	Pantex	1	25	30	0.014	0.669	0.304	0.014	0.027	0.010
	Sandia National Lab	2	1	0	0.005	0.005	0	0.003	0.005	0
	Grand Junction	0	2	0	0	0.076	0	0	0.038	0
Chicago	Ops. and Other Facilities	1	12	8	0.001	0.038	0.028	0.001	0.003	0.004
	ANL-E	33	16	17	0.704	0.523	0.591	0.021	0.033	0.035
	ANL-W	0	0	2	0	0	0.013	0	0	0.007
	BNL	29	30	18	0.817	0.223	0.302	0.028	0.007	0.017
Idaho	Idaho Site	7	5	22	0.116	0.083	2.141	0.017	0.017	**0.097** ◄
Oakland	LBNL	20	7	9	0.354	0.124	0.165	0.018	0.018	0.018
	LLNL	3	0	2	0.006	0	0.007	0.002	0	0.004
Oak Ridge	Oak Ridge Site	**1,518** ◄	**1,779** ◄	**1,559** ◄	59.506	**46.193** ◄	**54.653** ◄	0.039	0.026	0.035
	Paducah	11	2	10	0.231	0.041	0.104	0.021	0.021	0.010
	Portsmouth	1	2	4	0.018	0.013	0.026	0.018	0.007	0.007
Ohio	OH	29	31	28	0.292	0.302	0.188	0.010	0.010	0.007
	BMI - Columbus	33	43	35	0.142	0.228	0.083	0.004	0.005	0.002
	Fernald	60	20	24	3.450	0.093	0.162	0.058	0.005	0.007
	Mound Plant	108	77	276	0.642	0.538	2.161	0.006	0.007	0.008
	WVNS	0	0	38	0	0	1.088	0	0	0.029
Rocky Flats	Rocky Flats	76	47	99	3.398	3.327	2.902	0.045	**0.071** ◄	0.029
Richland	Hanford Site	18	23	24	0.208	0.919	0.263	0.012	0.040	0.011
Savannah River	Savannah River Site	237	143	102	0.860	2.611	0.309	0.004	0.018	0.003
Totals		**2,277**	**2,362**	**2,418**	**180.580**	**58.954**	**68.690**	**0.079**	**0.025**	**0.028**

Facilities with no new intakes reported during the past 3 years: Albuquerque Ops., ANL-W, DOE-HQ, Fermi Lab, NTS, Oakland Ops., SLAC, Umtra, and WVNS.

* 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.

The collective internal dose (CEDE) increased by 17% from 2001 to 2002. However, it remains well below the value for 2000. The increase was primarily due to a 20% increase in internal dose at the Oak Ridge Y-12 site. The Y-12 facility accounted for 77% of the collective CEDE for 2002. The increase was attributed to activities at the Enriched Uranium Operations' facilities.

Exhibit B-5: Neutron Dose Distribution by Operations/Site, 2002

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	829								829	0	0%	0	
	Los Alamos National Lab. (LANL)	9,770	927	146	39	12	7	5		10,906	**1,136** ◄	10%	**76.574** ◄	0.067
	Pantex Plant (PP)	5,228	116	32						5,376	148	3%	8.931	0.060
	Sandia National Lab. (SNL)	2,931	11							2,942	11	0%	0.279	0.025
Chicago	Chicago Operations	700								700	0	0%	0	0
	Argonne Nat'l. Lab. - East (ANL-E)	2,674	113	6						2,793	119	4%	3.774	0.032
	Argonne Nat'l. Lab. - West (ANL-W)	679	30	3						712	33	5%	1.230	0.037
	Brookhaven Nat'l. Lab. (BNL)	4,626	45	1						4,672	46	1%	0.997	0.022
	Fermi Nat'l. Accelerator Lab. (FERMI)	1,423	1							1,424	1	0%	0.080	0.080
DOE HQ	DOE Headquarters	16								16	0	0%	0	0
	Russian Federation Project	8								8	0	0%	0	0
Idaho	Idaho Site	4,689	40							4,729	40	1%	1.123	0.028
Nevada	Nevada Test Site (NTS)	3,901	8							3,909	8	0%	0.266	0.033
Oakland	Oakland Operations	176								176	0	0%	0	0
	Lawrence Berkeley National Lab. (LBNL)	1,534	4							1,538	4	0%	0.093	0.023
	Lawrence Livermore National Lab. (LLNL)	9,437	63	11	3	3				9,517	80	1%	6.638	0.083
	Stanford Linear Accelerator Center (SLAC)	2,664	12							2,676	12	0%	0.236	0.020
Oak Ridge	Oak Ridge Operations	1,684	1							1,685	1	0%	0.029	0.029
	Oak Ridge Site	14,237	60	20	4					**14,321** ◄	84	1%	6.103	0.073
	Paducah Gaseous Diff. Plant (PGDP)	1,073	112	1						1,186	113	10%	3.961	0.035
	Portsmouth Gaseous Diff. Plant (PORTS)	638	2							640	2	0%	0.060	0.030
Ohio	Ohio Field Office	374								374	0	0%	0	0
	Battelle Memorial Institute - Columbus	319								319	0	0%	0	0
	Fernald Environmental Mgmt. Project	2,220								2,220	0	0%	0	0
	Mound Plant	748	18							766	18	2%	0.336	0.019
	West Valley	777								777	0	0%	0	0
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	4,376	540	159	28	18	1			5,122	746	**15%** ◄	68.433	0.092
Richland	Hanford Site	9,763	799	82	14	7	3	1		10,669	906	8%	42.094	0.046
Savannah River	Savannah River Site (SRS)	8,849	180	146	34	10				9,219	370	4%	45.792	**0.124** ◄
	Totals	**96,343**	**3,082**	**607**	**122**	**50**	**11**	**6**		**100,221**	**3,878**	**4%**	**267.029**	**0.069**

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

LANL and Rocky Flats continue to contribute the majority (54%) of the collective neutron dose for 2002. Workers at these sites receive neutron dose from the handling of plutonium in gloveboxes. Combined with the neutron dose at Hanford and Savannah River, the top 4 sites account for 87% of the neutron dose in 2002.

Exhibit B-6a: Distribution of TEDE by Facility Type - 2000

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	9,591	1,327	81	17	4							11,020	13%	1,429	45.932	0.032
Fuel/Uran. Enrich.	4,169	627	37	14	1							4,848	14%	679	21.591	0.032
Fuel Fabrication	3,048	395	24	5								3,472	12%	424	15.121	0.036
Fuel Processing	2,908	1,025	80	9	1							4,023	28%	1,115	41.609	0.037
Maint. and Support	14,810	1,614	294	150	56	30	28				1	16,983	13%	2,173	325.407	**0.150** ◄
Other	16,948	1,280	93	49	9	2	1					**18,382** ◄	8%	1,434	68.201	0.048
Reactor	1,355	506	59	20	9	6						1,955	**31%** ◄	600	38.123	0.064
Research, General	15,023	1,721	288	101	23	1	4				2	17,163	12%	2,140	164.751	0.077
Research, Fusion	522	62	12	1		2	1					600	13%	78	7.149	0.092
Waste Proc./Mgmt.	4,701	1,246	172	30	4	3	5					6,161	24%	1,460	81.168	0.056
Weapons Fab. & Test	13,823	3,217	733	331	104	47	19					18,274	24%	**4,451** ◄	**457.482** ◄	0.103
Totals	**86,898**	**13,020**	**1,873**	**727**	**211**	**91**	**58**	**0**	**0**	**0**	**3**	**102,881**	**16%**	**15,983**	**1,266.534**	**0.079**

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

Exhibit B-6b: Distribution of TEDE by Facility Type - 2001

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	10,472	882	67	22	3	2						11,448	9%	976	40.147	0.041
Fuel/Uran. Enrich.	4,038	782	46	17	1							4,884	17%	846	25.845	0.031
Fuel Fabrication	1,824	330	24	1								2,179	16%	355	11.355	0.032
Fuel Processing	2,594	1,020	112	21	2							3,749	31%	1,155	52.461	0.045
Maint. and Support	11,679	1,800	275	175	83	41	15					14,068	17%	2,389	251.554	**0.105** ◄
Other	12,163	1,156	153	72	15	4	1					13,564	10%	1,401	90.807	0.065
Reactor	1,023	461	55	26	13	3	2					1,583	**35%** ◄	560	40.873	0.073
Research, General	21,821	1,809	253	110	32	8	14	1				**24,048** ◄	9%	2,227	170.584	0.077
Research, Fusion	455	94	11	10	1							571	20%	116	7.803	0.067
Waste Proc./Mgmt.	3,849	1,554	276	94	14							5,787	33%	1,938	129.898	0.067
Weapons Fab. & Test	11,213	3,671	619	292	95	31	16					15,937	30%	**4,724** ◄	**411.063** ◄	0.087
Totals	**81,131**	**13,559**	**1,891**	**840**	**259**	**89**	**48**	**1**	**0**	**0**	**0**	**97,818**	**17%**	**16,687**	**1,232.390**	**0.074**

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

Exhibit B-6c: Distribution of TEDE by Facility Type - 2002

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	9,679	945	91	43	4	4						10,766	10%	1,087	57.220	0.053
Fuel/Uran. Enrich.	4,436	677	57	8	2							5,180	14%	744	27.683	0.037
Fuel Fabrication	1,648	540	30	2								2,220	26%	572	16.982	0.030
Fuel Processing	2,555	1,023	97	17								3,692	31%	1,137	48.881	0.043
Maint. and Support	12,301	2,051	415	204	82	48	25					15,126	19%	2,825	316.582	0.112
Other	11,711	1,230	198	98	33	8	8	1				13,287	12%	1,576	29.295	0.019
Reactor	1,109	385	62	19	3	1						1,579	30%	470	135.818	**0.289◄**
Research, General	22,946	1,735	267	112	32	8	18					**25,118◄**	9%	2,172	175.900	0.081
Research, Fusion	361	137	15	1								514	30%	153	4.299	0.028
Waste Proc./Mgmt.	3,802	1,561	223	89	1	1						5,677	**33%◄**	1,875	110.320	0.059
Weapons Fab. & Test	12,622	3,216	747	326	112	25	14					17,062	26%	**4,440◄**	**436.597◄**	0.098
Totals	**83,170**	**13,500**	**2,202**	**919**	**269**	**95**	**65**	**1**				**100,221**	**17%**	**17,051**	**1,359.577**	**0.080**

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

Weapons Fabrication and Testing remains the facility type with the highest collective dose. It should be noted that Rocky Flats and Savannah River account for the majority (74%) of the dose reported under this facility type even though these sites are no longer actively involved in this activity. Maintenance and Support facilities received the highest average measurable TEDE since individuals reported under this facility type tend to perform maintenance and support work at multiple facility types involving work with radiological materials.

Exhibit B-7a: Collective TEDE by Facility Type - 2000

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	0.0	0.1	**0.3**
	Los Alamos National Lab. (LANL)	7.5				117.0	0.0	**50.1** ◄	0.2	1.1		19.6	**195.5**
	Pantex Plant (PP)										35.0		**35.0**
	Sandia National Lab. (SNL)	0.1				0.3	4.1	1.8		0.2	0.3	0.8	**7.6**
	Grand Junction											0.1	**0.1**
Chicago	Ops. and Other Facilities							0.6	2.9			0.0	**3.5**
	Argonne Nat'l. Lab. - East (ANL-E)	6.0				0.1		8.4		2.3		0.4	**17.2**
	Argonne Nat'l. Lab. - West (ANL-W)							20.9					**20.9**
	Brookhaven Nat'l. Lab. (BNL)	**12.8** ◄				1.7	1.6	3.0		2.7		0.7	**22.4**
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.3											**12.3**
DOE HQ	DOE Headquarters											0.1	**0.1**
	North Korea												
	Kazakhstan												
Idaho	Idaho Site				6.8	3.0	**26.9** ◄	15.6		5.6		0.9	**58.8**
Nevada	Nevada Test Site (NTS)					1.6							**1.6**
Oakland	Ops. and Other Facilities							0.9					**0.9**
	Lawrence Berkeley National Lab. (LBNL)	0.1						1.0					**1.1**
	Lawrence Livermore National Lab. (LLNL)	0.0	0.1			0.9		1.6	**4.0** ◄	0.0	2.6	3.4	**12.7**
	Stanford Linear Accelerator Center (SLAC)	5.5											**5.5**
Oak Ridge	Ops. and Other Facilities	1.6						0.3					**1.9**
	Oak Ridge Site		**15.0** ◄					35.8			67.3		**118.1**
	Paducah Gaseous Diff. Plant (PGDP)		5.0										**5.0**
	Portsmouth Gaseous Diff. Plant (PORTS)		1.5										**1.5**
Ohio	Ops. and Other Facilities					31.4						1.9	**33.3**
	Fernald Environmental Mgmt. Project			**15.0** ◄									**15.0**
	Mound Plant					0.9					0.2	0.0	**1.1**
	West Valley											16.5	**16.5**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**294.8** ◄	1.3	**296.1** ◄
Richland	Hanford Site			0.1	0.4	**157.7** ◄	2.2	10.1		26.7		**21.8** ◄	**219.0**
Savannah River	Savannah River Site (SRS)				**34.4** ◄	10.8	3.3	14.6		**42.3** ◄	57.3	0.5	**163.2**
	Totals	**45.9**	**21.6**	**15.1**	**41.6**	**325.4**	**38.1**	**164.8**	**7.1**	**81.2**	**457.5**	**68.2**	**1,266.5**

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

Exhibit B-7b: Collective TEDE by Facility Type - 2001

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									1.1		0.1	**1.2**
	Los Alamos National Lab. (LANL)	**11.3**				34.6	0.0	37.1	0.4	0.9		28.6	**112.9**
	Pantex Plant (PP)										43.6		**43.6**
	Sandia National Lab. (SNL)	0.1				0.4	2.3	0.7		0.1	0.6	0.6	**4.7**
	Grand Junction											0.1	**0.1**
Chicago	Ops. and Other Facilities	0.0						0.3	**7.4**			0.0	**7.8**
	Argonne Nat'l. Lab. - East (ANL-E)	6.3				0.3		13.1		3.3		0.0	**23.0**
	Argonne Nat'l. Lab. - West (ANL-W)						0.0	19.6		0.2			**19.8**
	Brookhaven Nat'l. Lab. (BNL)	8.1				1.2	0.5	2.9		1.5		0.4	**14.6**
	Fermi Nat'l. Accelerator Lab. (FERMI)	10.7											**10.7**
DOE HQ	DOE Headquarters											0.0	**0.0**
	North Korea											1.0	**1.0**
Idaho	Idaho Site				13.9	7.3	**33.3**	4.0		44.0		4.0	**106.6**
Nevada	Nevada Test Site (NTS)					1.3							**1.3**
Oakland	Ops. and Other Facilities							1.6					**1.6**
	Lawrence Berkeley National Lab. (LBNL)	0.1						0.6					**0.7**
	Lawrence Livermore National Lab. (LLNL)							18.6					**18.6**
	Stanford Linear Accelerator Center (SLAC)	1.4											**1.4**
Oak Ridge	Ops. and Other Facilities	2.3						0.3					**2.6**
	Oak Ridge Site		**19.6**					**47.2**			53.2	0.0	**120.0**
	Paducah Gaseous Diff. Plant (PGDP)		5.0										**5.0**
	Portsmouth Gaseous Diff. Plant (PORTS)		1.2										**1.2**
Ohio	Ops. and Other Facilities											2.0	**2.0**
	Fernald Environmental Mgmt. Project			**11.4**									**11.4**
	Mound Plant					0.8					0.5		**1.2**
	West Valley											22.2	**22.2**
	Battelle Memorial Institute - Columbus					35.2							**35.2**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**240.7**		**240.7**
Richland	Hanford Site					**154.3**		11.1		17.3		**31.0**	**213.6**
Savannah River	Savannah River Site (SRS)				**38.5**	16.3	4.7	13.3		**61.6**	72.5	0.7	**207.6**
	Totals	**40.1**	**25.8**	**11.4**	**52.5**	**251.6**	**40.9**	**168.8**	**7.8**	**129.9**	**411.0**	**91.6**	**1,232.4**

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

Exhibit B-7c: Collective TEDE by Facility Type - 2002

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									2.3	0.0	0.1	**2.5**
	Los Alamos National Lab. (LANL)	14.0				48.9	0.0	**43.4** ◄	0.6	1.9	0.0	**54.8** ◄	**163.5**
	Pantex Plant (PP)										47.3		**47.3**
	Sandia National Lab. (SNL)	0.3				0.2	2.1	0.8		0.1	0.6	0.4	**4.5**
Chicago	Ops. and Other Facilities							0.2	**3.7** ◄			0.6	**4.5**
	Argonne Nat'l. Lab. - East (ANL-E)	7.5				0.1		12.7		3.3			**23.6**
	Argonne Nat'l. Lab. - West (ANL-W)						0.0	24.9					**24.9**
	Brookhaven Nat'l. Lab. (BNL)	**18.4** ◄				2.4	0.4	2.6		1.6		0.8	**26.2**
	Fermi Nat'l. Accelerator Lab. (FERMI)	12.8											**12.8**
DOE HQ	DOE Headquarters												**0.0**
	Russian Federation Project												**0.0**
Idaho	Idaho Site				19.0	12.3	**22.8** ◄	6.0		13.4		2.6	**76.0**
Nevada	Nevada Test Site (NTS)					0.9							**0.9**
Oakland	Ops. and Other Facilities							3.2					**3.2**
	Lawrence Berkeley National Lab. (LBNL)	0.1						0.8					**0.9**
	Lawrence Livermore National Lab. (LLNL)							28.0					**28.0**
	Stanford Linear Accelerator Center (SLAC)	3.1											**3.1**
Oak Ridge	Ops. and Other Facilities	1.1						0.3					**1.4**
	Oak Ridge Site		**17.9** ◄					27.0			62.8		**107.8**
	Paducah Gaseous Diff. Plant (PGDP)		8.8										**8.8**
	Portsmouth Gaseous Diff. Plant (PORTS)		1.0										**1.0**
Ohio	Ops. and Other Facilities					0.0					0.0	0.6	**0.6**
	Battelle Memorial Institute - Columbus					44.4							**44.4**
	Fernald Environmental Mgmt. Project			**17.0** ◄									**17.0**
	Mound Plant					1.9					0.9		**2.7**
	West Valley					0.0						30.5	**30.5**
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)										**250.0** ◄		**250.0**
Richland	Hanford Site					**193.6** ◄		12.4		23.9		44.4	**274.4** ◄
Savannah River	Savannah River Site (SRS)				**29.8** ◄	11.9	4.0	13.5		**63.9** ◄	75.0	1.0	**199.1**
	Totals	**57.2**	**27.7**	**17.0**	**48.9**	**316.6**	**29.3**	**175.9**	**4.3**	**110.3**	**436.6**	**135.8**	**1,359.6**

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

Rocky Flats contributes 57% of the dose attributed to the Weapons Fabrication and Testing facility type, although the site is primarily involved in materials stabilization and waste management. Hanford contributes 61% of the Site-wide Maintenance and Support dose and is involved in stabilization and repackaging of plutonium-bearing materials and processing of spent nuclear fuel.

Exhibit B-8: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Accelerator Facilities, 2002

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**	**1.00-2.00**	**>2**	**Total Monitored**	**Percent of Monitored with Meas. TEDE**	**No. with Meas. TEDE**	**Collective TEDE (person-rem)**	**Avg. Meas. TEDE (rem)**
AL	Los Alamos National Laboratory	524	152	19	21					716	**27%** ◄	192	13.950	**0.073** ◄
CH	Brookhaven National Laboratory	2,662	206	33	10	4	3			**2,918** ◄	9%	256	**18.435** ◄	0.072
CH	Argonne National Laboratory - East	474	107	13	5		1			600	21%	126	7.544	0.060
OAK	Stanford Linear Accelerator Center	2,597	76	1	2					2,676	3%	79	3.075	0.039
AL	Sandia National Laboratory	362	8							370	2%	8	0.261	0.033
CH	Fermilab	1,035	363	21	5					1,424	**27%** ◄	**389** ◄	12.790	0.033
OR	Thomas Jefferson Nat'l. Accel. Facil.	1,549	30	4						1,583	2%	34	1.113	0.033
OAK	Lawrence Berkeley National Lab.	460	3							463	1%	3	0.052	0.017
AL	Johnson Controls, Inc.	2								2	0%	0	0.000	0.000
CH	Chicago Operations Office	11								11	0%	0	0.000	0.000
OR	Oak Ridge Field Office	3								3	0%	0	0.000	0.000
	Totals	**9,679**	**945**	**91**	**43**	**4**	**4**	**0**	**0**	**10,766**	**10%**	**1,087**	**57.220**	**0.053**

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

BNL and LANL contribute 57% of the collective dose for this facility type. Most of the increase in dose for this facility type between 2001 and 2002 is due to the increase at BNL, where accelerator research is performed.

Exhibit B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 2002

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)
ENRICHMENT														
OR	Bechtel Jacobs - ORNL	442	131	27	8	2				610	**28%** ◄	168	**12.345** ◄	**0.073** ◄
OR	Bechtel Jacobs - ETTP	1,265	53	3						**1,321** ◄	4%	56	2.206	0.039
OR	Bechtel Jacobs - Paducah	954	207	25						1,186	20%	232	8.798	0.038
OR	Bechtel Jacobs - Portsmouth	603	36	1						640	6%	37	0.963	0.026
OR	Bechtel Jacobs - Y-12	230	16							246	7%	16	0.229	0.014
OR	British Nuclear Fuels Ltd. - (BNFL) - ETTP	942	234	1						1,177	20%	**235** ◄	3.142	0.013
	Totals	**4,436**	**677**	**57**	**8**	**2**	**0**	**0**	**0**	**5,180**	**14%**	**744**	**27.683**	**0.037**
FABRICATION														
OH	Fluor Fernald Const Subcontractors	540	237	12	1					790	**32%** ◄	250	7.537	**0.030** ◄
OH	Fluor Fernald - Femp	1,060	303	18	1					**1,382** ◄	23%	**322** ◄	**9.445** ◄	0.029
OH	Femp Office Service Subcontractors	13								13	0%	0	0	0
OH	Fernald Env Mgmt Proj Office	33								33	0%	0	0	0
OH	Fluor Fernald Service Vendors	2								2	0%	0	0	0
	Totals	**1,648**	**540**	**30**	**2**	**0**	**0**	**0**	**0**	**2,220**	**26%**	**572**	**16.982**	**0.030**

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

The parameters for Fuel Enrichment and Fuel Fabrication remain nearly the same for 2002 as for 2001 with the Oak Ridge facilities contributing the majority of dose for Enrichment facilities, and Fernald contributing the majority of dose for Fuel Fabrication facilities.

Exhibit B-9: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 2002 (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)
PROCESSING														
ID	Bechtel BWXT Idaho - Services	728	214	43	11					996	27%	268	18.054	**0.067** ◄
ID	Bechtel BWXT Idaho - Construction	84	11	5						100	16%	16	0.986	0.062
SR	Bechtel Construction - SR	206	163	19	5					393	**48%** ◄	187	8.524	0.046
SR	Westinghouse Savannah River Co.	1,337	619	28	1					**1,985** ◄	33%	**648** ◄	**20.818** ◄	0.032
SR	Wackenhut Services, Inc. - SR	109	12	2						123	11%	14	0.436	0.031
SR	Savannah River Field Office	51	2							53	4%	2	0.040	0.020
SR	Westinghouse S.R. Subcontractors	36	2							38	5%	2	0.023	0.012
AL	Johnson Controls, Inc.	2								2	0%	0	0	0.000
AL	Los Alamos National Laboratory	1								1	0%	0	0	0
CH	Argonne National Laboratory - West	1								1	0%	0	0	0
	Totals	**2,555**	**1,023**	**97**	**17**	**0**	**0**	**0**	**0**	**3,692**	**31%**	**1,137**	**48.881**	**0.043**

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

Savannah River and Idaho contribute 80% of the collective dose for this facility type. The 7% decrease in the collective dose between 2001 and 2002 is primarily due to the 29% decrease at Savannah River.

Exhibit B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 2002

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	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
OH	Battelle Memorial Institute - Columbus	216	36	8	17	16	16	10				319	32%	103	44.363	**0.431** ◄
RL	Fluor Daniel Northwest Services	46	23	14	10	2	1					96	52%	50	9.009	0.180
AL	Los Alamos National Laboratory	1,008	187	46	27	14	3	3				1,288	22%	280	38.066	0.136
RL	Fluor Daniel - Hanford	2,027	996	242	123	50	28	12				**3,478** ◄	42%	**1,451** ◄	**182.904** ◄	0.126
ID	Bechtel BWXT Idaho - Services	339	148	17	17							521	35%	182	12.038	0.066
AL	Johnson Controls, Inc.	1,362	125	36	6							1,529	11%	167	10.317	0.062
SR	Westinghouse Savannah River Co.	303	165	44	1							513	41%	210	11.299	0.054
RL	SGN Eurisys Services Corp	6	2									8	25%	2	0.097	0.049
RL	Duke Engineering Services Hanford	11	2									13	15%	2	0.092	0.046
CH	Brookhaven National Laboratory	736	60	4	2							802	8%	66	2.427	0.037
ID	Bechtel BWXT Idaho - Construction	12	7									19	37%	7	0.232	0.033
RL	Hanford Security	98	19	1	1							119	18%	21	0.688	0.033
RL	Fluor Daniel Northwest	47	21									68	31%	21	0.676	0.032
SR	Bechtel Construction - SR	48	18									66	27%	18	0.579	0.032
NV	Bechtel Nevada - NTS	3,054	30									3,084	1%	30	0.915	0.031
CH	Argonne National Laboratory - East	372	3									375	1%	3	0.075	0.025
OH	Ohio Field Office	12	1									13	8%	1	0.024	0.024
RL	Environmental Restoration Contr. (ERC)	19	1									20	5%	1	0.023	0.023
RL	Rust Services Hanford	61	5									66	8%	5	0.113	0.023
SR	Wackenhut Services, Inc. - SR	8	1									9	11%	1	0.018	0.018
AL	Sandia National Laboratory	600	13									613	2%	13	0.221	0.017
OH	West Valley Nuclear Services, Inc.		1									1	**100%** ◄	1	0.017	0.017
RL	Battelle Memorial Institute (PNL)	23	1									24	4%	1	0.017	0.017
OH	BWX Technologies, Inc.	256	91	2								349	27%	93	1.312	0.014

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

Exhibit B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 2002 (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	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
OH	BWX Technologies, Inc.-Security Forces	27	1									28	4%	1	0.013	0.013
OH	BWX Technologies, Inc.-Subcontractors	151	45	1								197	23%	46	0.539	0.012
SR	Westinghouse S.R. Subcontractors	27	2									29	7%	2	0.023	0.012
AL	Protection Technologies Los Alamos	496	39									535	7%	39	0.431	0.011
AL	Los Alamos Area Office	46	5									51	10%	5	0.036	0.007
RL	Lockheed Martin Info Tech (LMIT)	20	2									22	9%	2	0.014	0.007
RL	Numatec Hanford	37	1									38	3%	1	0.004	0.004
NV	B.N. - NTS Subcontractors	1										1	0%	0	0	0
NV	B.N.-Washington Aerial Meas.	14										14	0%	0	0	0
NV	Nevada Miscellaneous Contractors	123										123	0%	0	0	0
NV	Nevada Operations	419										419	0%	0	0	0
NV	Nye County Sheriff	4										4	0%	0	0	0
NV	Science Applications Intl. Corp.-NV	10										10	0%	0	0	0
NV	Wackenhut Services, Inc. - NV	204										204	0%	0	0	0
OH	MEMP Office Subs	8										8	0%	0	0	0
OH	Miamisburg Env Mgmt Proj Office	14										14	0%	0	0	0
RL	CH2M Hill Hanford Group	3										3	0%	0	0	0
RL	Richland Field Office	11										11	0%	0	0	0
RL	Rust Federal Services Northwest	16										16	0%	0	0	0
RL	Verizon/Qwest	2										2	0%	0	0	0
SR	Savannah River Field Office	3										3	0%	0	0	0
SR	Univ. of Georgia Ecology Laboratory	1										1	0%	0	0	0
	Totals	**12,301**	**2,051**	**415**	**204**	**82**	**48**	**25**	**0**	**0**	**0**	**15,126**	**19%**	**2,825**	**316.582**	**0.112**

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

The collective dose for Maintenance and Support increased by 26% from 2001 to 2002. Fluor Daniel at Hanford has reported the largest collective dose for this facility type for the past 6 years. Battelle Memorial Institute (BMI) in Columbus has the highest average measurable dose in this category for the past 5 years and reported the highest average measurable dose for any organization in 2002. BMI-Columbus is involved in decontamination and remediation of facilities formerly dedicated to nuclear research and development for DOE.

Exhibit B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Reactor Facilities, 2002

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)**
AL	Sandia National Laboratory	51	8	6	2					67	24%	16	2.066	**0.129◄**
ID	Bechtel BWXT Idaho - Services	218	163	50	17	1	1			450	52%	**232◄**	**21.227◄**	0.091
ID	Bechtel BWXT Idaho - Construction	4	19			2				25	84%	21	1.583	0.075
SR	Bechtel Construction - SR	53	15	2						70	24%	17	0.751	0.044
CH	Brookhaven National Laboratory	91	8	2						101	10%	10	0.429	0.043
SR	Westinghouse Savannah River Co.	538	133	2						**673◄**	20%	135	2.704	0.020
CH	Argonne National Laboratory - West		1							1	**100%◄**	1	0.016	0.016
SR	Wackenhut Services, Inc. - SR	112	35							147	24%	35	0.492	0.014
SR	Savannah River Field Office	23	1							24	4%	1	0.013	0.013
AL	Los Alamos National Laboratory	3	1							4	25%	1	0.007	0.007
SR	Miscellaneous DOE Contractors - SR		1							1	**100%◄**	1	0.007	0.007
RL	Battelle Memorial Institute (PNL)	1								1	0%	0	0.000	0.000
RL	Environmental Restoration Contr. (ERC)	1								1	0%	0	0.000	0.000
SR	Westinghouse S.R. Subcontractors	14								14	0%	0	0.000	0.000
	Totals	**1,109**	**385**	**62**	**19**	**3**	**1**	**0**	**0**	**1,579**	**30%**	**470**	**29.295**	**0.062**

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

The collective dose for Reactor facilities decreased by 28% from 2001 to 2002. Bechtel BWXT Idaho Services continues to report the majority (72%) of collective dose for this facility type in 2002 and experienced a 17% decrease from 2001 to 2002.

Exhibit B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 2002

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	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
CH	Argonne National Laboratory - East	1,671	37	10	4	1		6				1,729	3%	58	12.681	**0.219** ◄
OAK	Lawrence Livermore National Lab.	8,320	112	20	10	5	5	7				**8,479** ◄	2%	159	27.880	0.175
AL	Los Alamos National Laboratory	1,241	272	57	30	15	1	5				1,621	23%	**380** ◄	**43.427** ◄	0.114
CH	Argonne National Laboratory - West	433	203	48	23	3						710	39%	277	24.932	0.090
RL	Battelle Memorial Institute (PNL)	527	125	12	11	2	2					679	22%	152	12.389	0.082
OR	UT-Battelle: ORNL	5,641	273	55	22	4						5,995	6%	354	27.046	0.076
SR	Westinghouse Savannah River Co.	645	238	39	4							926	30%	281	12.407	0.044
AL	Sandia National Laboratory	398	16	3								417	5%	19	0.811	0.043
ID	Bechtel BWXT Idaho - Services	787	120	13	3							923	15%	136	5.710	0.042
CH	Brookhaven National Laboratory	578	58	3	2	1						642	10%	64	2.586	0.040
OAK	Boeing, Rocketdyne -ETEC	89	72	5	3	1						170	48%	81	3.220	0.040
OAK	LLNL Subcontractors	659	3									662	0%	3	0.098	0.033
OAK	Lawrence Berkeley National Lab.	1,045	29	1								1,075	3%	30	0.843	0.028
ID	Bechtel BWXT Idaho - Construction	36	11									47	23%	11	0.249	0.023
SR	Westinghouse S.R. Subcontractors	30	11	1								42	29%	12	0.266	0.022
SR	Bechtel Construction - SR	61	26									87	30%	26	0.557	0.021

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

Exhibit B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, General, 2002 (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	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
OAK	Lawrence Livermore Nat'l Lab.-NV	360	1									361	0%	1	0.019	0.019
AL	Johnson Controls, Inc.	6	1									7	14%	1	0.014	0.014
SR	Savannah River Field Office	39	15									54	28%	15	0.168	0.011
SR	Univ. of Georgia Ecology Laboratory	23	4									27	15%	4	0.044	0.011
SR	Wackenhut Services, Inc. - SR	27	7									34	21%	7	0.062	0.009
CH	Ames Laboratory (Iowa State)	126	9									135	7%	9	0.076	0.008
CH	Chicago Office Subs	8	23									31	**74%** ◄	23	0.141	0.006
OR	Oak Ridge Inst. For Sci. & Educ. (ORISE)	30	69									99	70%	69	0.274	0.004
AL	Los Alamos Area Office	2										2	0%	0	0	0
AL	Nat. Renewable Energy Lab (NREL)-GO	20										20	0%	0	0	0
AL	Protection Technologies Los Alamos	8										8	0%	0	0	0
CH	Chicago Operations Office	37										37	0%	0	0	0
CH	New Brunswick Laboratory - Research	32										32	0%	0	0	0
OR	Wackenhut Services	66										66	0%	0	0	0
SR	Miscellaneous Doe Contractors - SR	1										1	0%	0	0	0
	Total	**22,946**	**1,735**	**267**	**112**	**32**	**8**	**18**	**0**	**0**	**0**	**25,118**	**9%**	**2,172**	**175.900**	**0.081**

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

LANL was the largest contributor to the collective dose in this category in 2002. The collective dose at LANL for Research facilities increased by 17%, which is consistent with the site's overall increase in collective dose of 45% from 2001 to 2002.

Exhibit B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research, Fusion, 2002

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)
AL	Los Alamos National Laboratory	36	6		1					43	16%	7	0.590	**0.084** ◄
CH	Princeton Plasma Physics Laboratory	281	130	15						**426** ◄	**34%** ◄	**145** ◄	**3.707** ◄	0.026
CH	Chicago Operations Office	8	1							9	11%	1	0.002	0.002
AL	Sandia National Laboratory	36								36	0%	0	0	0
	Totals	**361**	**137**	**15**	**1**	**0**	**0**	**0**	**0**	**514**	**30%**	**153**	**4.299**	**0.028**

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

With only four organizations reporting in this category, Princeton Plasma Physics Lab accounts for 86% of the collective dose and 83% of the monitored individuals.

Exhibit B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 2002

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)
AL	Los Alamos National Laboratory	74	11	2	1		1			89	17%	15	1.781	**0.119** ◄
ID	Bechtel BWXT Idaho - Services	208	83	33	11					335	38%	127	12.160	0.096
AL	Johnson Controls, Inc.		1							1	**100%** ◄	1	0.081	0.081
CH	Argonne National Laboratory - East	43	33	12	1					89	52%	46	3.260	0.071
RL	CH2M Hill Hanford Group	856	289	52	17					1,214	29%	358	23.874	0.067
SR	Westinghouse Savannah River Co.	1,313	706	94	54	1				**2,168** ◄	39%	**855** ◄	**51.845** ◄	0.061
CH	Brookhaven National Laboratory	92	29	3						124	26%	32	1.560	0.049
RL	Fluor Daniel - Hanford	2	1							3	33%	1	0.048	0.048
SR	Bechtel Construction - SR	169	211	25	5					410	59%	241	11.292	0.047
ID	BNFL - Idaho	147	31	2						180	18%	33	0.892	0.027
AL	Carlsbad Area Misc. Contractors	490	89							579	15%	89	2.298	0.026
SR	Wackenhut Services, Inc. - SR	5	1							6	17%	1	0.022	0.022

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

Exhibit B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing, 2002 (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)**
AL	Sandia National Laboratory	134	7							141	5%	7	0.137	0.020
ID	Bechtel BWXT Idaho - Construction	86	17							103	17%	17	0.330	0.019
SR	Westinghouse S.R. Subcontractors	98	46							144	32%	46	0.670	0.015
RL	Environmental Restoration Contr. (ERC)	4	1							5	20%	1	0.014	0.014
SR	Savannah River Field Office	47	5							52	10%	5	0.056	0.011
AL	Los Alamos Area Office	1								1	0%	0	0	0
AL	Waste Isolation Pilot Project (WIPP)	24								24	0%	0	0	0
RL	Bechtel National Inc - WTP	1								1	0%	0	0	0
RL	Battelle Memorial Institute (PNL)	1								1	0%	0	0	0
RL	SGN Eurisys Services Corp	1								1	0%	0	0	0
SR	Miscellaneous DOE Contractors - SR	6								6	0%	0	0	0
	Totals	**3,802**	**1,561**	**223**	**89**	**1**	**1**	**0**	**0**	**5,677**	**33%**	**1,875**	**110.320**	**0.059**

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

Westinghouse Savannah River Co. (WSRC) was the largest contributor (47%) of the collective dose in Waste Processing for 2002. The collective dose for WSRC increased by 20% from 2001 to 2002.

Exhibit B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Weapons Fabrication, 2002

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	0.75-1.0	1.0-2.0	2.0-3.0	>3	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)
SR	Westinghouse Savannah River Co.	238	112	47	49	22	14	3			485	51%	247	57.896	**0.234** ◄
AL	BWXT- Amarillo	4,906	156	62	47	24					**5,195** ◄	6%	289	47.228	0.163
RFO	Rocky Flats Prime Contractors	991	896	319	186	56	10	11			2,469	60%	**1,478** ◄	**206.310** ◄	0.140
SR	Wackenhut Services, Inc. - SR	55	21	77							153	64%	98	13.185	0.135
RFO	Rocky Flats Subcontractors	1,659	547	86	19	9	1				2,321	29%	662	42.786	0.065
SR	Bechtel Construction - SR	30	54	12	1						97	**69%** ◄	67	3.900	0.058
OR	BWXT, Y-12	3,431	1,308	142	24	1					4,906	30%	1,475	62.795	0.043
AL	Sandia National Laboratory	596	21	2							619	4%	23	0.629	0.027
RFO	Rocky Flats Office	297	35								332	11%	35	0.872	0.025
AL	Amarillo Area Office	77	3								80	4%	3	0.067	0.022
AL	Albuquerque Operations Office	123	2								125	2%	2	0.034	0.017
OH	BWX Technologies, Inc.	66	42								108	39%	42	0.728	0.017
AL	Los Alamos National Laboratory	7	1								8	13%	1	0.010	0.010
OH	BWX Technologies, Inc.-Subcont.	59	16								75	21%	16	0.154	0.010
OH	Miamisburg Env. Mgmt. Proj. Office	5	2								7	29%	2	0.003	0.002
AL	BWXT- Amarillo - Subcontractors	47									47	0%	0	0	0
AL	BWXT- Amarillo-Security Forces	1									1	0%	0	0	0
AL	Kirtland Area Office	1									1	0%	0	0	0
OH	MEMP Office Subs	2									2	0%	0	0	0
OH	Ohio Field Office	2									2	0%	0	0	0
SR	Savannah River Field Office	21									21	0%	0	0	0
SR	Westinghouse S.R. Subcontractors	8									8	0%	0	0	0
	Totals	**12,622**	**3,216**	**747**	**326**	**112**	**25**	**14**	**0**	**0**	**17,062**	**26%**	**4,440**	**436.597**	**0.098**

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

Rocky Flats and Westinghouse Savannah River Co. account for the majority (61%) of the collective dose for this facility type in 2002. It should be noted that these sites are no longer active in Weapons Fabrication and Testing and are now involved in nuclear materials stabilization and waste management. The collective dose increased by 6% in this category from 2001 to 2002 due to increases at Rocky Flats, Amarillo, and Y-12.

Exhibit B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2002

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)**
RL	Fluor Daniel Northwest Services	89	64	56	23	9				241	63%	152	25.534	**0.168** ◄
ID	Stoller Svc Subs - Grand Junction	9	3	8		1				21	57%	12	1.991	0.166
ID	Bechtel BWXT Idaho - Construction			1						1	**100%** ◄	1	0.156	0.156
RL	Rust Services Hanford	39	2	1	1					43	9%	4	0.586	0.147
CH	Environmental Meas. Lab. - Research	15	3			1				19	21%	4	0.567	0.142
OH	West Valley Nuclear Services, Inc.	538	165	27	34	11	1			776	31%	238	30.513	0.128
RL	CH2M Hill Hanford Group	150	7	1	3					161	7%	11	1.187	0.108
AL	Los Alamos National Laboratory	4,266	481	58	27	11	7	8	1	**4,859** ◄	12%	**593** ◄	**54.297** ◄	0.092
RL	Battelle Memorial Institute (PNL)	1,024	42	9	8					1,083	5%	59	5.284	0.090
CH	Brookhaven National Laboratory	74	7	3	1					85	13%	11	0.807	0.073
AL	Johnson Controls, Inc.	51	5	2						58	12%	7	0.385	0.055
RL	Environmental Restoration Contr. (ERC)	922	114	24	1					1,061	13%	139	7.657	0.055
RL	SGN Eurisys Services Corp.	65	10	2						77	16%	12	0.646	0.054
SR	Bechtel Construction - SR	25	7	1						33	24%	8	0.384	0.048
SR	Wackenhut Services, Inc. - SR	12	1							13	8%	1	0.032	0.032
ID	Idaho Field Office	26	6							32	19%	6	0.187	0.031

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

Exhibit B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2002 (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)
RL	Fluor Daniel Northwest	156	30	3						189	17%	33	0.980	0.030
RL	Hanford Security	34	17							51	33%	17	0.372	0.022
SR	Savannah River Field Office	7	2							9	22%	2	0.042	0.021
SR	Westinghouse Savannah River Co.	263	26	1						290	9%	27	0.554	0.021
RL	Richland Field Office	825	39							864	5%	39	0.779	0.020
RL	Rust Federal Services Northwest	54	5							59	8%	5	0.101	0.020
RL	Fluor Daniel - Hanford	785	66	1						852	8%	67	1.266	0.019
AL	Sandia National Laboratory	655	23							678	3%	23	0.409	0.018
AL	Protection Technologies Los Alamos	61	7							68	10%	7	0.116	0.017
ID	Bechtel BWXT Idaho - Services	956	20							976	2%	20	0.252	0.013
OH	RMI Environmental Services	282	46							328	14%	46	0.560	0.012
RL	Hanford Environ. Health Foundation	35	1							36	3%	1	0.012	0.012
RL	Duke Engineering Services Hanford	3	1							4	25%	1	0.011	0.011
SR	Miscellaneous DOE Contractors - SR	2	1							3	33%	1	0.007	0.007
AL	Honeywell, Federal Mfg. & Technol.	48	24							72	33%	24	0.127	0.005
RL	NUMATEC Hanford	18	1							19	5%	1	0.004	0.004

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

Exhibit B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 2002 (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)
AL	Kansas City Area Office	6	3							9	33%	3	0.010	0.003
RL	Lockheed Martin Info Tech (LMIT)	18	1							19	5%	1	0.003	0.003
AL	BWXT - Amarillo	53								53	0%	0	0	0
AL	Los Alamos Area Office	13								13	0%	0	0	0
HQ	DOE Headquarters	16								16	0%	0	0	0
HQ	Russian Federation Project - DOE HQ	8								8	0%	0	0	0
NV	Bechtel Nevada - NTS	50								50	0%	0	0	0
OAK	LLNL Subcontractors	1								1	0%	0	0	0
OAK	Lawrence Livermore National Lab.	14								14	0%	0	0	0
OAK	U. of Cal./Davis, Radiobiology Lab-LEHR	6								6	0%	0	0	0
OH	BWX Technologies, Inc.	9								9	0%	0	0	0
RL	Bechtel National Inc - WTP	1								1	0%	0	0	0
RL	Verizon/Qwest	19								19	0%	0	0	0
SR	Southern Bell Tel. & Tel.	1								1	0%	0	0	0
SR	Westinghouse S.R. Subcontractors	7								7	0%	0	0	0
	Totals	**11,711**	**1,230**	**198**	**98**	**33**	**8**	**8**	**1**	**13,287**	**12%**	**1,576**	**135.818**	**0.086**

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

The collective dose to "Other" facilities increased by 48% from 2001 to 2002 primarily due to a 99% increase at LANL. Increased dose at LANL was attributed to increased work on pit manufacturing, Pu-238 fuel and heat source work, nuclear material processing, nuclear materials science, pit disassembly, and associated support.

Exhibit B-17: Internal Dose by Facility Type and Nuclide, 2000-2002

Facility Type	Nuclide*	No. of Individuals with New Intakes**			Collective CEDE (person-rem)			Average CEDE (rem)		
		2000	2001	2002	2000	2001	2002	2000	2001	2002
Accelerator	Americium	1		1	0.015		0.002	0.015		0.002
	Hydrogen-3	3	5	3	0.092	0.074	0.057	0.031	0.015	0.019
	Uranium	2	2	3	0.009	0.014	0.031	0.005	0.007	0.010
	Total	**6**	**7**	**7**	**0.116**	**0.088**	**0.090**	**0.019**	**0.013**	**0.013**
Fuel Fabrication	Thorium	46	10	16	3.376	0.046	0.110	0.073	0.005	0.007
	Uranium	14	10	8	0.074	0.047	0.052	0.005	0.005	0.007
	Total	**60**	**20**	**24**	**3.45**	**0.093**	**0.162**	**0.058**	**0.005**	**0.007**
Fuel Processing	Americium		4			1.543			**0.386** ◄	
	Hydrogen-3	93	79	77	0.194	0.238	0.208	0.002	0.003	0.003
	Plutonium	1	3	5	0.011	0.286	0.082	0.001	0.095	0.016
	Total	**94**	**86**	**82**	**0.205**	**2.067**	**0.290**	**0.002**	**0.024**	**0.004**
Fuel/Uranium Enrichment	Americium			3			0.027			0.009
	Mixed and Other	1	3	3	0.017	0.103	0.041	0.017	0.034	0.014
	Thorium	7	1	3	0.159	0.002	0.017	0.023	0.002	0.006
	Plutonium			1			0.009			0.009
	Uranium	308	397	222	0.929	1.712	1.677	0.003	0.004	0.008
	Total	**316**	**401**	**232**	**1.105**	**1.817**	**1.771**	**0.003**	**0.005**	**0.008**
Maintenance and Support	Americium	6	8	23	0.104	0.069	0.117	0.017	0.009	0.005
	Hydrogen-3	55	58	88	0.142	0.135	0.313	0.003	0.002	0.004
	Mixed and Other	13		29	0.082		0.224	0.006		0.008
	Plutonium	25	55	108	**87.224** ◄	0.674	0.961	**3.489** ◄	0.012	0.009
	Radon-222			3			0.173			0.058
	Thorium	9	2	23	0.303	0.058	0.485	0.034	0.029	0.021
	Uranium	43	14	28	0.103	0.102	0.176	0.002	0.007	0.006
	Total	**151**	**137**	**302**	**87.958**	**1.038**	**2.449**	**0.583**	**0.008**	**0.008**
Other	Americium	5	2	15	0.262	0.032	0.715	0.052	0.016	0.048
	Hydrogen-3	31	27	21	0.119	0.111	0.147	0.004	0.004	0.007
	Mixed and Other	2	2		0.191	0.002		0.096	0.001	
	Plutonium	10	8	39	1.229	0.772	0.760	0.123	0.097	0.019
	Radon-222	2	2	12	0.020	0.076	1.942	0.010	0.038	**0.162** ◄
	Uranium	42	42	30	0.409	0.413	0.225	0.010	0.010	0.008
	Total	**92**	**83**	**117**	**2.230**	**1.406**	**3.789**	**0.024**	**0.017**	**0.032**
Reactor	Hydrogen-3	136	43	17	0.761	0.101	0.025	0.006	0.002	0.001
	Plutonium			1			0.022			0.022
	Total	**136**	**43**	**18**	**0.761**	**0.101**	**0.047**	**0.006**	**0.002**	**0.003**
Research, Fusion	Hydrogen-3	3	14	10	0.008	0.051	0.061	0.003	0.004	0.006
	Total	**3**	**14**	**10**	**0.008**	**0.051**	**0.061**	**0.003**	**0.004**	**0.006**
Research, General	Americium	6	1	3	0.129	0.002	0.098	0.022	0.002	0.033
	Hydrogen-3	37	60	24	0.602	0.383	0.329	0.016	0.006	0.014
	Mixed & Other	13	10	4	0.046	0.043	0.017	0.004	0.004	0.004
	Plutonium	8	10	10	21.108	2.399	1.614	2.639	0.240	0.161
	Radon-222	2			0.098			0.049		
	Uranium	22	25	26	0.096	0.172	0.711	0.004	0.007	0.027
	Total	**88**	**106**	**67**	**22.079**	**2.999**	**2.769**	**0.251**	**0.028**	**0.041**
Waste Processing	Americium	16	12	13	0.479	0.130	0.257	0.030	0.011	0.020
	Hydrogen-3	9	9		0.016	0.026		0.002	0.003	
	Mixed and Other		1			0.003			0.003	
	Plutonium	3	12	9	0.050	0.615	0.299	0.017	0.051	0.033
	Thorium		1			0.005			0.005	
	Uranium			1			0.016			0.016
	Total	**28**	**35**	**23**	**0.545**	**0.779**	**0.572**	**0.019**	**0.022**	**0.025**
Weapons Fab. and Testing	Americium		1	7		0.001	0.010		0.001	0.001
	Hydrogen-3	27	20	30	0.105	0.070	0.211	0.004	0.004	0.007
	Mixed and Other	1	3	3	0.014	0.221	0.050	0.014	0.074	0.017
	Plutonium	76	49	125	3.398	3.512	3.121	0.045	0.072	0.025
	Thorium		9	25		0.093	0.224		0.010	0.009
	Uranium	**1,199** ◄	**1,348** ◄	**1,346** ◄	58.606	**44.618** ◄	**53.074** ◄	0.049	0.033	0.039
	Total	**1,303**	**1,430**	**1,536**	**62.123**	**48.515**	**56.690**	**0.048**	**0.034**	**0.037**
	Totals	**2,277**	**2,362**	**2,418**	**180.580**	**58.954**	**68.690**	**0.079**	**0.025**	**0.028**

* 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.

Uranium intakes at Weapons Fabrication and Testing facilities account for the 17% increase in the collective CEDE from 2001 to 2002. The Oak Ridge Y-12 facility accounts for the increase due to intakes resulting from activities at the Enriched Uranium Operations facility.

Exhibit B-18a: Distribution of TEDE by Labor Category - 2000

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	56	1										57	2%	1	0.035	0.035
Construction	3,729	1,203	117	34	13	5	3					5,104	27%	1,375	73.837	0.054
Laborers	720	228	40	12		1						1,001	28%	281	17.825	0.063
Management	10,392	1,452	134	35	5	1	1					12,020	14%	1,628	74.672	0.046
Miscellaneous	4,823	1,207	207	83	34	20	12					6,386	24%	1,563	147.378	0.094
Production	2,747	1,520	354	212	61	38	29					4,961	**45%** ◀	2,214	284.647	**0.129** ◀
Scientists	22,880	2,754	176	50	15	3	3					25,881	12%	**3,001** ◀	114.503	0.038
Service	3,629	588	60	8	2							4,287	15%	658	27.101	0.041
Technicians	5,551	1,848	574	213	61	20	7					8,274	33%	2,723	**290.474** ◀	0.107
Transport	1,091	103	8	1								1,203	9%	112	4.622	0.041
Unknown	31,280	2,116	203	79	20	3	3				3	**33,707** ◀	7%	2,427	231.440	0.095
Totals	**86,898**	**13,020**	**1,873**	**727**	**211**	**91**	**58**	**0**	**0**	**0**	**3**	**102,881**	**16%**	**15,983**	**1,266.534**	**0.079**

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

Exhibit B-18b: Distribution of TEDE by Labor Category - 2001

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	44											44	0%	0	0	0
Construction	3,823	1,569	164	76	12	3	1					5,648	32%	1,825	98.676	0.054
Laborers	731	304	68	55	7							1,165	37%	434	44.593	0.103
Management	7,956	1,200	135	22	10		1					9,324	15%	1,368	64.666	0.047
Miscellaneous	4,932	1,340	199	88	28	11	1					6,599	25%	1,667	125.918	0.076
Production	2,666	1,601	345	208	86	38	18					4,962	**46%** ◄	2,296	283.679	**0.124** ◄
Scientists	23,850	2,735	169	47	11	8	8					26,828	11%	**2,978** ◄	125.279	0.042
Service	3,556	658	33	15	3	1						4,266	17%	710	29.181	0.041
Technicians	7,214	1,994	558	218	59	21	15					10,079	28%	2,865	**301.460** ◄	0.105
Transport	904	165	7	9	2							1,087	17%	183	9.337	0.051
Unknown	25,455	1,993	213	102	41	7	4	1				**27,816** ◄	8%	2,361	149.601	0.063
Totals	**81,131**	**13,559**	**1,891**	**840**	**259**	**89**	**48**	**1**	**0**	**0**	**0**	**97,818**	**17%**	**16,687**	**1,232.390**	**0.074**

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

Exhibit B-18c: Distribution of TEDE by Labor Category - 2002

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	95	1										96	1%	1	0.012	0.012
Construction	4,278	1,616	247	68	11	6	1					6,227	31%	1,949	118.805	0.061
Laborers	1,070	462	98	36	9							1,675	36%	605	45.835	0.076
Management	8,083	1,199	132	49	8	4						9,475	15%	1,392	75.608	0.054
Miscellaneous	4,478	1,155	201	123	42	3	3					6,005	25%	1,527	142.222	0.093
Production	2,744	1,681	378	211	90	37	22					5,163	**47%** ◄	2,419	306.094	**0.127** ◄
Scientists	23,493	2,656	150	70	19	8	5					26,401	11%	2,908	130.564	0.045
Service	3,945	499	114	17	1							4,576	14%	631	33.386	0.053
Technicians	7,554	2,025	622	219	48	24	18					10,510	28%	**2,956** ◄	**313.335** ◄	0.106
Transport	1,038	214	23	8								1,283	19%	245	10.558	0.043
Unknown	26,392	1,992	237	118	41	13	16	1				**28,810** ◄	8%	2,418	183.158	0.076
Totals	**83,170**	**13,500**	**2,202**	**919**	**269**	**95**	**65**	**1**	**0**	**0**	**0**	**100,221**	**17%**	**17,051**	**1,359.577**	**0.080**

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

Similar to prior years, Production and Technician personnel received the highest collective dose of any labor category and accounted for 46% of the collective dose at DOE for 2002.

Exhibit B-19: Internal Dose by Labor Category, 2000-2002

Labor Category	Number of Individuals with New Intakes*			Collective CEDE (person-rem)			Average CEDE (rem)		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
Construction	453	502	396	8.269	7.905	8.059	0.018	0.016	0.020
Laborers	37	36	62	2.005	2.751	3.885	0.054	**0.076** ◀	**0.063** ◀
Management	182	216	216	7.565	7.242	7.270	0.042	0.034	0.034
Miscellaneous	88	61	80	2.077	1.104	2.812	0.024	0.018	0.035
Production	**541** ◀	**551** ◀	**564** ◀	23.883	**17.219** ◀	**23.327** ◀	0.044	0.031	0.041
Scientists	254	263	239	7.543	5.310	5.259	0.030	0.020	0.022
Service	56	27	33	1.828	0.643	0.545	0.033	0.024	0.017
Technicians	269	295	293	11.727	8.781	8.053	0.044	0.030	0.027
Transport	2	3	8	0.008	0.024	0.026	0.004	0.008	0.003
Unknown	395	408	527	**115.675** ◀	7.975	9.454	**0.293** ◀	0.020	0.018
Totals	**2,277**	**2,362**	**2,418**	**180.580**	**58.954**	**68.690**	**0.079**	**0.025**	**0.028**

* 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.

For the second year, Production personnel received the largest percentage of the collective CEDE (34%). The high collective CEDE for the Unknown category that occurred in 2000 was due to three internal doses above 5 rem (50 mSv) at LANL.

Exhibit B-20: Dose Distribution by Labor Category and Occupation - 2002

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	4-5	>5	Total Monitored	Percent with Meas.	No. with Meas.	Collective TEDE	Average Meas. TEDE
Agriculture	Groundskeepers	95	1										96	1%	1	0.012	0.012
Construction	Carpenters	277	115	12	4								408	32%	131	6.980	0.053
	Electricians	1,009	445	58	9	3	2						1,526	34%	517	27.799	0.054
	Masons	23	11	1									35	34%	12	0.466	0.039
	Mechanics/Repairers	714	279	38	8	2	2	1					1,044	32%	330	20.574	0.062
	Miners/Drillers	53	6										59	10%	6	0.079	0.013
	Misc. Repair/Construction	1,625	475	65	18	2	2						2,187	26%	562	30.979	0.055
	Painters	133	50	8	3								194	31%	61	3.364	0.055
	Pipe Fitters	444	235	66	25	4							774	43%	330	28.564	0.087
Laborers	Handlers/Laborers/Helpers	1,070	462	98	36	9							1,675	36%	605	45.835	0.076
Management	Admin. Support and Clerical	3,125	410	53	25								3,613	14%	488	27.408	0.056
	Manager - Administrator	4,944	789	79	24	8	4						5,848	15%	904	48.200	0.053
	Sales	14											14	0%			
Miscellaneous	Military	1											1	0%			
	Miscellaneous	4,477	1,155	201	123	42	3	3					6,004	25%	1,527	142.222	0.093
Production	Machine Setup/Operators	122	203	40	4								369	**67%** ◄	247	14.517	0.059
	Machinists	292	39	4	1	1	2						339	14%	47	5.914	0.126
	Misc. Precision/Production	760	272	82	43	11	5	8					1,181	36%	421	56.456	0.134
	Operators, Plant/System/Utili	1,361	1,071	244	161	78	31	12					2,958	54%	1,597	**224.033** ◄	**0.140** ◄
	Sheet Metal Workers	127	66	4	3								200	37%	73	3.836	0.053
	Welders and Solderers	82	30	4									116	29%	34	1.338	0.039
Scientists	Doctors and Nurses	116	14										130	11%	14	0.261	0.019
	Engineer	8,539	1,172	54	23	3	1						9,792	13%	1,253	42.973	0.034
	Health Physicist	487	127	11	6	3	1						635	23%	148	9.653	0.065
	Misc. Professional	5,333	804	45	29	9	4						6,224	14%	891	43.080	0.048
	Scientist	9,018	539	40	12	4	2	5					9,620	6%	602	34.597	0.057
Service	Firefighters	469	63		1								533	12%	64	1.245	0.019
	Food Service Employees	28	2	1	1								32	13%	4	0.485	0.121
	Janitors	669	48	11	8	1							737	9%	68	6.509	0.096
	Misc. Service	562	99	17	4								682	18%	120	5.871	0.049
	Security Guards	2,217	287	85	3								2,592	14%	375	19.276	0.051
Technicians	Engineering Technicians	2,269	191	43	10	5	1	3					2,522	10%	253	23.649	0.093
	Health Technicians	94	48	7	3	2	2	1					157	40%	63	7.696	0.122
	Misc. Technicians	2,385	341	90	35	7	12	9					2,879	17%	494	61.348	0.124
	Radiation Monitors/Techs.	1,292	953	352	135	23	4	4					2,763	53%	1,471	158.931	0.108
	Science Technicians	613	135	23	12	5	3						791	23%	178	18.730	0.105
	Technicians	901	357	107	24	6	2	1					1,398	36%	497	42.981	0.086
Transport	Bus Drivers	12	4										16	25%	4	0.124	0.031
	Equipment Operators	271	125	21	7								424	36%	153	8.236	0.054
	Misc. Transport	438	39	2									479	9%	41	1.037	0.025
	Pilots	1											1	0%			
	Truck Drivers	316	46		1								363	13%	47	1.161	0.025
Unknown	Unknown	26,392	1,992	237	118	41	13	16	1				**28,810** ◄	8%	**2,418** ◄	183.158	0.076
Totals		**83,170**	**13,500**	**2,203**	**919**	**269**	**96**	**63**	**1**	**0**	**0**	**0**	**100,221**	**17%**	**17,051**	**1,359.577**	**0.080**

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

Plant Operators received the highest percentage of the collective dose and average measurable dose in 2002, which was also true in 2001. The large number of monitored individuals reported as "Unknown" are reported by LANL because they do not have the capability at this time to report occupation codes for each worker.

Exhibit B-21: Internal Dose Distribution by Site and Nuclide - 2002

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. -0.02	0.02-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.0-2.0	>2.0			
Albuquerque	Los Alamos National Lab (LANL)	Hydrogen-3	45	7							52	0.454	0.009
		Plutonium	1	9	4	1	1				16	2.080	0.130
		Other	1								1	0.001	0.001
		Uranium	34	6	2						42	0.665	0.016
	Pantex Plant	Thorium	20	2							22	0.187	0.009
		Uranium	5	2							7	0.069	0.010
		Mixed		1							1	0.048	0.048
Chicago	Ops. and Other Facilities	Hydrogen-3	8								8	0.028	0.004
	Argonne Nat'l. Lab.-East (ANL-E)	Americium	4	2							6	0.139	0.023
		Plutonium	2	9							11	0.452	0.041
	Argonne Nat'l. Lab.-West (ANL-W)	Other	1								1	0.002	0.002
		Plutonium	1								1	0.011	0.011
	Brookhaven National Lab (BNL)	Americium	13	3							16	0.241	0.015
		Uranium	1	1							2	0.061	0.031
Idaho	Idaho Site	Plutonim	4	1							5	0.082	0.016
		Radon-222		3	8		1				12	1.942	**0.162** ◄
		Uranium	3	2							5	0.117	0.023
Oakland	Lawrence Berkeley Nat'l. Lab. (LBNL)	Hydrogen-3	5	4							9	0.165	0.018
	Lawrence Livermore Nat'l. Lab. (LLNL)	Hydrogen-3	2								2	0.007	0.004
Oak Ridge	Oak Ridge Site	Americium	1								1	0.004	0.004
		Hydrogen-3	1								1	0.003	0.003
		Other	1								1	0.001	0.001
		Plutonium	1								1	0.009	0.009
		Thorium	1								1	0.012	0.012
		Uranium	826	605	108	15					**1,554** ◄	**54.624** ◄	0.035
	Paducah	Americium	3								3	0.027	0.009
		Mixed	2	1							3	0.041	0.014
		Uranium	4								4	0.036	0.009
	Portsmouth	Thorium	2								2	0.005	0.003
		Uranium	2								2	0.021	0.011
Ohio	Ops. and Other Facilities	Hydrogen-3	2								2	0.003	0.002
		Plutonium	1	1							2	0.024	0.012
		Uranium	23	1							24	0.161	0.007
	Battelle Memorial Inst. - Columbus	Mixed	2								2	0.003	0.002
		Plutonium	33								33	0.080	0.002
	Fernald Environ. Mgmt. Project	Thorium	15	1							16	0.110	0.007
		Uranium	8								8	0.052	0.007
	Mound Plant	Hydrogen-3	92	4							96	0.449	0.005
		Americium	24	2							26	0.117	0.005
		Mixed & Other	26	3							29	0.223	0.008
		Plutonium	77	3	1						81	0.618	0.008
		Radon-222	1	2							3	0.173	0.058
		Thorium	16	10							26	0.522	0.020
		Uranium	14	1							15	0.059	0.004
	West Valley Nuclear Services, Inc. (WVNS)	Americium	2	9	2						13	0.698	0.054
		Plutonium	18	7							25	0.390	0.016
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	Plutonium	64	28	6		1				99	2.902	0.029
Richland	Hanford Site	Hydrogen-3	2								2	0.002	0.001
		Uranium		1							1	0.097	0.097
		Plutonium	20	1							21	0.164	0.008
Savannah River	Savanah River Site (SRS)	Hydrogen-3	98								98	0.240	0.002
		Other	1								1	0.013	0.013
		Plutonium	1	2							3	0.056	0.019
Totals			**1,534**	**734**	**131**	**16**	**3**	**0**	**0**	**0**	**2,418**	**68.690**	**0.028**

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

The majority of internal dose is attributed to uranium intakes at the Oak Ridge Site, specifically the Y-12 facility. The intakes are attributed to activities at the Enriched Uranium Operations facility.

Exhibit B-22: Extremity Dose Distribution by Operations/Site - 2002

Operations	Site	No Meas. Dose	Meas. –0.1	0.1-1	1-5	5-10	10-20	20-30	>30	Total Monitored*	No. with Meas.	No. Above Monitoring Threshold. (5 rem)**	Collective Extremity Dose (person-rem)	Average Meas. Extremity Dose (rem)
Albuquerque	Albuquerque	783	40	6						829	46		3.254	0.071
	Los Alamos National Lab. (LANL)	10,268	248	271	101	11	6	1		10,906	638	18	517.434	0.811
	Pantex Plant (PP)	5,207	31	74	61	3				5,376	169	3	177.431	1.050
	Sandia National Lab. (SNL)	2,910	10	20	1	1				2,942	32	1	18.029	0.563
Chicago	Chicago Operations	683	17							700	17		0.759	0.045
	Argonne Nat'l. Lab. - East (ANL-E)	2,612	144	26	8	3				2,793	181	3	55.061	0.304
	Argonne Nat'l. Lab. - West (ANL-W)	429	194	72	14	3				712	283	3	73.363	0.259
	Brookhaven National Lab. (BNL)	4,290	278	97	6	1				4,672	382	1	57.498	0.151
	Fermi Nat'l. Accelerator Lab. (FERMI)	1,418	2	4						1,424	6		1.900	0.317
DOE HQ	DOE Headquarters	16								16				
	Russian Federation Project	8								8				
Idaho	Idaho Site	3,624	818	285	2					4,729	1,105		102.516	0.093
Nevada	Nevada Test Site (NTS)	3,899	9	1						3,909	10		0.522	0.052
Oakland	Oakland Operations	93	73	10						176	83		4.127	0.050
	Lawrence Berkeley National Lab. (LBNL)	1,508	16	11	1	1	1			1,538	30	2	25.483	0.849
	Lawrence Livermore Nat'l. Lab. (LLNL)	9,445	20	26	20	5			1	9,517	72	6	200.496	**2.785** ◄
	Stanford Linear Accelerator Center (SLAC)	2,676								2,676				
Ohio	Ohio Field Office	374								374				
	Battelle Memorial Institute - Columbus	210	39	33	37					319	109		82.959	0.761
	Fernald Environmental Mgmt. Project	2,220								2,220				
	Mound Plant	766								766				
	West Valley	497	186	89	5					777	280		49.036	0.175
Oak Ridge	Oak Ridge Operations	1,685								1,685				
	Oak Ridge Site	14,135	39	114	32	1				**14,321** ◄	186	1	104.072	0.560
	Paducah Gaseous Diff. Plant (PGDP)	1,182	4							1,186	4		0.167	0.042
	Portsmouth Gaseous Diff. Plant (PORTS)	640								640				
Rocky Flats	Rocky Flats Env. Tech. Site (RFETS)	2,880	1,406	607	202	26	1			5,122	2,242	27	868.930	0.388
Richland	Hanford Site	7,495	2010	941	146	44	29	4		10,669	3,174	**77** ◄	**1,423.581** ◄	0.449
Savannah River	Savannah River Site (SRS)	5,968	2318	774	141	16	2			9,219	**3,251** ◄	18	699.463	0.215
	Totals	**87,921**	**7,902**	**3,461**	**777**	**115**	**39**	**5**	**1**	**100,221**	**12,300**	**160**	**4,466.081**	**0.363**

* 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.

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

The Oak Ridge Site reports the largest number of individuals monitored for extremity dose. However, Hanford, Rocky Flats, and Savannah River contribute 67% of the collective extremity dose. At Hanford, the majority of extremity dose is received by plant operations personnel.

Facility Type Code Descriptions

DOE M 231.1-1 [13] 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 judgment by 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.

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

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.

In general, radiation doses received by occupational workers at accelerator facilities are largely attributable to the beta/gamma radiation emitted from the activated structural and mechanical components. The nature of the radiation fields and the magnitude of dose rates inside the primary shielding vary considerably depending upon the operational parameters of the machine, the types of particles accelerated, and the energies achieved. Doses received by personnel who enter the accelerator enclosures are dependent upon these factors. In many cases dependent upon the radiological conditions, personnel are prevented from entering the accelerator enclosures when the beam is operational. Outside of the shielding, exposure rates due to prompt radiation from the accelerator are typically very low. Average annual doses of exposed personnel at these facilities are comparable to the overall average for DOE. However, the collective dose is lower than the collective dose for most other DOE facilities' categories because of the relatively small number of employees at accelerator facilities who work on or around the activated components. 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. 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 and transuranics from recycled uranium. 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 exposures, although neutron exposures can occur, especially when work is performed near highly enriched uranium.

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. 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.

Fuel Processing

The DOE administers several facilities that reprocess spent reactor fuel. These facilities separate the plutonium produced in reactors. 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.

Penetrating doses are attributable primarily to gamma photons, although some neutron exposures do occur. Skin and extremity doses can result from handling samples. 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.

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.

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.

By 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.

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.

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.

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 (1 mSv). 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 elevated, sometimes exceeding 1 rem/year (10 mSv/year). Penetrating doses at waste processing facilities are attributable primarily to gamma photons; however, neutron exposures also occur at the large-scale facilities.

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 these facilities, workers can receive neutron radiation dose when processing plutonium isotopes, as well as penetrating dose from gamma photons and plutonium x-rays, and skin and extremity dose from plutonium x-rays. An additional pathway for radiation exposure at these facilities is the inhalation of plutonium, where the inhalation of material can result in some of the highest individual doses based on the calculation of the 50-year committed effective dose equivalent. To prevent plutonium intakes, strict controls are in place, including process containment, contamination control procedures, and air monitoring and bioassay programs.

No DOE facilities currently are involved in weapons testing. Several of the sites reporting under this category are no longer actively involved in weapons fabrication and testing, but are in the process of stabilization and waste management.

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 types described above include construction and irradiation facilities. 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

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. This overestimation only affects the data prior to 1987 presented in Appendix Exhibits B-2a, B-2b, and B-3.

The dose distributions presented in this report are based on the individual dose records reported to REMS. Individuals may be counted more than once as some sites report multiple dose records for an individual who visits the site more than once, or the individual may visit more than one site during the year. (See Section 3.6.)

Monitoring Practices

Radiation monitoring practices vary 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 to determine which workers are monitored. All sites have achieved compliance with the DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurements. 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 increase the number of monitored workers with no dose, it also can add an increased 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 increase the site's 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 above the monitoring threshold. This can decrease the site's collective dose while increasing the average measurable dose.

AEDE vs CEDE

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. The AEDE methodology requires the calculation of the summation of dose for all tissues and organs multiplied by the appropriate weighting factor for a specified year. Note that per 5480.11, AEDE included components of internal and external dose. Therefore, the AEDE was analogous to the TEDE. However, 5480.11 does not define TEDE.

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 CEDE represents the dose equivalent delivered to all organs and tissues over the next 50 years and the 50-year CEDE is reported to REMS and assigned to the individual in the year of intake. The change was made to provide consistency with scientific recommendations, facilitate the transfer of workers between DOE- and NRC-regulated facilities, and simplify recordkeeping by recording all dose in the year of intake. The CEDE methodology is now codified in 10 CFR 835. From 1993 to the present, the TEDE is defined as the summation of the Deep Dose Equivalent (DDE) to the whole body and the CEDE.

This report primarily analyzes dose information for the past 5 years, from 1998 to 2002. 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 in Exhibits B-2a, B-2b, and B-3.

Occupation Codes

Each individual's dose record includes the occupation code for the individual while he 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 30%) of the occupations is 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.

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 members of the public 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.

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. For example, the Mound Plant, Fernald, and West Valley Project changed Operations Office between 1993 & 1994 and are now shown under the Ohio Field Office. Footnotes indicate the change in Operations Offices when applicable.

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.

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 5 years, DOE Headquarters has requested additional information from the six 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 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 Corporate Performance Assessment
(EH-32)
Germantown, MD 20874
nimi.rao@eh.doe.gov

Appendix E

Access to Radiation Exposure Information

E

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. The database consists of individual monitoring records of occupational exposure for DOE workers from 1987 to the present. REMS also contains career exposure records for individuals who terminated employment between 1969 and 1986, and additional historical records voluntarily submitted to REMS from the sites that participated in the epidemiologic surveillance pilot project. Over 3 million exposure records are contained in the REMS central repository. In 1995, REMS underwent an extensive redesign effort in combination with the efforts involved in revising the annual report. One of the main goals of the redesign effort was 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-faceted 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. To obtain further information, a contact name and phone number are provided.

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.

REMS Web Page

As noted in *Exhibit E-1*, a web page has been established to disseminate radiation exposure information at DOE. The web site contains the latest published annual report on occupational exposure, information on reporting exposure data to DOE, points of contact for requesting information from REMS, DOE Orders and Standards related to radiation exposure, and links to other related sites. The site contains a web-based data query tool that allows users to obtain specific data reported to REMS from 1987 to the most recent year available. The data can be selected and grouped by year, site, organization, facility type, labor category, occupation, and monitoring status. The web page query tool allows access to summary information for over 1.7 million monitoring records.

Visit the REMS web page at:

http://rems.eh.doe.gov

Comprehensive Epidemiologic Data Resource

Of interest to researchers in radiation exposure are the health effects associated with worker exposure to radiation. While the health effects from occupational exposure are 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 effects 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. The program's holdings have been expanded to include data from both occupational and historical community health studies, such as those examining the impact of fallout from atmospheric nuclear weapons testing, community dose reconstructions, and data from the decades of follow-up on atomic bomb survivors.

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 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 health risks of occupational radiation exposure.

For further information about CEDR, access the CEDR internet web page at:

http://cedr.lbl.gov

Or the CEDR Program Manager may be contacted at:

barbara.brooks@eh.doe.gov

Exhibit E-1: Methods of Accessing REMS Information

REMS Information Access Method	Information Available	Eligibility Requirements	Software Requirements	To Get Access
Hardcopy Annual Report	Analysis and data for annual occupational exposure information, primarily for the past 5 years. Tables and graphs present data and trends for the most commonly asked questions concerning exposure information at DOE facilities.	None.	None.	Contact EH-32* to request that you be added to the Annual Report mailing list.
Web Page	• Annual reports from 1992 to the most recent report. • Information on reporting exposure data to DOE. • How to request information from REMS. • A query tool for extracting summary data from REMS. • DOE Orders and Standards on radiation exposure. • Links to other related sites.	None.	Internet access. Web browser client software.	Connect to http://rems.eh.doe.gov
Access to REMS Database	Individual annualized dose records submitted to REMS from 1987 to the present. In addition, dose records are available for individuals who terminated employment at a DOE facility from 1969 to 1986.	Records are subject to the privacy Act of 1974. Records are only available to researchers within DOE or other governmental agency upon approval by the REMS Project Manager in accordance with System of Records #35. Contact the REMS Project Manager* for further information on accessing individual dose records in REMS.	Internet access (TCP/IP). Oracle SQLNet and encryption software (provided). Database access tool for querying data that can connect to an Oracle database.	Contact EH-32* to request access.

* EH-32 contact Ms. Nirmala Rao, DOE REMS Project Manager, EH-32, 270 Corporate Square Building, U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, D.C. 20585-0270
Phone: (301) 903-2297, Fax: (301) 903-7773, E-mail: nimi.rao@eh.doe.gov

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Prepared by:
Science Applications International Corporation
301 Laboratory Road • Oak Ridge, TN 37830