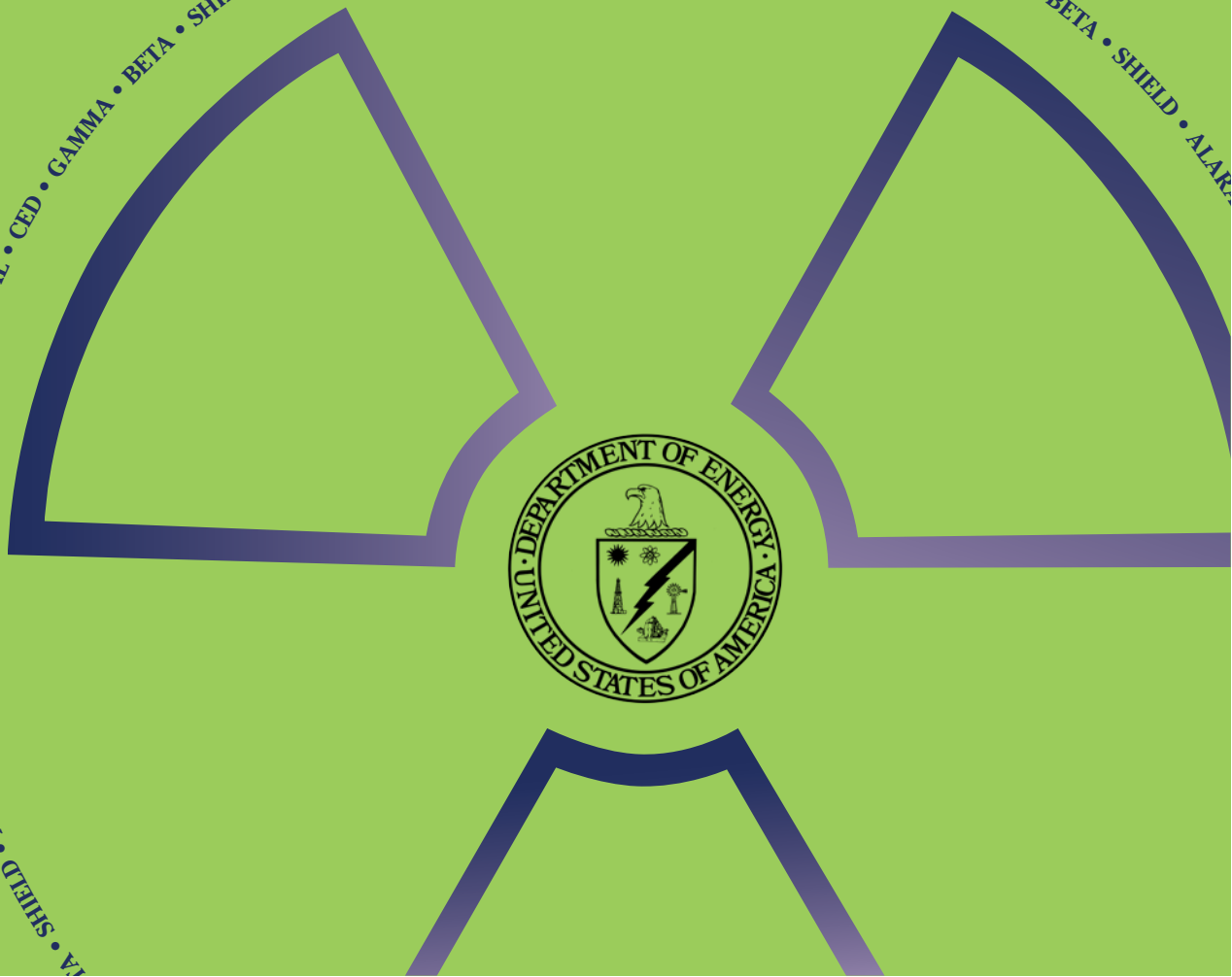
Office of Environment, Health, Safety and Security

DOE 2015 Occupational Radiation Exposure

October 2016

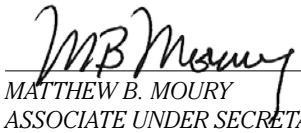


Foreword

It is the responsibility of the U.S. Department of Energy (DOE) to protect the health and safety of DOE employees, contractors, and subcontractors. The Office of Environment, Health, Safety and Security (AU) provides the corporate-level leadership and strategic vision necessary to establish clear expectations for health, safety, environment, and security programs. In support of this mission, the AU Office of Environment, Safety, & Health (ES&H) Reporting and Analysis collects, analyzes, and disseminates data and performance indicators, such as occupational radiation exposure information.

A safety focus for DOE is to maintain radiation exposures below the administrative control levels (ACL) and the DOE radiation dose limits, and to further reduce exposure through the as low as reasonably achievable (ALARA) process. The *DOE 2015 Occupational Radiation Exposure Report* provides an evaluation of DOE-wide performance regarding compliance with Title 10, Code of Federal Regulations (CFR), Part 835, *Occupational Radiation Protection* dose limits and an overview of the status of radiation exposures of the DOE workforce. In addition, this report serves as a risk management tool for radiological safety programs and provides useful information to DOE organizations, epidemiologists, researchers, and national and international agencies involved in developing policies to protect workers and members of the public from the harmful effects of radiation.

The Radiation Exposure Monitoring System (REMS) program remains a key component of AU evaluation and analysis to inform management and stakeholders of the continued vigilance and success of the DOE sites in minimizing radiation exposure to workers. One of the objectives of this report is to provide useful, accurate, and complete information to DOE and the public. As part of a continuing improvement process, we would appreciate your response to the User Survey included at the end of this report.



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LIST OF ABBREVIATIONS AND ACRONYMS

ACL	Administrative Control Level
ALARA	As Low As Reasonably Achievable
AMWTP	Advanced Mixed Waste Treatment Project
ANL	Argonne National Laboratory
ATR	Advanced Test Reactor
AU	Office of Environment, Health, Safety and Security
BNL	Brookhaven National Laboratory
CED	Committed Effective Dose
CEDE	Committed Effective Dose Equivalent
CEqD	Committed Equivalent Dose
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
DUF_6	Depleted Uranium Hexafluoride
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
EqD	Equivalent Dose
ES&H	Environment, Safety, & Health
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park
Fermilab	Fermi National Accelerator Laboratory
ICP	Idaho Cleanup Project
ICRP	International Commission on Radiological Protection
INL	Idaho National Laboratory
KCP	Kansas City Plant
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LCLS	LINAC Coherent Light Source
LINAC	Linear Accelerator
LLNL	Lawrence Livermore National Laboratory
mSv	Millisievert
NBL	New Brunswick Laboratory
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site, formally known as Nevada Test Site (NTS)
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORP	Office of River Protection
OST	Office of Secure Transportation
PGDP	Paducah Gaseous Diffusion Page
PNNL	Pacific Northwest National Laboratory
PORTS	Portsmouth Gaseous Diffusion Plant

PPPL	Princeton Plasma Physics Laboratory
Pu-238	Plutonium-238
RCS	Radiological Control Standard
rem	Roentgen equivalent man
REMS	Radiation Exposure Monitoring System
RF	Radio Frequency
RH-TRU	Remote-Handled Transuranic
RL	Richland Operations Office
SDS	Sodium Distillation System
SLAC	SLAC National Accelerator Laboratory
SNM	Special Nuclear Material
SNL	Sandia National Laboratories
SPEAR3	Stanford Positron-Electron Asymmetric Ring
SRP	Sludge Repackaging Project
SPRU	Separations Process Research Unit
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
Sv	Sievert
TED	Total Effective Dose
TEqD	Total Equivalent Dose
TJNAF	Thomas Jefferson National Accelerator Facility
TREAT	Transient Reactor Test
TRU	Transuranic
TSS	Transportation Safeguards System
TWPC	Transuranic Waste Processing Center
U	Uranium
U-234	Uranium-234
U-238	Uranium-238
UMTRA	Uranium Mill Tailings Remediation Action Project
WIPP	Waste Isolation Pilot Plant
WVDP	West Valley Demonstration Project
Y-12	Y-12 National Security Complex

Executive Summary

The Office of ES&H Reporting and Analysis within the DOE AU publishes the annual *DOE Occupational Radiation Exposure Report* to provide an overview of the status of radiation protection practices at DOE (including the National Nuclear Security Administration [NNSA]). The *DOE 2015 Occupational Radiation Exposure Report* provides an evaluation of DOE-wide performance regarding compliance with Title 10, Code of Federal Regulations, Part 835, *Occupational Radiation Protection* (10 CFR 835) dose limits and ALARA process requirements. In addition, the report provides data to DOE organizations responsible for developing policies for protection of individuals from the adverse health effects of radiation. The report provides a summary and an analysis of occupational radiation exposure data from the monitoring of individuals involved in DOE activities. Over the past 5-year period, the occupational radiation exposure information has been analyzed in terms of dose to individuals, dose by site, and aggregate data.

Analysis of individual dose data includes an examination of:

- Doses exceeding the 5 rem (50 millisievert [mSv]) DOE regulatory limit; and
- Doses exceeding the 2 rem (20 mSv) DOE ACL.

The overall amount of radiation dose received during the conduct of operations at DOE is tracked by collective dose (aggregate data). The collective dose is the sum of the doses received by all individuals with a measurable dose and is measured in units of person-roentgen equivalent in man (person-rem) and person-mSv. In this report, "dose" refers to the Total Effective Dose (TED) and the collective TED is the summation of the TED reported for all monitored individuals. The TED is composed of the effective dose from external sources, which includes neutron, photon and energetic beta radiation, and the internal committed effective dose (CED), which results from the intake of radioactive material into the body. The total DOE collective TED increased by 20 percent from 2014 to 2015, as shown in *Exhibit ES-1*, due to increases in activities at key DOE sites as described below.

Another primary indicator of the level of radiation exposure covered in this report is the average measurable dose, which normalizes the collective dose over the population of workers who actually received a measurable dose. The average measurable TED increased by almost 14 percent from 2014 to 2015, as shown in *Exhibit ES-2*.

Exhibit ES-1:
Collective TED (person-rem), 2011–2015.

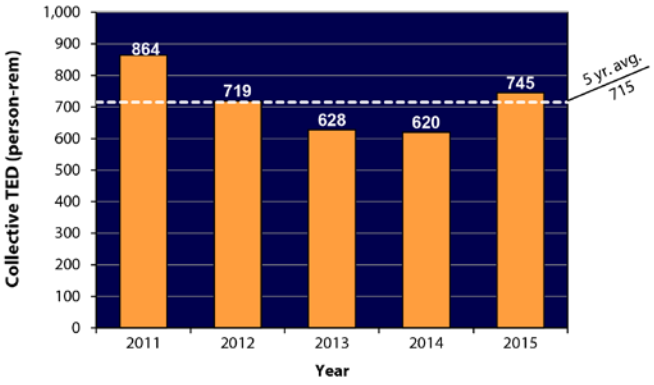
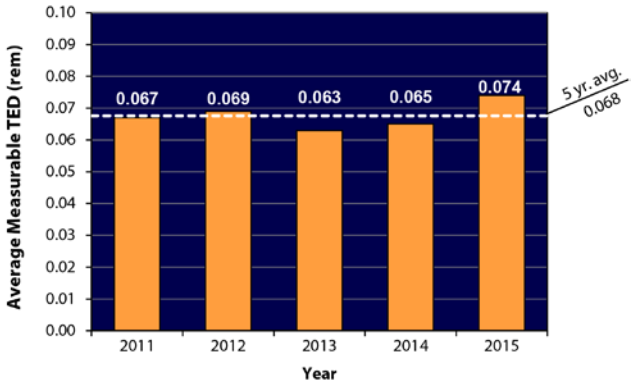


Exhibit ES-2:
Average Measurable TED (rem), 2011–2015.



The report contains information and analyses that can be summarized as follows:

- No doses exceeded the DOE occupational dose limit of 5 rem (50 mSv) TED in 2015 and no doses exceeded the DOE ACL of 2 rem (20 mSv) TED.
- The collective TED increased 20 percent from 620 person rem (6,200 person- mSv) in 2014 to 745 person-rem (7,450 person-mSv) in 2015.
- The sites contributing to the majority of the collective TED were (in descending order of collective TED) Idaho, Oak Ridge, Hanford, Los Alamos National Laboratory (LANL), and Savannah River Site (SRS). These sites accounted for 73 percent of the collective TED at DOE in 2015.
- The collective TED increased at four of the five sites with the largest collective TED; i.e., Idaho, Hanford, LANL, and SRS. At Idaho, the increase was due to an increase in Homeland Security training exercises, maintenance at the analytical and radiochemistry laboratories, spent fuel treatment product handling, transuranic (TRU) waste retrieval and characterization, and maintenance and upgrade of the sodium distillation system. At Hanford, the increase was because of work at the plutonium finishing plant facility. This work included the dismantlement of two large glove boxes in the process lines and the cleanout of the plutonium recovery facility canyon. The increase at LANL was due to the TA-55 plutonium facility operations—historically consistent for LANL. Occupational dose was accrued from weapons manufacturing, plutonium-238 (Pu-238) work, and repackaging materials. At SRS, another increase of occupational dose was attributed to resuming process operations in portions of the H Canyon to allow for continued spent nuclear fuel dissolution.
- Uranium-234 (U-234) accounted for the largest percentage of the collective CED (internal exposure), with over 99 percent of this dose accrued at the Y-12 National Security Complex (Y-12).
- The collective CED (internal exposure) decreased by 5 percent from 54.1 person-rem (541 person-mSv) in 2014 to 51.4 person rem (514 person-mSv) in 2015, as a result of small decreases in internal doses across the DOE complex including Y-12.
- The collective TED for transient workers (individuals monitored at more than one DOE site) increased by 6 percent from 21.7 person-rem (217 person-mSv) in 2014 to 22.9 person-rem (229 person-mSv) in 2015.

Over the past 5-year period, all monitored individuals received measurable TED below the 2 rem (20 mSv) TED ACL, which is well below the DOE regulatory limit of 5 rem (50 mSv) TED annually. The occupational radiation exposure records show that in 2015, DOE facilities continued to comply with DOE dose limits and ACLs and worked to minimize exposure to individuals.

To access this report and other information on occupational radiation exposure at DOE, visit the DOE AU web site at:

http://energy.gov/ehss/occupational-radiation-exposure

Introduction

The *DOE 2015 Occupational Radiation Exposure Report* presents the results of analyses of occupational radiation exposures at DOE facilities during 2015. This report includes occupational radiation exposure information for all DOE employees, contractors, and subcontractors, as well as members of the public in controlled areas that are monitored for exposure to radiation. The 103 DOE organizations submitting radiation exposure reports for 2015 have been grouped into 34 sites. This information has been analyzed and trends over time provide a measure of DOE's performance in protecting its workers from radiation.

1.1 Report Organization

This report is organized into the five sections listed below. Additional supporting technical information, tables of data, and additional items are available on the DOE web site for Information on Occupational Radiation Exposure (http://energy.gov/ehss/occupational-radiation-exposure) and as appendices to this report. A User Survey form is included at the end of this report and users are encouraged to provide feedback.

1.2 Report Availability

This report is available online and may be downloaded from:

http://energy.gov/ehss/occupational-radiation-exposure

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

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Visit the DOE web site for more information on occupational radiation exposure, such as the following:

- Annual occupational radiation exposure reports in portable document format (PDF) since 1974;
- Guidance on reporting radiation exposure information to the DOE Headquarters REMS;
- New improved REMS-Online Query Tool;
- Guidance on how to request a dose history for an individual;
- Statistical data since 1987 for analysis;
- Applicable DOE orders and manuals for the recordkeeping and reporting of occupational radiation exposure at DOE;
- Occupational Exposure Dashboard—interactive data explorer;
- Ten Year Summary—graphical comprehensive overview of past 10 years of radiation exposure data; and
- ALARA activities at DOE.

Section 1	Describes the content and organization of this report.
Section 2	Discusses the radiation protection and dose reporting requirements.
Section 3	Presents the 2015 occupational radiation dose data along with trends over the past 5 years.
Section 4	Provides instructions to submit successful ALARA projects. A detailed ALARA Activity summary is provided on the DOE Radiation Exposure web site once the final report is published. Please visit http://energy.gov/ehss/occupational-radiation-exposure and select Annual Reports to review.
Section 5	Discusses conclusions.
Appendices	The appendices are offered on the DOE Radiation Exposure web site once the final report is published. Please visit http://energy.gov/ehss/occupational-radiation-exposure and select Annual Reports to review. The appendices provide a comprehensive breakdown of dose by field office and site, as well as distributions by facility type and occupation, type of dose, and internal dose by radionuclide.

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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, the DOE AU establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The basic DOE standards for occupational radiation protection include radiation dose limits that establish maximum permissible doses to workers. In addition, contractors and subcontractors are required to maintain exposures as far below the limits as is reasonable through application of the ALARA process which incorporates pre-job planning, engineering controls, and worker training.

This section discusses the radiation protection standards and requirements in effect for 2015. For more information on past requirements, visit the DOE web site for DOE Directives, Delegations, and Requirements at https://www.directives.doe.gov/. See the Archives section under the Directives menu for historical references.

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]. This guidance, initially implemented by DOE in 1989, was based on the 1977 recommendations of the International Commission on Radiological Protection (ICRP) Publication 26 [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements Publication 91 [3]. The EPA guidance recommends that internal dose be added to the external whole-body dose to determine the total effective dose equivalent. Prior to this guidance, the external dose and internal dose were each limited separately. It should be noted that 10 CFR 835, Occupational Radiation Protection, was revised in June 2007, with full implementation required by July 2010. The revision adopted ICRP Publications 60 [4] and 68 [5] dosimetric quantities and units (see section 2.4, Amendments to 10 CFR 835). Title 10 CFR 835 was further revised in April 2011 when Appendix C was updated. The laws and requirements for occupational radiation protection pertaining to the information collected and presented in this report are summarized in *Exhibit 2-1*.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835.202, 206, 207, and 208 [6] and are summarized in *Exhibit 2-2*.

2.3 Reporting Requirements

On June 27, 2011, DOE Order (O) 231.1A was updated and reissued as DOE O 231.1B, *Environment, Safety and Health Reporting* [7], which contains the requirements for reporting

Exhibit 2-1:
Laws and Requirements Pertaining to the Collection and Reporting of Radiation Exposures.

Title	Date	Description
10 CFR 835, *Occupational Radiation Protection* [6]	Issued 12/14/93 Amended 11/4/98 Amended 6/8/07 Amended 4/13/11	Establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation that results from the conduct of DOE activities.
DOE Order 231.1B, *Environment, Safety and Health Reporting* [7]	Approved 6/27/11	Requires the annual reporting of occupational radiation exposure records to the DOE REMS repository.
REMS Reporting Guide [8]	Issued 2/23/12	Specifies the current format and content of the reports required by DOE Order 231.1B.

Exhibit 2-2:
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. The sum of the effective dose (for external exposures) and the committed effective dose.	TED	5 rem
		The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye.	EqD-WB + CEqD (TOD)	50 rem
		Equivalent Dose to the Lens of the Eye	EqD-Eye	15 rem
		The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity	EqD-SkWB + CEqD-SK and EqD to the maximally exposed extremity + CEqD-SK	50 rem
Declared pregnant workers*	835.206	Total equivalent dose	TEqD	0.5 rem per gestation period
Minors	835.207	Total effective dose	TED	0.1 rem
Members of the public in a controlled area	835.208	Total effective dose	TED	0.1 rem

*Limit applies to the embryo/fetus.

annual individual radiation exposure records to the REMS repository. DOE Manual 231.1-1A, *Environment, Safety, and Health Reporting Manual*, has been cancelled and specific instructions for preparing occupational exposure data for submittal to the REMS repository are contained in the REMS Reporting Guide available online at: http://energy.gov/ehss/downloads/radiation-exposure-monitoring-systems-data-reporting-guide [8].

2.4 Amendment to 10 CFR 835

In August 2006, DOE published a proposed amendment to 10 CFR 835 in the *Federal Register*, and in June 2007, the amended rule was published. The amendment:

- Specified new dosimetric terminology and quantities based on ICRP 60/68 in place of ICRP 26/30;
- Specified ICRP 60 *tissue weighting factors* in place of ICRP 26 *weighting factors*;
- Specified ICRP 60 *radiation weighting factors* in place of ICRP 26 *quality factors*;
- Amended other parts of the regulation that changed as a result of adopting ICRP 60 dosimetry system;
- Used the ICRP 68 dose conversion factors to determine values for the derived air concentrations; and
- Adopted other changes intended to enhance radiation protection.

The amended rule became effective on July 9, 2007, and was required to be fully implemented by DOE sites by July 9, 2010. Because all sites began complying with the new requirements during 2010, all terminology used in this annual report reflects that of the amendment. In addition, 10 CFR 835 was revised in April 2011 when Appendix C (Derived Air Concentration for Workers) was updated.

Occupational Radiation Dose at DOE

3.1 Analysis of the Data

Key indicators are useful when evaluating occupational radiation exposures received at DOE facilities. The key indicators are analyzed to identify and correlate parameters that impact radiation doses at DOE.

Key indicators for the analysis of aggregate data are the following:

- number of records for monitored individuals;
- individuals with measurable dose;
- collective dose;
- average measurable dose; and
- dose distribution.

Analysis of individual dose data includes an examination of:

- doses exceeding the 5 rem (50 mSv) DOE regulatory limit; and
- doses exceeding the 2 rem (20 mSv) DOE ACL.

Additional information is provided in this report concerning activities at sites contributing to the majority of the collective dose. The data for prior years contained in this report are subject to change because sites may submit corrections for previous years.

3.2 Analysis of Aggregate Data

3.2.1 Number of Records for Monitored Individuals

As stated in Section 2, DOE requires the reporting of the results of annual individual occupational radiation exposure monitoring to the REMS repository. The results are reported by each facility in the form of a record for a monitoring period for each monitored individual. An individual may have been monitored more than once at the same facility (e.g. multiple short-term assignments) or may have been monitored at more than one facility during the year. These situations result in more than one record for an individual during the year in the REMS repository. However, the impact of multiple records per person on the annual trends and aggregate analysis of the data in this report is not significant since it occurs consistently from year to year. An analysis of the number of individuals that are monitored at more than one location during the year is provided in Section 3.5 that supports this assertion.

For this reason, the number of records for monitored individuals can be considered equivalent to the number of monitored individuals in the aggregate analysis presented in this section. The term "number of monitored individuals" will be used herein with the understanding that it is determined by the count of records for monitored individuals.

3.2.2 Number of Individuals with Measurable Dose

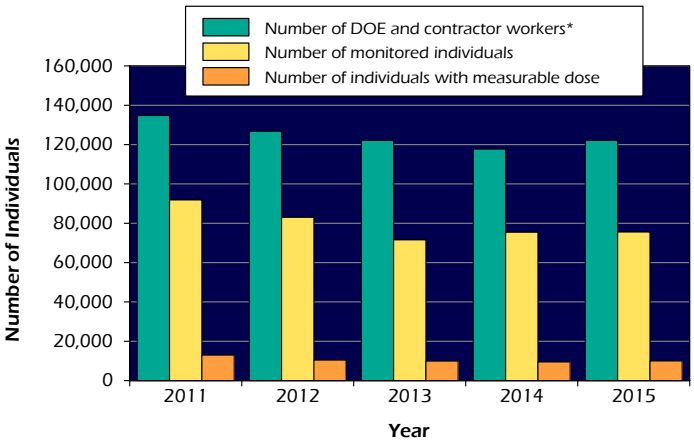
DOE uses the number of individuals with measurable dose to represent the exposed workforce size. In this context, "with measurable dose" means that a detectable value was reported for the individual.

Over the past 5-year period, all monitored individuals received measurable TED below the 2 rem (20 mSv) TED ACL, which is well below the DOE regulatory limit of 5 rem (50 mSv) TED annually.

Exhibit 3-1a and *Exhibit 3-1b* show the number of DOE and contractor workers, the total number of individuals monitored for radiation dose, the number of individuals with a measurable dose, and the relative percentages for the past 5 years. The number of DOE and contract workers was calculated by converting the total number of hours worked each year into an estimate of the number of workers by dividing the total hours worked by the average number of work hours per year. It is therefore, not a true count of individuals, but is a representation of the total size of the DOE workforce and is included here in order to compare it to the number of workers who are monitored.

Sixteen of the 34 reporting sites experienced decreases in the number of workers with a measurable TED from 2014 to 2015. The largest decrease in total number of workers with a measurable TED occurred at LANL with a decrease of 266 workers.

Exhibit 3-1a:
Monitoring of the DOE Workforce, 2011–2015.



* The number of DOE and contractor workers was determined from the total annual work hours at DOE [9] converted to full-time equivalents.

For 2015, 62% of the DOE workforce was monitored for radiation dose, and 13% of monitored individuals received a measurable dose.

Exhibit 3-1b:
Monitoring of the DOE Workforce, 2011–2015.

Year	DOE & Contractor Workforce	Number of Monitored Individuals	Percent of Monitored Individuals*	Number of Individuals w/Measurable Dose	Percent of Individuals w/Measurable Dose*
2011	134,790	91,857	68% ▼	12,965	14%
2012	126,776	83,043	66% ▼	10,461	13% ▼
2013	122,159	71,581	59% ▼	9,904	14% ▲
2014	117,727	75,445	64% ▲	9,501	13% ▼
2015	122,163	75,540	62% ▼	10,023	13%
5-Year Average	**125,363**	**80,482**	**64%**	**10,708**	**13%**

* Up arrows indicate an increase from the previous year's value. Down arrows indicate a decrease from the previous year's value.

Eighteen of the reporting sites experienced increases in the number of workers with a measurable TED from 2014 to 2015. The largest increase in the number of workers receiving a measurable TED occurred at SRS with an increase of 298 workers. A discussion of activities at the highest dose facilities is included in section 3.4.3.

3.2.3 Collective Dose

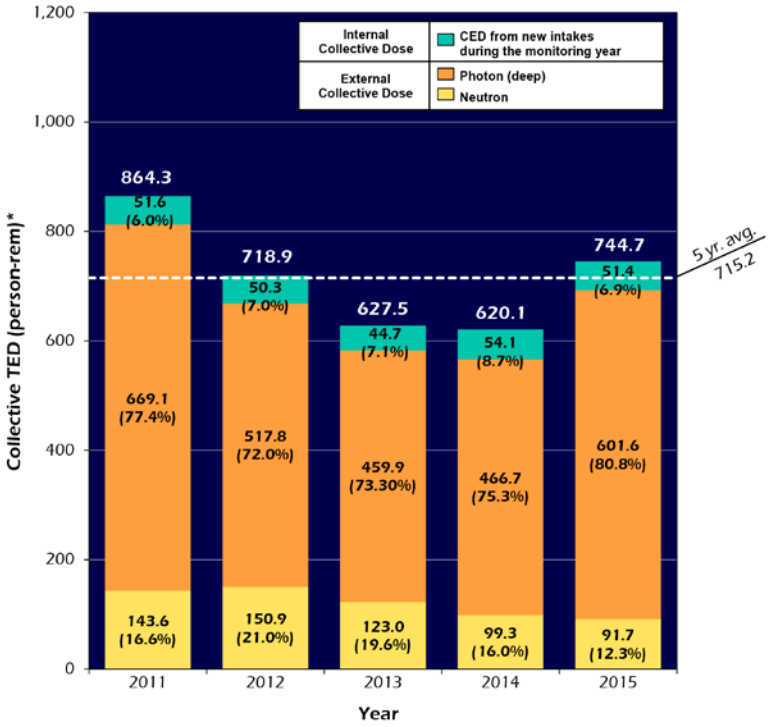
The collective dose is the sum of the dose received by all individuals with a measurable dose and is measured in units of person-rem and person-mSv. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

In this report, the term "collective dose" is also applied to various types of radiation dose, such as external or internal, and will be specified in conjunction with the term "collective" to clarify the intended meaning.

As shown in *Exhibit 3-2*, the collective TED increased at DOE by 20 percent from 620.1 person-rem (6,201 person-mSv) in 2014 to 744.7 person-rem (7,447 person-mSv) in 2015.

The internal dose is based on the 50-year CED methodology. Under this methodology, the cumulative dose received from the intake of radioactive material over the next 50 years is assigned to the individual as a one-time dose in the year of intake. In other words, the CED is the effective dose from radionuclides taken into the body during the reporting year integrated over the next 50 years. The internal dose component of the collective TED decreased by 5 percent from 54.1 person-rem (541 person-mSv) in 2014 to 51.4 person-rem (514 person-mSv) in 2015, due to small decreases in internal doses across the DOE complex

Exhibit 3-2:
Components of TED, 2011–2015.



The collective TED increased by 20% at DOE from 2014 to 2015.

The collective internal dose decreased by 5% from 2014 to 2015.

The collective neutron dose decreased by 8% from 2014 to 2015.

The collective photon dose increased by 29% from 2014 to 2015.

Effective Dose from photons—the component of external dose from gamma or X-ray electromagnetic radiation (also includes energetic betas)

Effective dose from neutrons 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

* The percentages in parentheses represent the percentage of each dose component to the collective TED.

including Y-12. The collective photon dose increased by 29 percent from 466.7 person-rem (4,667 person-mSv) in 2014 to 601.6 person-rem (6,016 person-mSv) in 2015.

The neutron component of the collective TED decreased by 8 percent from 99.3 person-rem (993 person-mSv) in 2014 to 91.7 person-rem (917 person-mSv) in 2015. The decrease resulted primarily from decreases at SRS, Oak Ridge National Laboratory (ORNL), and Hanford, while the top contributor in 2015 (LANL) actually increased. This is the third consecutive year of reduction in collective neutron dose.

Twenty-two of the 34 DOE sites reported decreases in the collective TED from the 2014 values, while 12 of the DOE sites reported increases.

The five sites that contributed most (73 percent) of the DOE collective TED in 2015 were (in descending order of collective TED): Idaho Site—17 percent (including the Idaho National Laboratory [INL], Idaho Cleanup Project [ICP] and the Advanced Mixed Waste Treatment Project [AMWTP]); Oak Ridge—16 percent (including East Tennessee Technology Park [ETTP], Y 12, ORNL, and Oak Ridge Institute for Science and Education [ORISE]); Hanford—15 percent (including the Hanford Site, Pacific Northwest National Laboratory [PNNL], and Office of River Protection [ORP]); LANL—13 percent; and SRS—13 percent.

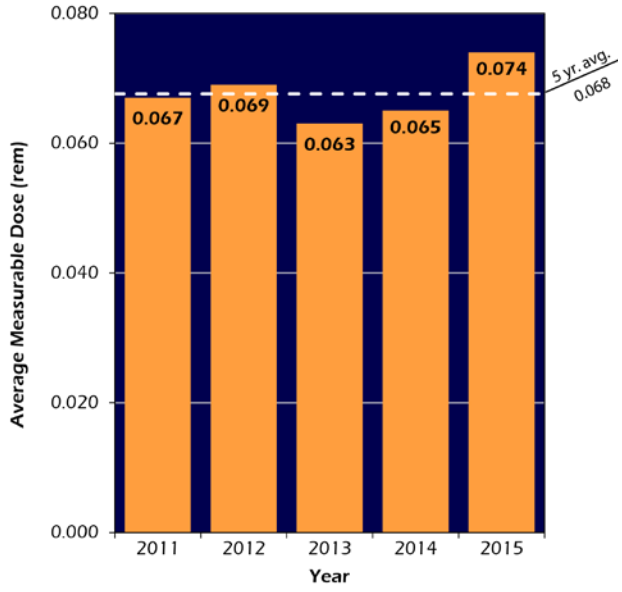
Oak Ridge is the only site of the five sites that had a decrease in collective TED in 2015 compared with 2014 (10 percent decrease). The other four top contributors reported increases in collective TED. In descending order of the percent increase in collective TED are Hanford (63 percent higher), Idaho (43 percent higher), SRS (2 percent higher), and LANL (2 percent higher). (See section 3.4.3.)

3.2.4 Average Measurable Dose

The average measurable dose (TED) to DOE workers, a key radiation dose indicator, is calculated by dividing the collective dose (in this case, TED) by the number of individuals with measurable dose for TED. 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.

The average measurable TED is shown in *Exhibit 3-3*. The average measurable TED increased by 14 percent from 0.065 rem (0.650 mSv) in 2014 to 0.074 rem (0.740 mSv) in 2015. While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not depict the distribution of doses among the worker population.

Exhibit 3-3:
Average Measurable TED, 2011–2015.



3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the dose (TED) distribution among the worker population. *Exhibit 3-4* shows the number of individuals in each of 11 different dose ranges. The number of individuals receiving doses above 0.1 rem (1 mSv) is included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c) [6].

Exhibit 3-4 shows that the dose (TED) distribution for 2015 was higher in all ranges compared with the 2014 data. Ninety-nine percent of the individuals monitored had doses less than 0.25 rem (2.5 mSv). *Exhibit 3-5* presents the dose distribution in terms of the percentage of individuals with measurable TED in each range. Note that the percentage of monitored individuals with measurable TED that receive a dose below 0.1 rem has been over 80 percent during the last 5 years. The large number of monitored individuals that fall below the threshold specified in 10 CFR 835.402 (a) and (c) shows how few individuals exceed the threshold and that many more individuals are monitored than is strictly required. This reflects on DOE's conservative practice of monitoring more individuals than are required in order to ensure the adequate protection of the worker and that ALARA principles are being effectively implemented at reducing radiation exposure.

Exhibit 3-4:
Distribution of TED by Dose Range, 2011–2015.

	TED Range (rem)	2011	2012	2013	2014	2015
Number of Individuals in Each Dose Range*	Less than measurable	78,892	72,582	61,677	65,944	65,517
	Measurable to 0.100	10,514	8,443	8,152	7,707	8,022
	0.100–0.250	1,736	1,360	1,246	1,257	1,341
	0.250–0.500	564	529	421	444	447
	0.500–0.750	99	87	48	72	123
	0.750–1.000	41	27	28	15	49
	1–2	11	15	9	6	41
	2–3					
	3–4					
	4–5					
	>5					
Total number of records for monitored individuals		91,857	83,043	71,581	75,445	75,540
Number with measurable dose		12,965	10,461	9,904	9,501	10,023
Number with dose >0.100 rem		2,451	2,018	1,752	1,794	2,001
% of individuals with measurable dose		14%	13%	14%	13%	13%
Collective TED (person-rem)		864.315	718.903	627.549	620.103	744.734
Average measurable TED (rem)		0.067	0.069	0.063	0.065	0.074

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

Exhibit 3-5:
Percentage of Individuals with Measurable TED by Dose Range, 2011 – 2015.

	TED Range (rem)	2011	2012	2013	2014	2015
Percentage of Individuals with Measurable TED*	Measurable <0.100	81.10%	80.71%	82.31%	81.12%	80.04%
	0.100–0.250	13.39%	13.00%	12.58%	13.23%	13.38%
	0.250–0.500	4.35%	5.06%	4.25%	4.67%	4.46%
	0.500–0.750	0.76%	0.83%	0.48%	0.76%	1.23%
	0.750–1.000	0.32%	0.26%	0.28%	0.16%	0.49%
	1–2	0.08%	0.14%	0.09%	0.06%	0.41%
	2–3	0.00%	0.00%	0.00%	0.00%	0.00%
	>3	0.00%	0.00%	0.00%	0.00%	0.00%

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

3.3 Analysis of Individual Dose Data

The previous analysis is based on aggregate data for DOE. From an individual worker perspective and a regulatory perspective, it is important to examine the doses received by individuals in the elevated dose ranges to understand the circumstances leading to these doses in the workplace and to better manage, or where practical, avoid these doses in the future.

3.3.1 Doses in Excess of DOE Limit

No individual exceeded the TED regulatory limit (5 rem [50 mSv]) from 2011 through 2015.

3.3.2 Doses in Excess of Administrative Control Level

The Radiological Control Standard (RCS) [10] recommends a 2 rem (20 mSv) ACL for TED 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. The RCS recommends that each DOE site establish its own more restrictive ACL that would require contractor management approval to be exceeded.

No individual exceeded 2 rem (20 mSv) TED from 2011 through 2015.

3.3.3 Intakes of Radioactive Material

DOE tracks the number of intakes as a performance measure in the report. DOE emphasizes the importance of taking measures to avoid intakes and maintain doses as low as reasonable through the ALARA process.

Exhibit 3-6 shows the number of individuals with measurable CED, collective CED, and average measurable CED for 2011 to 2015. The number of individuals with measurable CED decreased by 5 percent from 1,200 in 2014 to 1,146 in 2015, and the collective CED decreased by 5 percent. The average measurable CED remained unchanged from 2014 to 2015 at 0.045 rem (0.450 mSv) and was slightly above the 5-year average measurable CED.

Ninety-nine percent of the collective CED in 2015 was from uranium intakes at Y-12 during the operation and management of Enriched Uranium Operations facilities at the site. Compared with external dose, few workers at DOE receive measurable internal dose, so larger fluctuations may occur from year to year in the number of workers and collective CED than for other components of TED.

Exhibit 3-7 shows the distribution of the internal dose (CED) from 2011 to 2015. The total number of individuals with measurable CED in each dose range is the sum of the number of individuals receiving an internal dose (CED) in the dose range. Individuals may have had more than one intake of radioactive material, but these intakes resulted in one annual CED total per individual. Doses below 0.020 rem (0.200 mSv) are shown as a separate dose range, to show the large number of individuals in this low dose range.

Exhibit 3-6:
Number of Individuals with Measurable CED, Collective CED, and Average Measurable CED, 2011-2015

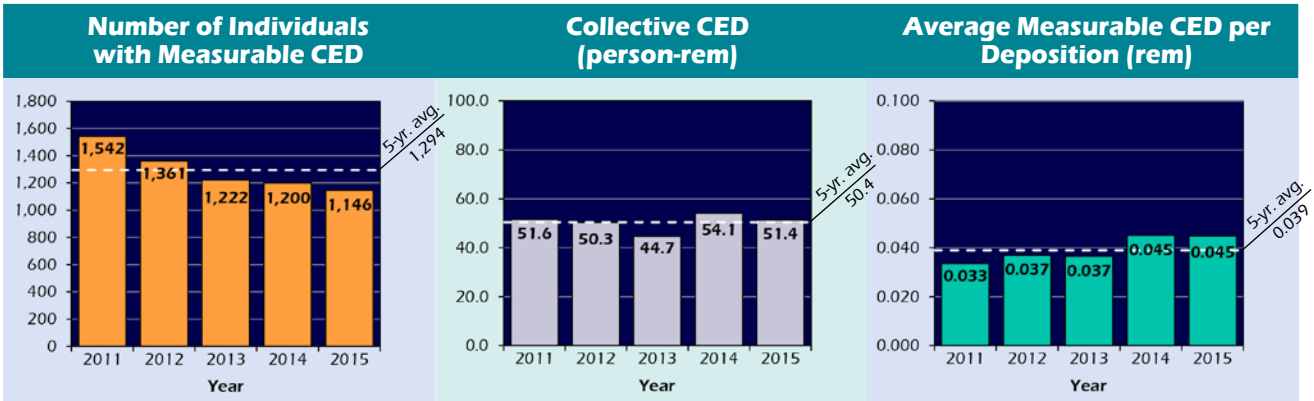


Exhibit 3-7:
Internal Dose Distribution from Intakes, 2011–2015.

Year	Number of Individuals with CED in the Ranges (rem)*											Total No. of Indiv.	Total Collective CED (person-rem)
	Meas. <0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0		
2011	886	535	107	12	1		1					1,542	51.601
2012	737	481	125	17	1							1361	50.253
2013	668	439	107	5	2	1						1,222	44.687
2014	565	479	140	14	2							1200	54.082
2015	542	464	116	23	1							1,146	51.417

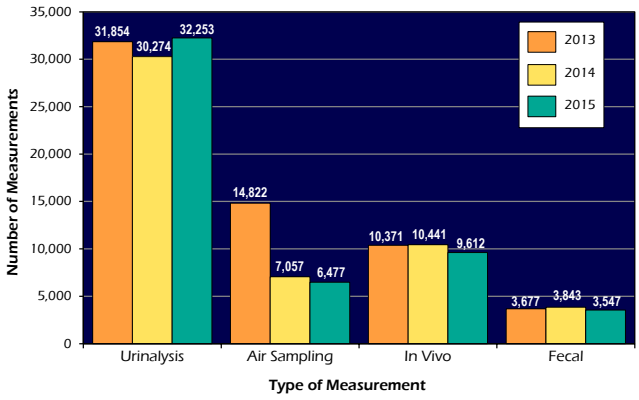
* Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.

The internal dose records indicate that the majority of the intakes resulted in very low doses. In 2015, 47 percent of the internal dose records were for doses below 0.020 rem (0.200 mSv). Over the 5-year period, internal doses accounted for 7 percent of the collective TED, and only 10 percent of the individuals who received internal doses had estimated doses above the monitoring threshold (0.1 rem [1 mSv]) specified in 10 CFR 835.402(c) [6].

3.3.4 Bioassay and Intake Summary Information

For the monitoring year 2015, bioassay and intake summary information was required to be reported under the REMS Reporting Guide [8]. During the past 3 years, "Urinalysis" has been reported as the most common method of bioassay measurement used to determine internal doses to the individuals. *Exhibit 3-8* shows the breakdown of bioassay measurements by measurement type and number of measurements. The measurements reported as "In Vivo" include direct measurements of the radioactive material in the body of the monitored person. Examples of "In Vivo" measurements include whole body counts and lung or thyroid counts. Two sites, SRS and Hanford, accounted for 46 percent of the "In Vivo" measurements.

Exhibit 3-8:
Bioassay and Air Sampling Measurements, 2013-2015.



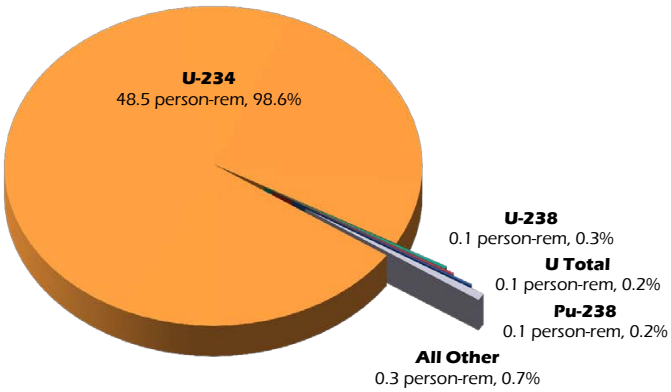
The measurements reported as "Air Sampling" are used to calculate the amount of airborne radioactive material taken into the body and the resultant internal dose. The numbers shown are based on the number of measurements taken and not the number of individuals monitored. Individuals may have measurements taken more than once during the year. The majority of the measurements reported as "Air Sampling" accounted for 12 percent of the total measurements. The Separations Process Research Unit (SPRU) had the largest percentage increase (333 percent) in the number of "Urinalysis" measurements in 2015 (see section 3.4.4 for additional information) and ORNL reported the largest decrease (50 percent) in the number of "Air Sampling" measurements.

Sixty-six percent of the "Urinalysis" measurements in 2015 were performed at four sites: Y-12, LANL, SRS, and the Portsmouth Gaseous Diffusion Plant (PORTS).

Y-12 performed the largest number of bioassay measurements overall, comprising 22 percent of the total measurements taken.

Exhibit 3-9 shows the breakdown of the collective CED by radionuclide for 2015. U-234 accounted for the largest percentage of the collective CED, with over 99 percent of this dose accrued at Y-12. The collective CED per radionuclide for *Exhibit 3-9*, which is based on intake summaries, does not equal the collective CED found in *Exhibit 3-7*, which is based on individual dose records.

Exhibit 3-9:
Collective CED by Radionuclide from Internal Exposure, 2015.



The annual REMS appendices are located at http://energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports, within each annual report. *Exhibits B-4*, Internal Dose by Site; *B-17*, Internal Dose by Facility Type and Nuclide; *B-19*, Internal Dose by Labor Category; and *B-21*, Internal Dose Distribution by Site and Nuclide offer more detailed information regarding intake data.

3.4 Analysis of Site Data

3.4.1 Collective TED by Site and Other Facilities

The collective TED values for 2013 through 2015 for the major DOE sites and operations/field offices are shown graphically in *Exhibit 3-10*. A list of the collective TED and number of individuals with measurable TED by DOE sites is shown in *Exhibit 3-11*. The collective TED increased 20 percent from 620 person-rem (6,200 person-mSv) in 2014 to 745 person-rem (7,450 person-mSv) in 2015, with Idaho (including INL, ICP, and AMWTP); Oak Ridge (including ETTP, Y-12, ORNL, and ORISE); Hanford (including the Hanford Site, PNNL, and ORP); LANL; and Savannah River contributing 73 percent of the total DOE collective TED.

3.4.2 Changes by Site from 2014 to 2015

Exhibit 3-12 shows the collective TED, the number with a measurable TED, and the average measurable TED, as well as the percentage change in these values from the previous year. Some of the largest percentage changes occurred at relatively small facilities, where conditions may fluctuate from year to year due to changes in workload and tasks conducted.

Changes that have the most impact in the overall values at DOE typically occur at sites with large collective TED. However, in 2015, the largest percentage of change was observed at SPRU, which increased by almost 60 rem (600 mSv), representing a 642 percent change from 2014. (See section 3.4.4.).

Exhibit 3-10:
Collective TED by DOE Site for 2013–2015.

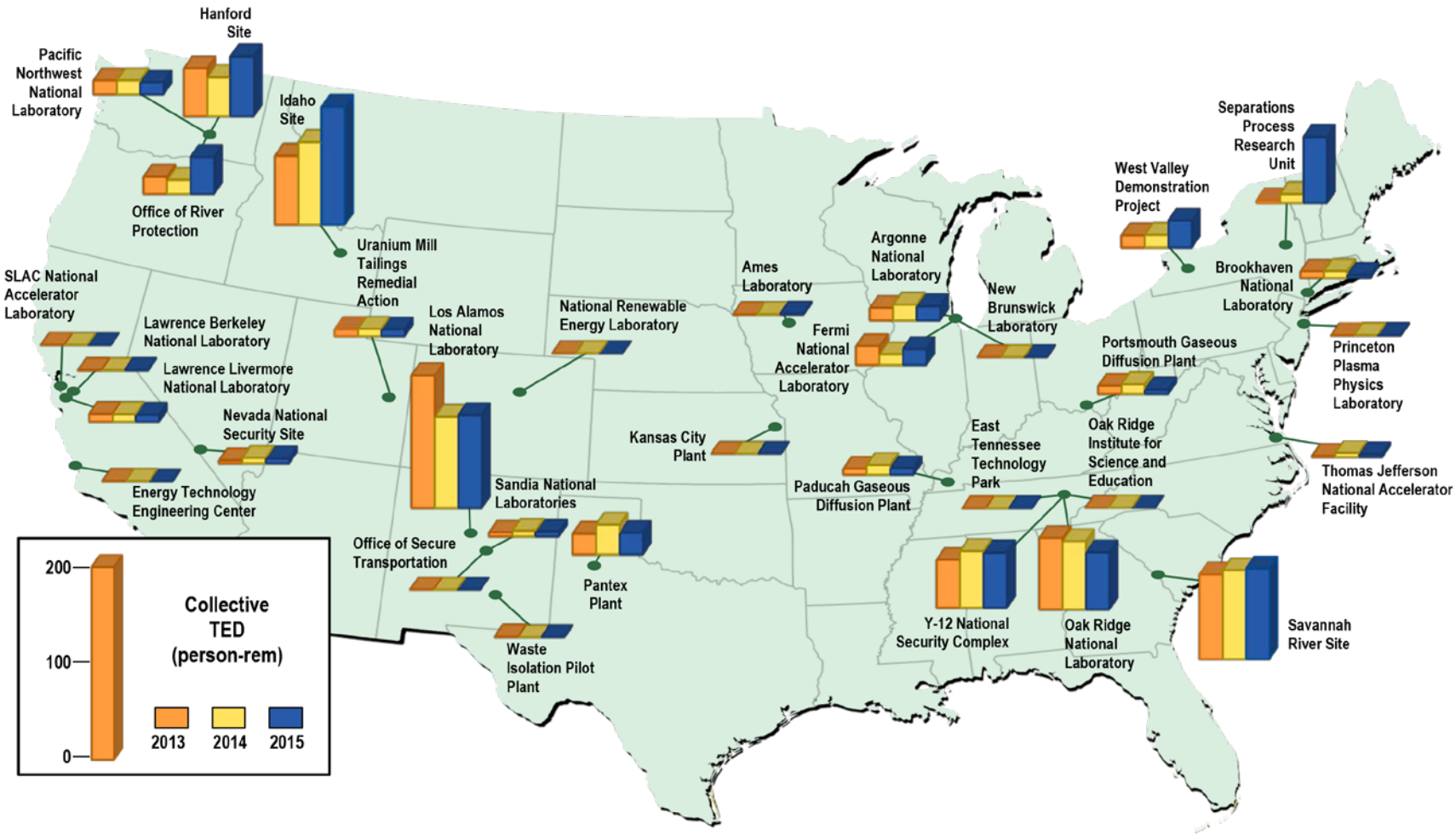


Exhibit 3-11:
Collective TED and Number of Individuals with Measurable TED by DOE Site, 2013–2015.

Site	2013		2014		2015	
	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED
Ames Laboratory	0.730	24	0.873	33	1.247	39
Argonne National Laboratory	13.091	74	16.492	84	14.767	82
Brookhaven National Laboratory	6.988	194	7.282	129	3.345	134
Energy Technology Engineering Center	0.479	57	0.489	69	0.068	3
Fermi National Accelerator Laboratory	19.750	175	11.070	193	16.640	235
Hanford:						
Hanford Site	50.081	715	40.715	659	62.612	687
Office of River Protection	18.228	448	14.653	412	38.608	648
Pacific Northwest National Laboratory	14.550	403	14.634	479	12.581	461
Idaho Site	71.814	1,437	86.202	1,174	**123.232**	1,331
Kansas City Plant	0.001	1	0.022	11	0.020	12
Lawrence Berkeley National Laboratory	0.623	9	0.463	8	0.796	11
Lawrence Livermore National Laboratory	8.475	103	8.353	108	7.602	106
Los Alamos National Laboratory	**138.734**	**1,703**	**95.436**	1,401	97.209	1,135
National Renewable Energy Laboratory	0.068	5	0.107	7	0.028	4
Nevada National Security Site	3.218	89	5.638	116	5.045	98
New Brunswick Laboratory	0.012	1	0.023	2	0.000	0
Oak Ridge:						
East Tennessee Technology Park	0.040	4	0.004	1	0.059	4
Oak Ridge Institute for Science and Education	0.083	6	0.210	23	0.122	10
Oak Ridge National Laboratory	74.531	642	71.304	618	59.802	598
Y-12 National Security Complex	50.136	1,337	59.296	1,326	57.783	1,200
Office of Secure Transportation	0.176	9	0.090	5	0.029	2
Paducah Gaseous Diffusion Plant	6.450	92	10.306	139	7.058	337
Pantex Plant	21.829	330	31.084	305	22.618	301
Portsmouth Gaseous Diffusion Plant	8.634	102	10.302	95	4.716	59
Princeton Plasma Physics Laboratory	0.339	58	0.693	123	0.623	126
Sandia National Laboratories	4.260	115	5.982	88	5.284	99
Savannah River Site	88.623	1,472	93.027	**1,584**	94.871	**1,882**
Separations Process Research Unit	2.927	50	9.338	76	69.291	149
SLAC National Accelerator Laboratory	0.281	10	0.246	9	0.069	2
Thomas Jefferson National Accelerator Facility	1.503	48	4.452	42	3.153	47
Uranium Mill Tailings Remedial Action Project	7.407	55	7.756	61	7.177	86
Waste Isolation Pilot Plant	0.552	32	0.034	3	0.161	12
West Valley Demonstration Project	12.901	101	13.424	112	28.107	122
Service Center Personnel*	0.035	3	0.103	6	0.011	1
Totals	**627.549**	**9,904**	**620.103**	**9,501**	**744.734**	**10,023**

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

* Includes personnel at National Nuclear Security Administration (NNSA) Albuquerque complex, Oak Ridge, and WIPP in addition to several smaller facilities not associated with a DOE site.

Exhibit 3-12:
Site Dose Data, 2015.

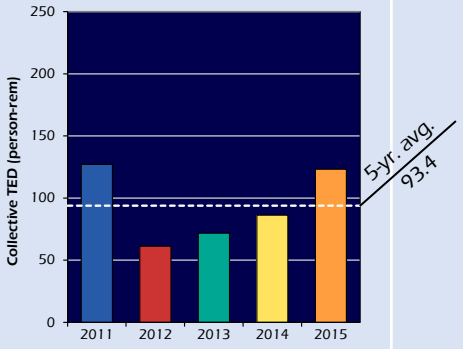
Site	2015					
	Collective TED (person-rem)	Percent Change from 2014	Number with Meas. TED	Percent Change from 2014	Avg. Meas. TED (rem)	Percent Change from 2014
Ames Laboratory	1.247	43% ▲	39	18% ▲	0.032	21% ▲
Argonne National Laboratory	14.767	-10% ▼	82	-2% ▼	0.180	-8% ▼
Brookhaven National Laboratory	3.345	-54% ▼	134	4% ▲	0.025	-56% ▼
Energy Technology Engineering Center	0.068	◊	3	◊	0.023	◊
Fermi National Accelerator Laboratory	16.640	50% ▲	235	22% ▲	0.071	23% ▲
Hanford:						
Hanford Site	62.612	54% ▲	687	4% ▲	0.091	48% ▲
Office of River Protection	38.608	163% ▲	648	57% ▲	0.060	68% ▲
Pacific Northwest National Laboratory	12.581	-14% ▼	461	-4% ▼	0.027	-11% ▼
Idaho Site	**123.232**	43% ▲	1,331	13% ▲	0.093	26% ▲
Kansas City Plant	0.020	◊	12	◊	0.002	◊
Lawrence Berkeley National Laboratory	0.796	◊	11	◊	0.072	◊
Lawrence Livermore National Laboratory	7.602	-9% ▼	106	-2% ▼	0.072	-7% ▼
Los Alamos National Laboratory	97.209	2% ▲	1,135	-19% ▼	0.086	26% ▲
National Renewable Energy Laboratory	0.028	◊	4	◊	0.007	◊
Nevada National Security Site	5.045	-11% ▼	98	-16% ▼	0.051	6% ▲
New Brunswick Laboratory	0.000	◊	0	◊	0.000	◊
Oak Ridge:						
East Tennessee Technology Park	0.059	◊	4	◊	0.015	◊
Oak Ridge Institute for Science and Education	0.122	◊	10	◊	0.012	◊
Oak Ridge National Laboratory	59.802	-16% ▼	598	-3% ▼	0.100	-13% ▼
Y-12 National Security Complex	57.783	-3% ▼	1,200	-10% ▼	0.048	8% ▲
Office of Secure Transportation	0.029	◊	2	◊	0.015	◊
Paducah Gaseous Diffusion Plant	7.058	-32% ▼	337	**142%** ▲	0.021	-72% ▼
Pantex Plant	22.618	-27% ▼	301	-1% ▼	0.075	-26% ▼
Portsmouth Gaseous Diffusion Plant	4.716	-54% ▼	59	-38% ▼	0.080	-26% ▼
Princeton Plasma Physics Laboratory	0.623	◊	126	◊	0.005	◊
Sandia National Laboratories	5.284	-12% ▼	99	13% ▲	0.053	-21% ▼
Savannah River Site	94.871	2% ▲	**1,882**	19% ▲	0.050	-14% ▼
Separations Process Research Unit	69.291	**642%** ▲	149	96% ▲	**0.465**	**278%** ▲
SLAC National Accelerator Laboratory	0.069	◊	2	◊	0.035	◊
Thomas Jefferson National Accelerator Facility	3.153	-29% ▼	47	12% ▲	0.067	-37% ▼
Uranium Mill Tailings Remedial Action Project	7.177	-7% ▼	86	41% ▲	0.083	-34% ▼
Waste Isolation Pilot Plant	0.161	◊	12	◊	0.013	◊
West Valley Demonstration Project	28.107	109% ▲	122	9% ▲	0.230	92% ▲
Service Center Personnel*	0.011	◊	1	◊	0.011	◊
Totals	**744.734**	**20%** ▲	**10,023**	**5%** ▲	**0.074**	**14%** ▲

Note: Bold and boxed values indicate the greatest value in each column.
◊ The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv).
* Includes personnel at NNSA Albuquerque complex, Oak Ridge, and WIPP in addition to several smaller facilities not associated with a DOE site.

3.4.3 Activities Significantly Contributing to Collective Dose in 2015

In an effort to identify the reasons for changes in the collective dose at DOE, all of the larger sites were contacted to provide information on activities that significantly contributed to the collective dose for 2015. These sites, presented in descending order of collective TED (Idaho, Oak Ridge, Hanford, LANL, and SRS) each had a collective TED over 90 person-rem (900 person-mSv) and were the top contributors to the collective TED in 2015. These sites comprised 73 percent of the total collective TED at DOE. Four sites reported increases in the collective TED, which contributed to a 20 percent increase in the DOE collective TED from 620 person-rem (6,200 person-mSv) in 2014 to 745 person-rem (7,450 person-mSv) in 2015. The sites significantly contributing to the collective TED in 2015 are shown in *Exhibit 3-13*, including a description of activities that affected the collective TED.

Exhibit 3-13:
Activities Significantly Contributing to Collective TED in 2015 .

Idaho Site	Percent Change for Last Year 2014-2015	Percent Change for Past 3 Years 2013-2015	Percent Change for Past 5 Years 2011-2015
	43.0% ▲	71.6% ▲	-3.1% ▼

Description of Activities at the Idaho Site

The 2015 collective TED at Idaho was 123.232 person-rem (1,232.32 person-mSv), a 43 percent increase compared with 86.202 person-rem (862.020 person-mSv) in 2014.

Idaho National Laboratory

In 2015, 4,143 individuals were monitored at INL, and of these, 722 individuals had measurable TED, a 23 percent increase from 2014. There was a collective TED of 48.188 person-rem (481.880 person-mSv) in 2015. This represents an increase of 33 percent compared with 2014 (36.162 person-rem [361.620 person-mSv]).

The radiation exposure activities performed during 2015 at the INL Site included work at the Advanced Test Reactor (ATR) Complex, including experiment system operations, plant maintenance modifications, routine ATR power operations, routine ATR outage operations, and Research and Development Operations/Laboratory Support.

In addition, activities at the Materials and Fuel Complex included maintenance at the analytical and radiochemistry laboratories, operations maintenance at the experimental fuels facility, spent fuel treatment product handling, conditioning and manufacturing facilities, stress testing, routine operations, and Zero Power Physics Reactor fuel handling. At the Central Facilities Area, Transient Reactor Test (TREAT) reactor, and Idaho Falls Facilities, training exercises increased for the Homeland Security/Defense Threat Reduction Agency (DTRA) and radiation instrument calibrations and health physics instrumentation laboratory work was conducted.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Advanced Mixed Waste Treatment Project (AMWTP)

In 2015, there were 864 persons monitored at AMWTP, and of these, 251 individuals had measurable TED, representing a 15 percent increase from 2014. The collective TED in 2015 was 20.633 person-rem (206.330 person-mSv) . This represents a 39 percent increase from 2014 (14.894 person-rem [148.940 person-mSv]).

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

Exhibit 3-13 (Continued):
Activities Significantly Contributing to Collective TED in 2015.

Description of Activities at the Idaho Site (continued)

The primary work activities at the AMWTP that contributed to workforce dose consisted of TRU waste retrieval, waste characterization, waste handling operations, maintenance activities, and shipment of TRU and by-product waste materials. Shipments of TRU waste are prepared for permanent disposal at DOE's Waste Isolation Pilot Plant (WIPP) facility and Low Level Waste or Mixed Low Level Waste are being sent to other commercial disposal sites. There were no significant unplanned radiological events encountered in 2015.

The general increase in collective TED in 2015 can be attributed to processing waste with a higher external exposure rate.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Idaho Cleanup Project (ICP)

The DOE contractor at ICP submitted 1,301 records, which included 351 individuals with measurable dose (a 1 percent decrease from 2014). The collective TED for 2015 was 54.305 person-rem (543.050 person-mSv). This represents a 55 percent increase from 2014 (34.972 person-rem [349.720 person-mSv]).

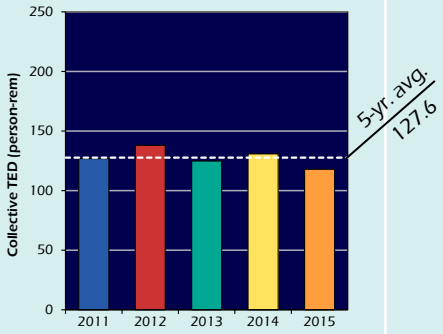
ICP activities during 2015 leading to radiation exposure included Waste Management activities working with remote-handled transuranic (RH-TRU) waste. Nuclear Material Disposal, Balance of Plant, and work performed to support Battelle Energy Alliance, LLC, exposure activities included maintenance and upgrade of the Sodium Distillation System (SDS), the CPP-666 Resin Changeout, and Navy fuel shipments; Valve box B-3 modifications and cleanout; radioactive material (RAM) calibrations in high radiation areas; and waste removal from the Zircex project. Other exposure activities involved the Accelerated Retrieval Project drums for targeted waste and the Sludge Repackaging Project (SRP) drums of waste that had higher radiation levels than these activities in 2014.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Department of Energy Idaho Operations Office

The Department of Energy Idaho Operations Office monitored 222 individuals in 2015, and of those, 7 individuals had measurable TED (a 46 percent decrease from the 13 individuals in 2014). The collective TED for 2015 was 0.106 person-rem (1.060 person-mSv), which was a 49 percent decrease from 2014 (0.208 person-rem [2.080 person-mSv]). The largest individual TED for the year was 0.034 rem (0.340 mSv)

No individual exceeded 2 rem (20 mSv) TED in 2015.

Oak Ridge	Percent Change for Last Year 2014-2015	Percent Change for Past 3 Years 2013-2015	Percent Change for Past 5 Years 2011-2015
	-10.0% ▼	-5.6% ▼	-7.1% ▼

Description of Activities at Oak Ridge

The 2015 collective TED at all Oak Ridge Sites was 117.766 person-rem (1,177.660 person-mSv), a 10 percent decrease compared with 2014 (130.814 person-rem [1,308.140 person-mSv]).

Y-12 National Security Complex (Y-12)

During 2015, Y-12 reported monitoring 5,726 individuals and 1,200 individuals had measurable TED, a 10 percent decrease from 2014 (see *Exhibit 3-12* for more details). The collective TED decreased 3 percent from 59.296 person-rem (592.960 person-mSv) in 2014 to 57.783 person-rem (577.830 person-mSv) in 2015. While statistically consistent with the

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

Exhibit 3-13 (Continued):
Activities Significantly Contributing to Collective TED in 2015.

Description of Activities at Oak Ridge (continued)

previous year, the decrease in TED can be attributed to intermittent work stoppages throughout the year because of weather and other factors.

The collective CED remained consistent in 2015 at 48.5 person-rem (485 person-mSv) compared with 49.0 person rem (490 person-mSv) in 2014.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Oak Ridge National Laboratory (ORNL)

In 2015, ORNL reported monitoring 4,032 individuals, and 598 individuals received a measurable TED (see *Exhibit 3-12* for more details). This was a 3 percent decrease in the number of individuals with measurable TED compared with 2014. The collective TED for ORNL in 2015 was 59.802 person-rem (598.020 person-mSv). This represents a 16 percent decrease from 2014 (71.304 person-rem [713.040 person-mSv]).

The transuranic waste processing center (TWPC) reported a collective TED of 24.018 person-rem (240.180 person-mSv) for 2015, a decrease of 36 percent from 2014 (37.300 person-rem [373 person-mSv]). TWPC's reduction in collective TED was due to several production processes completing or ramping down considerably near the end of their life cycle. These processes include cask processing enclosure RH-TRU waste processing and the contact handled TRU waste stream. Waste movements on site, historically TWPC's highest dose, decreased as a result of less onsite activity.

No individual exceeded 2 rem (20 mSv) TED at ORNL during 2015.

Oak Ridge Institute for Science and Education (ORISE)

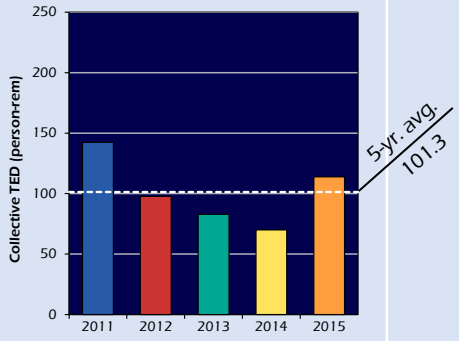
In 2015, ORISE reported 91 individuals, which included 10 individuals with measurable dose (see *Exhibit 3-11* for more details). The collective TED for the 2015 monitoring year was 0.122 person-rem (1.220 person-mSv), a decrease from 2014 (0.210 person-rem [2.100 person-mSv]).

East Tennessee Technology Park (ETTP)

In 2015, the DOE cleanup contractor monitored 359 individuals and 4 individuals had measurable TED (see *Exhibit 3-11* for more details). The 2015 collective TED was 0.059 person-rem (0.590 person-mSv), a slight increase from 2014 (0.004 person-rem [0.040 person mSv]).

The major activities performed at DOE cleanup contractor-managed sites in 2015 consisted of environmental restoration work, decontamination and demolition of facilities, surveillance and maintenance tasks, stabilization of inactive facilities, and waste disposition.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Hanford	Percent Change for Last Year 2014-2015	Percent Change for Past 3 Years 2013-2015	Percent Change for Past 5 Years 2011-2015
	62.6% ▲	37.3% ▲	-20.0% ▼

Description of Activities at Hanford

The 2015 collective TED at Hanford was 113.801 person-rem (1,138.010 person-mSv), a 63 percent increase compared with 2014 (70.002 person-rem [700.020 person-mSv]).

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

Exhibit 3-13 (Continued):
Activities Significantly Contributing to Collective TED in 2015.

Description of Activities at Hanford (continued)

At Hanford, the primary reasons for the increase in collective TED were associated with work at the plutonium finishing plant facility. This work included the dismantlement of two large glove boxes in the process lines and the cleanout of the plutonium recovery facility canyon. These work activities were also the main driver for the 70 percent increase in extremity dose. The collective dose from the DOE ORP increased by a factor of 2.7. The largest work scope contributors to this increase were the 102-AP pump work in October and the AX duct isolation. This work also contributed to a collective extremity dose increase nearly 4 times the dose seen in 2014. Due to changes in funding, several Hanford projects continued to operate at minimal levels.

Hanford Site

There were 6,653 individuals monitored at Hanford in 2015. Of these, 687 individuals had measurable TED, which was a 4 percent increase from 2014 (see *Exhibit 3-12* for more details). The TED increased 54 percent from 40.715 person-rem (407.150 person-mSv) in 2014 to 62.612 person-rem (626.120 person-mSv) in 2015.

No individual exceeded 2 rem (20 mSv) TED in 2015.

The Office of River Protection (ORP)

In 2015, the ORP monitored 2,596 individuals, which included 648 individuals with measurable TED, a 57 percent increase from 2014 (see *Exhibit 3-12* for more details). The 2015 collective TED increased 163 percent from 14.653 person-rem (146.530 person-mSv) in 2014 to 38.608 person-rem (386.080 person-mSv) in 2015.

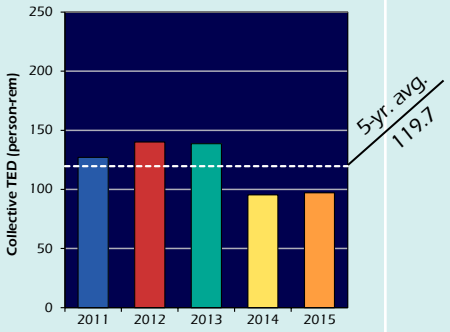
No individual exceeded 2 rem (20 mSv) TED in 2015.

Pacific Northwest National Laboratory (PNNL)

In 2015, PNNL monitored 2,413 individuals, and of these, 461 individuals had measurable TED, a 4 percent decrease from 2014 (see *Exhibit 3-12* for more details). The collective TED at PNNL in 2015 was 12.581 person-rem (125.810 person-mSv), a 14 percent decrease from the previous year (14.634 person-rem [146.340 person-mSv]).

The collective dose for 2015 compared with 2014 was lower due to a reduction of source-term used at PNNL.

No individual exceeded 2 rem (20 mSv) TED in 2015.

Los Alamos National Laboratory	Percent Change for Last Year 2014-2015	Percent Change for Past 3 Years 2013-2015	Percent Change for Past 5 Years 2011-2015
	1.9% ▲	29.9% ▲	-23.5% ▼

Description of Activities at Los Alamos National Laboratory

The 2015 collective TED at LANL was 97.209 person-rem (972.090 person-mSv). This was a 2 percent increase from the previous year (95.436 person-rem [954.360 person-mSv]). LANL monitored 9,509 individuals, and of these, 1,135 had measurable TED, a 19 percent decrease from 2014 (see Exhibit 3-12 for more details).

TA-55 Plutonium Facility operations accounted for the majority of occupational dose at LANL in 2015—historically consistent for LANL. Occupational dose was accrued from weapons manufacturing and related work, Pu-238 work, repackaging materials, and providing radiation control technicians (RCT) and other infrastructure support for radiological work and facility maintenance at TA-55. The top 25 doses at LANL in 2015 were accrued at TA-55. A primary contributor to dose in 2015 was work with Pu-238, producing general purpose heat sources for use individually and in radioisotope

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

Exhibit 3-13 (Continued):
Activities Significantly Contributing to Collective TED in 2015.

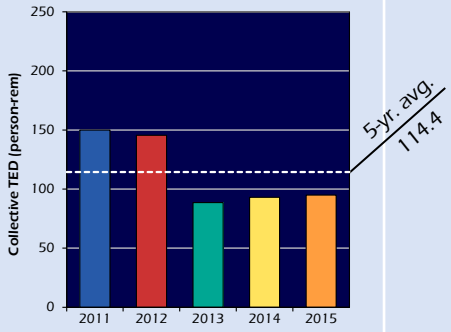
Description of Activities at Los Alamos National Laboratory (continued)

thermoelectric generators. Doses at TA-55 would have been significantly higher in the balance of these areas; however, affected programmatic work was in the process of formal resumption following a work pause in 2013 associated with the criticality safety program.

In addition to TA-55 operations, a significant portion of LANL dose was accrued by workers commensurate with programmatic and maintenance work at the TA-53 Los Alamos Neutron Science Center.

Also, a portion of LANL dose was accrued by workers performing retrieval, repackaging, and shipping of radioactive solid waste within LANL facilities and at waste facilities TA-50 and TA-54. Work with solid waste was curtailed early in 2014 due to the contamination release event at the Waste Isolation Pilot Plant and its association with LANL waste.

No individual received over 2 rem (20 mSv) TED at LANL during 2015.

Savannah River Site	Percent Change for Last Year 2014-2015	Percent Change for Past 3 Years 2013-2015	Percent Change for Past 5 Years 2011-2015
	2.0% ▲	7.1% ▲	-36.7% ▼

Description of Activities at the Savannah River Site

The 2015 collective TED at SRS was 94.871 person-rem (948.710 person-mSv). This was 2 percent higher than 2014 (93.027 person-rem [930.270 person-mSv]). The SRS collected records for 6,241 individuals in 2015, and 1,882 individuals had a measurable TED (see *Exhibit 3-12* for more details). The number of individuals with measurable TED increased by 19 percent from 2014 to 2015.

This increase was attributed to resuming process operations in portions of the H Canyon to allow for continued spent nuclear fuel dissolution. The H Canyon is the only operating production-scale, radiologically shielded chemical separations facility in the United States. In addition, Savannah River Nuclear Solutions (SRNS) dismantled a 10,000-square-foot former waste storage facility that formerly stored hundreds of 55-gallon drums containing radioactive TRU waste.

No individual exceeded 2 rem (20 mSv) TED in 2015.

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

In addition to the information provided in *Exhibit 3-13*, 22 DOE sites reported a description of activities as they relate to occupational exposure, as requested in the REMS Reporting Guide, Item 1. The full text of these descriptions can be found in section 3.4.4. In this section, explanations for increases and decreases in the collective dose at DOE sites ranging from improvements in implementing the ALARA process to changes in decommissioning activities are discussed.

Overall, the majority of sites reported minimal increases in collective dose.

3.4.4 Additional Site Descriptions

The following descriptions were provided by the sites not previously included in *Exhibit 3-13*. The REMS Reporting Guide, Item 1, specifies that the sites should provide a description of activities conducted at the site as they relate to the collective radiation exposure received.

Ames

Ames Laboratory is a government-owned, contractor-operated research facility of the DOE. For over 65 years, the Ames Laboratory has sought solutions to energy-related problems through the exploration of chemical, engineering, materials, mathematical, and physical sciences.

There were 158 individuals monitored in 2015, and of these, 39 individuals had measurable TED, an 18 percent increase from 2014. The collective TED was 1.247 person-rem (12.470 person-mSv) in 2015, which was a 43 percent increase from 2014. No individuals exceeded 2 rem (20 mSv) TED for this monitoring year.

The use of X-ray devices and remediation of radiological legacy contamination are the primary paths of potential exposure. The laboratory has 22 X-ray systems and one Mossbauer spectroscopy system. Limited radioactive material research activities are conducted utilizing microgram quantities.

ANL

Argonne National Laboratory (ANL) is one of the DOE's largest national laboratories for scientific and engineering research. The lab's mission is to apply a unique mix of world-class science, engineering, and user facilities to deliver innovative research and technologies.

There were 1,950 individuals monitored in 2015, and of these, 82 individuals had measurable TED, a slight decrease from 2014. The collective TED was 14.767 person-rem (147.670 person-mSv) in 2015, which was a 10 percent decrease from 2014. No individuals exceeded 2 rem (20 mSv) TED for this monitoring year.

The decrease in collective TED can be attributed to the reduction of the laboratory administrative ALARA goal from 1 rem (10 mSv) to 0.500 rem (5 mSv) and a concerted effort to pre-plan work. Also, the downgrading of Alpha Gamma Hot Cell Facility from hazard category 2 to 3 and the reduction of the source term also contributed to the decrease in collective dose.

BNL

Brookhaven National Laboratory (BNL) conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security. BNL also builds and operates major scientific facilities available to university, industry, and government researchers.

There were 3,013 individuals monitored in 2015, and of these, 134 individuals had measurable TED, a 4 percent increase from 2014. The collective TED was 3.345 person rem (33.450 person mSv) in 2015, which was a 54 percent decrease from 2014. No individuals exceeded 2 rem (20 mSv) TED for this monitoring year.

ETEC

The Energy Technology Engineering Center (ETEC) is located within area IV of the Santa Susana Field Laboratory. The laboratory comprises four discrete operational areas with two adjacent undeveloped properties. In 1988, DOE decided to close the remaining ETEC operations. With the closing of DOE operations, the focus turned to the disposition of government property, cleanup of facilities, the investigation and remediation of soil and groundwater, demolition of facilities, and site restoration. Area IV is undergoing characterization for cleanup of the area. ETEC is currently in a safe shutdown mode, pending the completion of the Environmental Impact Statement.

There were 6 individuals monitored in 2015, and of these, 3 individuals had measurable TED, a 96 percent decrease from 2014. The collective TED was 0.068 person-rem (0.680 person-mSv) in 2015, which was an 86 percent decrease from 2014. No individuals exceeded 2 rem (20 mSv) TED for this monitoring year.

The former ETEC facility is not operational and only maintenance activities are being performed until preparation of the Environmental Impact Statement is completed.

Fermilab

Fermi National Accelerator Laboratory (Fermilab) advances the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers of high-energy physics and related disciplines.

In 2015, Fermilab reported 1,301 monitored individuals, and of these, 235 individuals had measurable TED, a 22 percent increase compared with 2014. During 2015, the collective TED was 16.640 person-rem (166.400 person-mSv), which was a 50 percent increase from 2014.

During 2015, the primary activities at Fermilab that resulted in occupational radiation exposures were upgrade and repair activities of the Fermilab accelerator. A 16-week shutdown of the accelerator complex occurred during 2015. Nearly all radiation doses to personnel were due to exposures to items activated by the accelerated beams. One unanticipated exception is the SeaQuest collaboration. Nine members of this collaboration received a neutron dose while working in the SeaQuest experimental hall during 2015, with a collective dose of 380 person-mrem (3,380 person-mSv). On July 4, 2015, Fermilab began a maintenance and upgrade shutdown to prepare the accelerator and associated facilities for new experiments at much larger beam powers to support the current and future research at the laboratory. The vast majority of the work performed during this shutdown was also intended to improve operational reliability and, hence, reduce maintenance needs in the future. This included upgrades in booster, recycler, main injector, and neutrinos at main injector areas.

KCP

The NNSA Kansas City Plant (KCP) is responsible for manufacturing and procuring nonnuclear components for nuclear weapons, including electronic, mechanical, and engineered material components. It supports national laboratories, universities, and U.S. industry and is located in Kansas City, Missouri.

In 2015, KCP reported 100 monitored individuals, and of these, 12 individuals had measurable TED compared with 11 persons with measurable TED in 2014. The collective TED was very low, 0.020 person-rem (0.200 person-mSv) in 2015 and 0.022 person-rem (0.220 person-mSv) in 2014. No individuals exceeded 2 rem (20 mSv) TED for this monitoring year.

LBNL

Lawrence Berkeley National Lab (LBNL) is a member of the national laboratory system supported by DOE through its Office of Science and is charged with conducting unclassified research across a wide range of scientific disciplines. Located on a 200-acre site, Berkeley Lab employs approximately 4,200 scientists, engineers, support staff, and students.

The total number of employees monitored for radiation exposure at LBNL in 2015 was 866, and of these, 11 individuals had measurable TED, a slight increase from 8 in 2014. The collective TED was 0.796 person-rem (7.960 person-mSv), an increase of 72 percent from 2014.

An increase in the number of experiments performed in the Center for Functional Imaging, specifically activities associated with new radiopharmaceutical (Fluorine-18/Carbon-11) development, accounted for the increase in collective TED for 2015. No individual exceeded 2 rem (20 mSv) TED for this monitoring year.

LLNL

Lawrence Livermore National Laboratory (LLNL) is a DOE facility operated by the Lawrence Livermore National Security, LLC management team, which includes Bechtel, the University of California, BWX Technologies, Washington Group, and Battelle. The site serves as a national resource of scientific, technical, and engineering capability with a special focus on national security. LLNL's mission encompasses such areas as strategic defense, energy, the environment, biomedicine, technology transfer, education, counter-terrorism, and emergency response. Support of these operations requires the use of a wide range of radiation-producing devices (e.g., X-ray machines, accelerators, electron-beam welders) and radioactive material. The types of radioactive materials range from tritium to TRU; the quantities range from nanocuries (i.e., normal environmental background values) to kilocuries.

The combined total number of employees monitored for radiation exposure at LLNL (which includes LLNL and LLNL-Nevada) in 2015 was 8,146, and of these, 106 individuals had measurable TED, a 2 percent decrease from 2014. The collective TED was 7.602 person-rem (76.020 person-mSv), a 9 percent decrease from 2014.

In 2015, 7,944 people were monitored at LLNL, and of these, 99 people had measurable TED, a 1 percent decrease from 2014. The collective TED for LLNL in 2015 was 7.219 person-rem (72.190 person-mSv), a 5 percent decrease from 2014. This was due to decreased operations in the plutonium facility and at LLNL. There was also a decrease in the monitored population. No individual exceeded 2 rem (20 mSv) TED for this monitoring year.

LLNL-Nevada is a DOE facility that serves as a national resource of scientific, technical, and engineering capability with a special focus on national security.

For 2015, LLNL-Nevada monitored 202 individuals and 7 individuals had measurable TED, a 13 percent decrease from 2014. The collective TED for LLNL-Nevada was 0.383 person-rem (3.830 person-mSv) compared with 0.791 person-rem (7.910 person-mSv) in 2014.

No individual exceeded 2 rem (20 mSv) TED for this monitoring year.

NBL

The New Brunswick Laboratory (NBL) is a Government-owned, Government-operated center of excellence in the measurement science of nuclear materials. Specific operations involving radioactive material include destructive and nondestructive measurements of nuclear materials including plutonium and uranium. Additionally, NBL conducts research to develop improved measurement technology applied to nuclear materials and management of interlaboratory measurement evaluation programs.

In 2015, NBL monitored 20 individuals, and of these, no individuals had measurable TED. The collective TED at NBL for 2015 was zero because analytical chemistry operations with radioactive material remained suspended for the year 2015. Radiological work consisted of maintenance of mechanical systems, radiological surveillance activities in controlled and radiological areas, packaging and shipping of small quantities of radioactive material, and walkthroughs and inspections of controlled and radiological areas.

No individual exceeded 2 rem (20 mSv) TED this monitoring year.

NNSS

The Nevada National Security Site (NNSS) is located approximately 65 miles northwest of Las Vegas, Nevada. It is a remote facility that covers approximately 1,375 square miles of land. The NNSS has been the primary location for testing nuclear experiments in the continental United States since 1951. Current activities include operating low-level radioactive and mixed-waste disposal facilities; assembly and execution of subcritical experiments; confined critical experiments; assembly/disassembly of special experiments; operation of pulsed X-ray machines and neutron generators; accelerator experiments; development, testing, and evaluation of radiation detectors; emergency response training; surface cleanup and site characterization of contaminated land areas; environmental activity by the University of Nevada system; and non-nuclear test operations such as controlled spills of hazardous materials.

In 2015, NNSS monitored 2,267 people, and of these, 98 people had a measurable TED, a 16 percent decrease compared with 2014. The collective TED for 2015 at NNSS was 5.045 person-rem (50.450 person-mSv), which represented an 11 percent decrease in TED from 2014.

The decrease in dose was caused by delayed activities associated with critical experiments and the termination of accelerator activities. No individual exceeded 2 rem (20 mSv) TED this monitoring year.

NREL

The National Renewable Energy Laboratory (NREL) focuses on creative answers to today's energy challenges. From fundamental science and energy analysis to validating new products for the commercial market, NREL researchers are dedicated to transforming the way the world uses energy. With more than 35 years of successful innovation in energy efficiency and renewable energy, NREL discoveries provide sustainable alternatives for powering homes, businesses, and transportation systems.

In 2015, NREL monitored 8 people, and of these, 4 people had a measurable TED, a 43 percent decrease from 2014. The collective TED decreased by 74 percent from 2014 (0.107 person-rem [1.070 person-mSv]) to 2015 (0.028 person-rem [0.280 person-mSv]).

The primary reason for the decrease was a reduction in work involving radiation exposure. The number of individuals exceeding 2 rem (20 mSv) TED for this monitoring year was zero.

OST

The Office of Secure Transportation (OST) is the NNSA organization tasked to provide secure ground transportation of nuclear weapons, special nuclear material (SNM), nuclear weapon components, and nuclear explosive-like assemblies. OST operates both secure ground transporters and Federal aircraft, which combined make up the Transportation Safeguards System (TSS). TSS Federal Agent and vehicle maintenance facilities are located in Oak Ridge, Tennessee, Amarillo, Texas, and Albuquerque, New Mexico. OST Administrative Headquarters are located on Kirtland Air Force Base in Albuquerque, New Mexico. The TSS is a national security transportation asset specifically assigned to transport cargoes in the national interest for which commercial carriage is largely prohibited. OST is also tasked to be the Federal air carrier to support US weapon accident, national nuclear, and radiological response capability. In support of the active U.S. nuclear weapon stockpile, OST delivers by air and ground limited life components to the Department of Defense and NNSA production sites. OST also provides secure ground transportation services to other DOE and NNSA program offices, to the Department of the Navy, and to the U.S. Nuclear Regulatory Commission (NRC), as well as when requested to other Federal agencies. Federal Agents provide physical security and safety inspection of air and ground transporters and cargoes and thus are primarily the OST employees enrolled in the OST dosimetry monitoring program.

OST employees are monitored and OST ALARA-based instructions are in place such that 10 CFR 835 occupational worker limits are observed. OST ES&H staff track and on occasion will direct cargo loading revisions so as to minimize radiation exposure to both DOE contractor loading personnel as well as OST Federal Agents. With concurrence of DOE sites, OST prefers to track OST employee dose under OST's dosimetry reporting program rather having OST employees be tracked by each DOE site that the TSS services.

In 2015, OST monitored 345 individuals, and of these, 2 individuals had measurable TED, a 60 percent decrease from 2014. The TED to OST workers in 2015 was 0.029 person-rem (0.290 person-mSv), which represented a 68 percent decrease from the total person-rem dose in 2014. No individual exceeded their assigned ACL in 2015.

Between 2010 and 2015, it was expected that OST annual TED would continue to fall as a result of retirement of several higher exposure weapons systems and design enhancement to Type B packaging.

Pantex

The DOE/NNSA Pantex Plant is the nation's only facility for assembly and disassembly of nuclear explosives. The operations that contribute the majority of the dose to Pantex Plant workers are operations that expose them to large numbers of bare weapon pits (the pits contain significant quantities of SNMs). These operations include nuclear explosive assembly/disassembly operations, weapon dismantlement programs, life-extension programs, Special Nuclear Material Component Re-qualification, and SNM staging.

In 2015, Pantex monitored 3,288 individuals, and of these, 301 individuals had measurable TED, a 1 percent decrease from 2014. The TED to Pantex Plant workers in 2015 was 22.618 person-rem (226.180 person-mSv), which represented a 27 percent decrease from the total person-rem dose in 2014. No individual exceeded their assigned ACL in 2015.

The primary reason for the decreased population dose in 2015 was a union strike that curtailed production near the end of the year.

PGDP

PGDP is located 3 miles south of the Ohio River and is 12 miles west of Paducah, Kentucky. The plant began enriching uranium in 1952, first for the nation's nuclear weapons program and then for nuclear fuel for commercial power plants. In 1994, the enrichment facilities were leased to United States Enrichment Corporation (USEC). In August 2013, USEC notified DOE that they were discontinuing enrichment operations and planning to de-lease the enrichment facilities.

In 2015, the PGDP monitored 2,786 individuals, which included 337 individuals with measurable TED, a 242 percent increase compared with 2014. The overall collective TED for the PGDP was 7.058 person-rem (70.580 person-mSv), a 32 percent decrease from 2014. The following description provides a breakdown of the various activities at this site.

The DOE remediation services contractor's exposure information for 2015 covers activities performed under the DOE contract scope for environmental remediation, facility decontamination, and final assessment of buildings and areas at the Paducah Site.

The collective TED for 2015 was 0.179 person-rem (1.790 person-mSv) and 12 individuals received a measurable dose. The number of individuals exceeding 2 rem (20 mSv) TED for 2015 was zero. There were no unusual events related to occupational radiation exposure at the Los Alamos Technical Associates Kentucky facilities for 2015.

The Depleted Uranium Hexafluoride (DUF_6) contractor monitored 537 individuals, and of these, 149 received a measurable TED. The collective TED for 2015 was 5.51 person-rem (55.100 person-mSv). The primary reason for this 82 percent decrease was due to operations near the UF_6 storage location. The number of individuals exceeding 2 rem (20 mSv) TED for 2015 was zero. There were no unusual events related to occupational radiation exposure for 2015.

The DOE oversight contractor's collective TED for the 2015 monitoring year was 0.270 person-rem (2.700 person-mSv). In 2015, the number of individuals with measurable TED remained the same (39) compared with 2014. The collective TED was due to a major change in work scope that involved adding multiple facilities and work areas that were previously not maintained. In addition to the added work scope, staffing was increased by 13 percent from the previous year in order to maintain the added work load.

The DOE Paducah Deactivation Project contractor's collective TED for the 2015 monitoring year was 1.099 person-rem (10.990 person-mSv) and included 137 individuals with measurable TED. The primary reason for this collective TED was due to a full year of Paducah Deactivation Project work activities in 2015 versus only one quarter of work activities on the new 2014. The number of individuals exceeding 2 rem (20 mSv) TED for this monitoring year was zero.

PORTS

The Portsmouth Gaseous Diffusion Plant (PORTS) is located in Pike County, Ohio. PORTS was one of three large gaseous diffusion plants initially constructed to produce enriched uranium to support the nation's nuclear weapons program and later enriched uranium used by commercial nuclear reactors. The plant is shut down and currently undergoing decontamination and decommissioning (D&D). In 2015, PORTS monitored 2,382 individuals, which included 59 people with measurable TED, a 38 percent decrease from 2014. The collective TED in 2015 at PORTS was 4.716 person-rem (47.160 person-mSv), a 54 percent decrease compared with 2014. The following description provides a breakdown of the various activities at this site.

The DOE D&D contractor's exposure information for 2015 covers activities performed under the DOE contract and includes environmental remediation, facility decontamination, and uranium barter transfers at the Portsmouth Site. The collective TED for 2015 was 2.442 person-rem (24.420 person-mSv), a 31 percent decrease compared with 2014. The number of individuals with measurable TED decreased by 15 percent in 2015 (33) compared with 2014 (39). This decrease was primarily due to three contributing factors. The first two factors were in support of the barter production project, which had a 4-week period during 2015 where production was nearly halted (contributing to less dose exposure). Secondly, the barter production project handled cylinders that contained less material. This clearly accounted for a further reduction in dose for 2015. Third, the drum overpack campaign in the X-744G (a dose contributor last year) was completed and replaced with a thorium overpack container box operation that contributed very little, if any, dose. These three factors appear to account for the reduction of TED this year.

The depleted uranium hexafluoride (DUF_6) contractor's collective TED for 2015 was 2.274 person-rem (22.740 person-mSv), a 66 percent decrease compared with 2014. The number of individuals with measurable TED decreased by 54 percent in 2015 (26) compared with 2014 (56). The decrease in overall collective dose at the Babcock & Wilcox Conversion Services Portsmouth DUF_6 Conversion Facility was largely a result of the plant's operational status. During calendar year 2015, there were a number of issues that lead to the ultimate shut down of the Portsmouth facility. Additionally, with limited operational work, all support functions had limited support, which also reduced the overall collective dose.

The number of individuals exceeding 2 rem (20 mSv) TED for 2015 was zero.

PPPL

The DOE's Princeton Plasma Physics Laboratory (PPPL) is a collaborative national center for fusion energy research. The Laboratory advances the coupled fields of fusion energy and plasma physics research and is developing with collaborators the scientific understanding and key innovations needed to realize fusion as an energy source for the world.

In 2015, data were submitted for 380 individuals, and of these, 126 individuals had measurable TED, a 2 percent increase compared with 2014 (123 individuals with measurable TED). The collective TED decreased by 10 percent from 2014 (0.693 person-rem [6.930 person-mSv]) to 2015 (0.623 person-rem [6.230 person-mSv]).

The primary reason for this change was attributed to reduced access to the NSTX-U test cell during the last quarter of 2014. Work continued on NSTX-U for more than half of 2015, in preparation for the start of operations to begin in fiscal year 2016. In early September, the vessel went into a testing and bakeout phase, resulting in limited access to the test cell by individuals. The commissioning phase started in the beginning of November, further restricting access. Plasma operations began in mid-December with access only on second shift, after a cool down period.

A work-for-others project necessitated the use of ring dosimetry in February 2015. Subsequently, 3 individuals received positive extremity doses within the expected dose limits. No individual exceeded 2 rem (20 mSv) TED or any DOE occupational dose limit during 2015 at PPPL.

SLAC

SLAC National Accelerator Laboratory (SLAC) is one of 10 U.S. Department of Energy (DOE) Office of Science laboratories and is operated by Stanford University on behalf of DOE. Since its opening in 1962, SLAC has been helping create the future. SLAC built the world's longest particle accelerator and discovered some of the fundamental building blocks of matter.

SLAC's scientific mission has diversified from an original focus on particle physics and accelerator science to include cosmology, materials and environmental sciences, biology, chemistry, and alternative energy research. The main instrument of research is the 3.2-km linear accelerator (LINAC), which can generate high-intensity beams of electrons and positrons up to 50 GeV. New research areas and projects at SLAC have often evolved as the offspring of the original linear accelerator and storage rings.

Sections of the linear accelerator that defined the lab and its mission in its formative years are still driving electron beams today as the high-energy backbone of two cutting-edge facilities. The world's first hard X-ray free-electron laser, the LINAC coherent light source (LCLS), began operating in 2009. The LCLS uses the last kilometer of the SLAC LINAC. The facility for accelerator science and experimental test in LINAC was completed in 2011 to study plasma acceleration, using short, intense pulses of electrons and positrons to create an acceleration source called a plasma wakefield accelerator.

There is also an active program in the development of accelerators, radio frequency (RF) power sources, detectors, and new sources and instrumentation for synchrotron radiation research. Another facility, Stanford synchrotron radiation lightsource, has a smaller storage ring, the Stanford positron-electron asymmetric ring (SPEAR3), and a separate, shorter linear accelerator and a booster ring for injecting accelerated beams of electrons into SPEAR3. The klystron test laboratory manufactures all the klystrons used in SLAC accelerators, as well as novel structures and components for future accelerators; it supports RF operations of SLAC accelerators; and it operates a 70-MeV X band research accelerator and laser facility capable of producing subpicosecond beam bunches.

The 2015 report contained 1,975 records, which included 2 people with measurable TED, a 78 percent decrease compared with 2014. Collective TED in 2015 was 0.069 person-rem (0.690 person-mSv), a 72 percent decrease compared with 2014. This decrease was attributed to reductions in radiological entries (or workloads) into various radiological control areas compared with 2014. The 2015 collective TED is still low and reflects normal routine operations at SLAC.

No individual exceeded 2 rem (20 mSv) TED or any DOE occupational dose limit during 2015 at SLAC.

SNL

Sandia National Laboratories (SNL) radiological operations include operation of a research reactor, gamma irradiation facility, hot cell facility, and several accelerators; light laboratory work involving X-ray machines and use of tracer radionuclides; and waste operations.

In 2015, SNL monitored 1,974 individuals, and of these, 99 individuals had measurable TED, a 13 percent increase from 2014. The total collective TED reported was 5.284 person-rem (52.840 person-mSv), a 12 percent decrease from 2014.

The 2015 TED decrease was attributed to a decreased number of waste and material disposition campaigns at the auxiliary hot cell facility and experiments at the annular core research reactor, as compared with those occurring in 2014.

SPRU

The Separations Process Research Unit (SPRU) is located at Knolls Atomic Power Laboratory based in upstate New York. Built in the 1940s, the buildings supported the SPRU mission to research the chemical process to extract plutonium from irradiated materials. Although equipment was flushed and drained and bulk waste was removed following the shutdown of the facilities in 1953, residual materials are present in the tanks, buildings H2 and G2, and interconnecting pipe tunnels.

In 2015, SPRU monitored 231 individuals, and of these, 149 had measurable TED, a 96 percent increase compared with 2014. The collective TED for 2015 was 69.291 person-rem (692.910 person-mSv), a 642 percent increase from 2014. The number of individuals exceeding 2 rem (20 mSv) TED for this monitoring year was zero.

The primary reason for this change was due to significant work activity in both the G2 and H2 buildings for maintenance, characterization, dewatering, venting and draining, and D&D. The activities resulting in the major person rem contribution were the characterization and D&D of the G2 and H2 buildings, as well as the shipping of higher activity piping and equipment and debris removal from the G2 cells. In addition, the continued surveillance and maintenance activities to maintain site conditions, process and shipment of low activity water, and shipment of low activity debris added to the collective TED contribution.

TJNAF

Thomas Jefferson National Accelerator Facility (TJNAF) is one of 17 national laboratories funded by DOE. TJNAF's primary mission is to conduct basic research of the atom's nucleus using the unique particle accelerator known as the Continuous Electron Beam Accelerator Facility.

In 2015, TJNAF monitored 1,168 individuals, which included 47 individuals with measurable TED, a 12 percent increase from 2014. The 2015 collective TED for TJNAF was 3.153 person-rem (31.530 person-mSv), a decrease of 29 percent from 2014. No individual exceeded 2 rem (20 mSv) TED for this monitoring year.

In general, collective TED was attributed to maintenance, modification, and repair to activated components associated with the Continuous Electron Beam Accelerator Facility and other ancillary activities (e.g., transport, storage, and disposal of radioactive materials). Typically, collective TED fluctuates up or down from year to year, depending on maintenance associated with unique experimental set-ups performed in radiation areas. The decrease in collective TED was commensurate with the type of work performed by the individuals in 2015.

UMTRA

The Uranium Mill Tailings Remediation Action Project (UMTRA) site is located approximately 3 miles northwest of Moab in Grand County, Utah, and includes a former uranium-ore processing facility. The site encompasses 480 acres, of which approximately 130 acres are covered by a uranium mill tailings pile. The UMTRA Project ships two trainloads of tailings each day. The trains have up to 36 railcars, each holding four lidded containers, for a total of about 5,000 tons of tailings per shipment. Tailing shipments began in April 2009 and are expected to continue through 2025.

In 2015, UMTRA monitored 128 individuals, which included 86 individuals with measurable TED, a 41 percent increase from 2014. The collective TED for 2015 was 7.177 person-rem (71.770 person-mSv) and represented a 7 percent decrease from 2014.

WIPP

The Waste Isolation Pilot Plant (WIPP) is located in the Chihuahuan Desert near Carlsbad, New Mexico. This DOE facility safely disposes of the nation's defense-related TRU radioactive waste. WIPP began disposal operations in March 1999.

In 2015, WIPP monitored 631 individuals, and of these, 12 individuals had measurable TED, a 300 percent increase compared with 2014. The collective TED for 2015 was 0.161 person-rem (1.610 person-mSv), which represented an increase of 374 percent from 2014 (0.034 person-rem [0.340 person-mSv)]).

The primary reasons for this change were the decontamination efforts in the WIPP underground as well as resumption of limited activities.

No individual exceeded 2 rem (20 mSv) TED for this monitoring year.

WVDP

The West Valley Demonstration Project (WVDP) is a unique operation within DOE. It came into being through the WVDP Act of 1980. The Act requires the Department to be responsible for solidifying the high-level waste and disposing of waste created by the solidification and decommissioning of the facilities used in the process. The land and facilities are not owned by the Department. Rather, the project premises are the property of the New York State Energy Research and Development Authority (NYSERDA) and represent only 200 acres of the larger Western New York Service Center, which is approximately 3,300 acres, also owned by NYSERDA. After DOE's responsibilities under the Act are complete, the Act requires that the premises be returned to New York State.

In 2015, WVDP monitored 363 individuals, and of these, 122 individuals had measurable TED, a 9 percent increase from 2014. The collective TED for 2015 was 28.107 person-rem (281.070 person-mSv), which represented a 109 percent increase from 2014.

The major project contributing to dose in 2015 was facility disposition's demolition preparation work in the liquid waste cell, all three extraction cells, the off gas cell/off gas blower room, sample storage cell, and the vitrification facility. The high-level waste department prepared the equipment decontamination room, vitrification tunnel, and the chemical process cell crane room for high-level waste canister movements and the removal of the first three casks containing the vitrified high-level waste. The waste operations department activities supported waste packaging and movements onsite and the preparation of the remote handling waste facility operations.

3.4.5 Summary by Program Office

DOE has divided the responsibility of managing its missions among specific program offices. A site may include facilities or project areas that perform work in support of the mission of multiple program offices. In these cases, the dose records are separated by the reporting organization and assigned to the corresponding program office. For this reason, some sites will have portions of the collective dose shown under more than one program office.

Exhibit 3-14 shows the number of individuals with measurable TED, the collective TED, and the average measurable TED by DOE program office. The Office of Environmental Management (EM) and the NNSA account for the largest percentages of the collective TED (56 and 26 percent, respectively). The mission of EM is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. NNSA is responsible for the management and security of the nation's nuclear weapons, nuclear nonproliferation, and naval reactor programs, as well as responding to radiological emergencies and the transportation of nuclear weapons and SNM. In general, the missions of EM and NNSA require more interaction with and activities involving radioactive materials. These offices account for 82 percent of the collective TED at DOE.

The primary sites contributing to the collective TED within EM are SRS and Idaho. For NNSA, the primary contributors are LANL and Y-12.

A more detailed breakdown of the exposure information by site, program office, and contractor is available at http://energy.gov/ehss/occupational-radiation-exposure in the Appendices section of the Annual Report.

3.5 Transient Individuals

Transient individuals, or transients, are defined as individuals who are monitored at more than one DOE site during the calendar year. For the purpose of this report, a DOE site is defined as a geographic location. During the year, some individuals performed work at multiple sites and, therefore, had more than one monitoring record reported to the repository. In addition, some individuals transferred from one site to another. This section presents information on transient individuals to determine the extent to which individuals traveled from site to site and to examine the doses received by these individuals.

Exhibit 3-14:
Program Office Dose Data, 2015.

Program Office	Collective TED (person-rem)	Percent Change from 2014	Number with Meas. Dose	Percent Change from 2014	Avg. Meas. TED (rem)	Percent Change from 2014
Office of Energy Efficiency and Renewable Energy (EE)					**Total Monitored**	**8***
National Renewable Energy Laboratory	0.028	◊	4	◊	0.007	◊
EE Totals	**0.028**	◊	**4**	◊	**0.007**	◊
Office of Environmental Management (EM)					**Total Monitored**	**23,081***
East Tennessee Technology Park	0.059	◊	4	◊	0.015	◊
Energy Technology Engineering Center	0.068	◊	3	◊	0.023	◊
Hanford Site	62.612	54% ▲	687	4% ▲	0.091	48% ▲
Idaho Site (ICP, AMWTP and DOE IOO)	75.044	50% ▲	609	4% ▲	0.123	44% ▲
Nevada National Security Site	0.034	◊	2	◊	0.017	◊
Oak Ridge National Laboratory	26.551	-34% ▼	221	-22% ▼	0.120	-16% ▼
Office of River Protection	38.608	163% ▲	648	57% ▲	0.060	68% ▲
Paducah Gaseous Diffusion Plant	7.058	-32% ▼	337	**142%** ▲	0.021	-72% ▼
Portsmouth Gaseous Diffusion Plant	4.716	-54% ▼	59	-38% ▼	0.080	-26% ▼
Savannah River Site	**94.871**	2% ▲	**1,882**	19% ▲	0.050	-14% ▼
Separations Process Research Unit	69.291	**642%** ▲	149	96% ▲	**0.465**	**278%** ▲
Service Center Personnel	0.011	◊	1	◊	0.011	◊
Uranium Mill Tailings Remedial Action Project	7.177	-7% ▼	86	41% ▲	0.083	-34% ▼
Waste Isolation Pilot Plant	0.161	◊	12	◊	0.013	◊
West Valley Demonstration Project	28.107	109% ▲	122	9% ▲	0.230	92% ▲
EM Totals	**414.368**	**43%** ▲	**4,822**	**18%** ▲	**0.086**	**21%** ▲
National Nuclear Security Administration (NNSA)					**Total Monitored**	**31,241***
Kansas City Plant	0.020	◊	12	◊	0.002	◊
Lawrence Livermore National Laboratory	7.602	-9% ▼	106	-2% ▼	0.072	-7% ▼
Los Alamos National Laboratory	**97.209**	**2%** ▲	1,135	-19% ▼	**0.086**	**26%** ▲
Office of Secure Transportation	0.029	◊	2	◊	0.015	◊
Nevada National Security Site	5.011	-10% ▼	96	-16% ▼	0.052	7% ▲
Pantex Plant	22.618	-27% ▼	301	-1% ▼	0.075	-26% ▼
Sandia Ntional Laboratories	5.284	-12% ▼	99	**13%** ▲	0.053	-21% ▼
Y-12 National Security Complex	57.783	-3% ▼	**1,200**	-10% ▼	0.048	8% ▲
NNSA Totals	**195.556**	**-5%** ▼	**2,951**	**-12%** ▼	**0.066**	**8%** ▲
Office of Nuclear Energy, Science and Technology (NE)					**Total Monitored**	**4,142***
Idaho National Laboratory	48.188	33% ▲	722	23% ▲	0.067	9% ▲
NE Totals	**48.188**	**33%** ▲	**722**	**23%** ▲	**0.067**	**9%** ▲
Office of Science (SC)					**Total Monitored**	**16,965***
Ames Laboratory	1.247	43% ▲	39	18% ▲	0.032	21% ▲
Argonne National Laboratory	14.767	-10% ▼	82	-2% ▼	**0.180**	-8% ▼
Brookhaven National Laboratory	3.345	-54% ▼	134	4% ▲	0.025	-56% ▼
Fermi National Accelerator Laboratory	16.640	**50%** ▲	235	**22%** ▲	0.071	**23%** ▲
Lawrence Berkeley National Laboratory	0.796	◊	11	◊	0.072	◊
New Brunswick Laboratory	0.000	◊	0	◊	◊	◊
Oak Ridge Institute for Science and Education	0.122	◊	10	◊	0.012	◊
Oak Ridge National Laboratory	**33.251**	7% ▲	377	12% ▲	0.088	-5% ▼
Pacific Northwest National Laboratory	12.581	-14% ▼	**461**	**-4%** ▼	0.027	-11% ▼
Princeton Plasma Physics Laboratory	0.623	◊	126	◊	0.005	◊
Service Center Personnel	0.000	◊	0	◊	◊	◊
SLAC National Accelerator Laboratory	0.069	◊	2	◊	0.035	◊
Thomas Jefferson National Accelerator Facility	3.153	-29% ▼	47	12% ▲	0.067	-37% ▼
SC Totals	**86.594**	**-1%** ▼	**1,524**	**4%** ▲	**0.057**	**-5%** ▼

Note: Bold and boxed values indicate the greatest value in each column.

◊ The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv).

* Individuals who worked at more than one program office are represented within each grouping, therefore the total monitored values will not match the annual number of workers monitored.

Exhibit 3-15 shows the dose distribution and total number of transient individuals from 2011 to 2015. Over the past 5 years, the records of transient individuals have averaged 3 percent of the total records for all monitored individuals at DOE. These individuals received, on an average, 3.5 percent of the collective TED. The collective TED for transients increased slightly from 21.7 person-rem (217 person-mSv) in 2014 to 22.9 person-rem (229 person-mSv) in 2015. The average measurable TED increased 6 percent from 0.050 rem (0.500 mSv) in 2014 to 0.053 rem (0.530 mSv) in 2015. The increase of the average measurable TED was a result of the 1 percent decrease in the number of transient individuals with measurable dose (433 in 2014 to 429 in 2015) and the 6 percent increase of the collective TED. Since 1993, the percentages have remained relatively constant.

The tracking and analysis of transient workers are important aspects of the AU REMS project. While each site is responsible for monitoring individuals during their work at that site, the REMS project collects dose records from all sites and verifies that individuals do not exceed regulatory limits by accruing doses at multiple facilities. Although the number of transient individuals and average doses have been low, the examination of these records remains an important function of AU in assessing performance of DOE worker health and safety programs.

3.6 Historical Data

3.6.1 Prior Years

In order to analyze recent radiation exposure data in the context of the history of radiation exposure at DOE, it is useful to include information prior to the past 5 years as presented in this report. For this reason, *Exhibit 3-16* and *Exhibit 3-17* are presented to show a summary of occupational exposures back to 1974, when the Atomic Energy Commission split into the NRC and the Energy Research and Development Administration, which subsequently became DOE. *Exhibit 3-16* and *Exhibit 3-17* show the collective dose, average measurable dose, and number of workers with a measurable dose from 1974 to 2015. As can be seen from the graphs, all three parameters decreased dramatically between 1986 and 1993. 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.

Exhibit 3-15:
Dose Distribution of Transient Individuals, 2011–2015.

	Dose Ranges (TED in rem)	2011	2012	2013	2014	2015
Transients	Less than measurable	2,085	1,869	1,506	2,152	2,129
	measurable <0.100	493	395	379	377	375
	0.100–0.250	52	39	27	43	39
	0.250–0.500	11	19	15	12	10
	0.500–0.750	1	2	1		3
	0.750–1.000	3	2		1	2
	1–2	2				
	>2					
	Total number of individuals monitored*	2,647	2,326	1,928	2,585	2,558
	Number with measurable dose	562	457	422	433	429
	% with measurable dose	21%	20%	22%	17%	17%
	Collective TED (person-rem)	31.120	26.423	21.947	21.670	22.901
	Average measurable TED (rem)	0.055	0.058	0.052	0.050	0.053
All DOE	Total number of records for monitored individuals	91,857	83,043	71,581	75,445	75,540
	Number with measurable dose	12,965	10,461	9,904	9,501	10,023
	% of total monitored who are transient	2.9%	2.8%	2.7%	3.4%	3.4%
	% of the number with measurable dose who are transient	4.3%	4.4%	4.3%	4.6%	4.3%

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

Exhibit 3-16:
Collective Dose and Average Measurable Dose, 1974–2015.

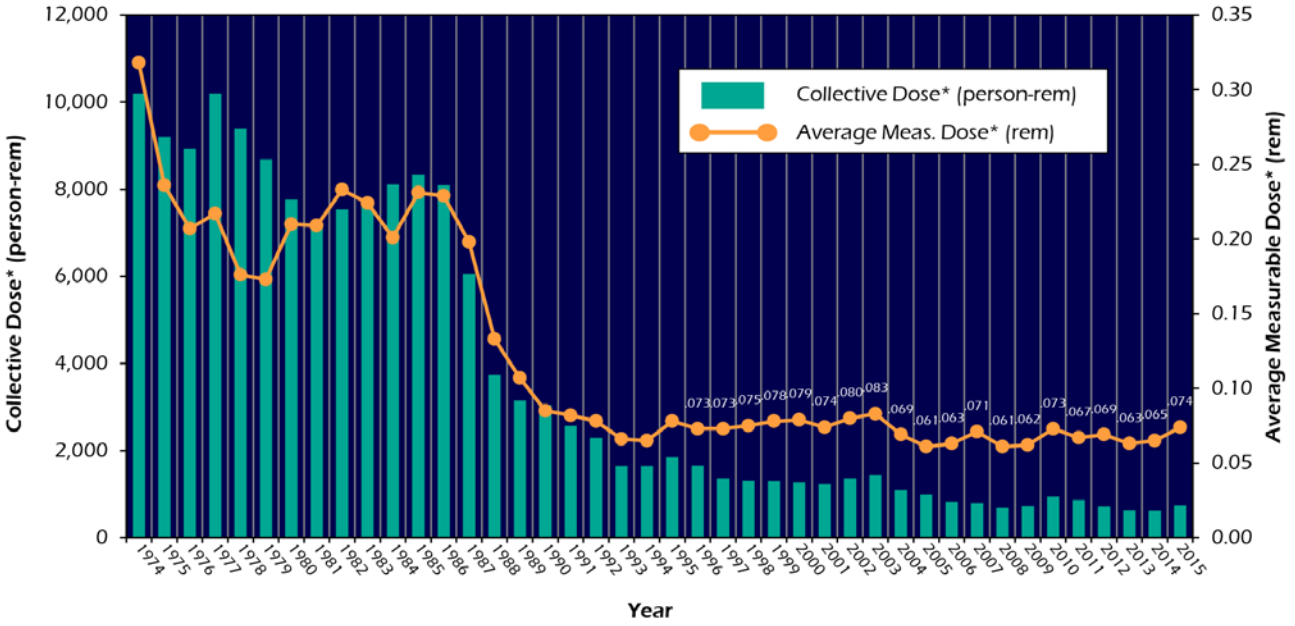
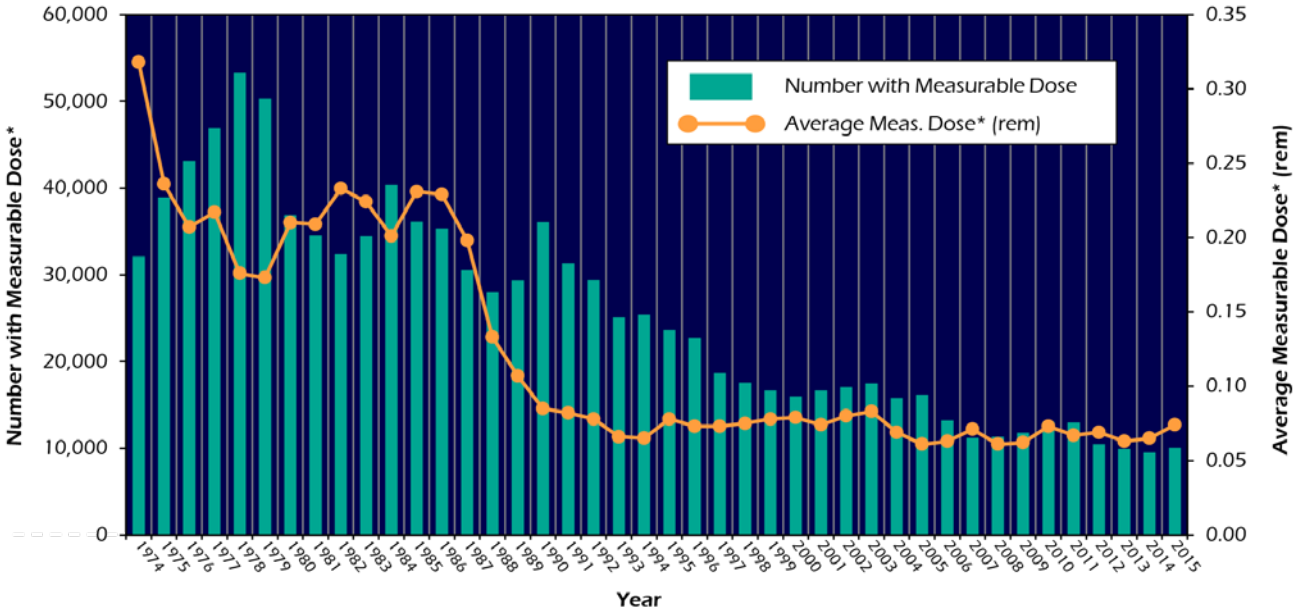


Exhibit 3-17:
Number of Workers with Measurable Dose and Average Measurable Dose, 1974–2015.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2009 collective dose = DDE + CEDE
2010–2015 collective dose = ED + CED

1946–1974 Atomic Energy Commission (AEC)
1974–1977 Energy Research and Development Administration (ERDA)
1977–Present Department of Energy (DOE)

3.6.2 Historical Data Collection

In section 3.7 of the 2000 and 2001 annual reports on occupational exposure, information was presented on historical data that had been collected to date. Sites were requested by DOE to voluntarily provide historical exposure data, and many sites have subsequently responded. No additional sites reported historical data during the year 2015.

Sites that have not yet reported historical dose records are encouraged to contact Ms. Nirmala Rao at DOE (see section 1.2) to obtain further information on reporting these records. This is a request to voluntarily report historical data (records prior to 1987) that are available in electronic form or in whatever format that is most convenient for the site. The data will be stored as reported in 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 as follows:

- Fernald Environmental Management Project;
- Hanford Site;
- Idaho National Laboratory;
- Kansas City Plant;
- Lawrence Berkeley National Laboratory;
- Lawrence Livermore National Laboratory;
- Nevada National Security Site;
- Oak Ridge K-25 Site;
- Pantex Plant;
- Portsmouth Gaseous Diffusion Plant;
- Rocky Flats Environmental Technology Site;
- Sandia National Laboratories; and
- Savannah River Site.

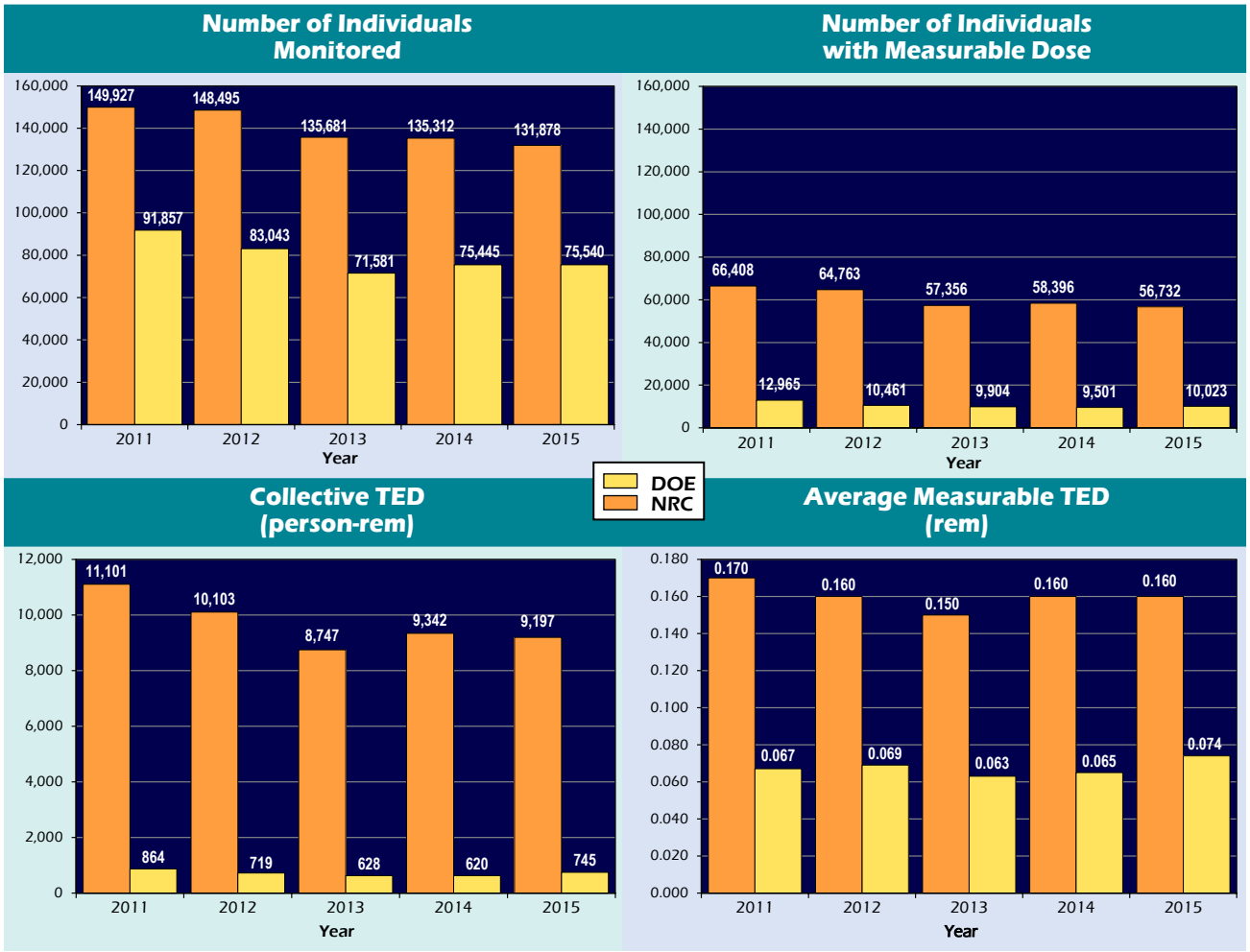
3.7 DOE Occupational Dose in Relation to Other Activities

3.7.1 Activities Regulated by the U.S. Nuclear Regulatory Commission

The purpose of this section is to show DOE occupational radiation exposure in relation to other industrial and governmental endeavors in order to gain an understanding of the relative scale of the radiation exposure at DOE operations compared with other activities. The 2015 report includes the DOE occupational exposure in relation to activities regulated by the NRC. It should be noted that the purpose of this information is simply to put the DOE radiation exposure in context with other endeavors that involve radiation exposure. A direct comparison is not appropriate due to the differences in the missions of DOE and NRC. While the mission of DOE is broad in scope and includes activities from energy research to national defense, NRC-licensed activities are dominated by radiation exposure received at commercial nuclear power plants. Reactor operations account for approximately 76 percent of the collective TED, while industrial radiographers, manufacturers, and distributors of radiopharmaceuticals; independent spent fuel storage installations; and fuel cycle licensees comprise the remainder.

The DOE and NRC occupational exposure data shown in *Exhibit 3-18* cover the past 5 years (2011 to 2015). While the number of workers monitored at NRC and DOE are comparable over the past 5 years, the number of individuals with a measurable dose at DOE was 17 percent of the NRC total for this time period. The percentages of DOE's collective dose (TED) and average measurable dose (TED) were 7 percent and 42 percent of the NRC totals, respectively.

Exhibit 3-18:
Comparison of Occupational Exposure for DOE and NRC, 2011 –2015.



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ALARA Activities at DOE

Descriptions of ALARA activities at DOE are provided on the AU web site for the purpose of sharing strategies and techniques that have shown promise in the reduction of radiation exposure and to facilitate the dissemination among DOE radiation protection managers and others interested in these project descriptions. Readers should be aware that the project descriptions are voluntarily submitted from the sites and are not independently verified or endorsed by 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.

4.1 Submitting ALARA Project Descriptions for Future Annual Reports

Individual project descriptions may be submitted to the DOE Office of ES&H Reporting and Analysis through the REMS web site. The submissions 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 web site provides a form to collect the following information about the project:

- Mission statement;
- Project description;
- Radiological concerns;
- Total collective dose for the project;
- Dose rate to exposed workers before and after exposure controls were implemented;
- 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); and
- Point of contact for follow-up by interested professionals.

The REMS web page for submitting ALARA project descriptions can be accessed on the Internet at:

http://energy.gov/ehss/downloads/line-alara-project submittal-form-report-alara-project descriptions-rems

4.2 Operating Experience Program

DOE has a mature operating experience program, which has been enhanced from the lessons learned program that was initially developed in 1994. The current DOE operating experience program is described in DOE O 210.2A, *DOE Corporate Operating Experience Program* [11]. The objective is to institute a DOE-wide program for the management of operating experience to prevent adverse operating incidents and to expand the sharing of good work practices among DOE sites. The purpose is to provide a systematic review, identification, collection, screening, evaluation, and dissemination of operating experience from U.S. and foreign government agencies and industry, professional societies, trade associations, national academies, universities, and DOE and its contractors. DOE Headquarters takes corporate responsibility for identifying, analyzing, and sharing operating experience information, combined with the operating experience/lessons learned provided by DOE field sites, and optimizes the knowledge gained and shared with others through various products, including a corporate database.

DOE posts operating experience information and links to other operating experience resources on the Internet. DOE uses the Internet to openly disseminate such information so that not only DOE but also other external entities will have a source of information to improve the health and safety aspects of operations within their facilities, including reducing the number of accidents and injuries.

The specific operating experience web site address may be subject to change. Information services can be accessed through the DOE AU web site as follows:

http://energy.gov/ehss/corporate operating-experience-program

1000 Independence Avenue, SW
Washington, D.C. 20585-1290

E-mail: Ashley.Ruocco@hq.doe.gov

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Conclusions

The occupational radiation exposure records show that in 2015, DOE facilities continued to comply with DOE dose limits and ACL and worked to minimize exposure to individuals. Only 13 percent of the monitored workers received a measurable dose, and the average measurable dose received was less than 2 percent of the DOE limit. In 2015, the collective dose and the number of individuals with measurable dose increased 20 and 5 percent, respectively. These increases in the dose and number of individuals with measurable dose were the result of increased activities involving radioactive materials, particularly at the DOE sites that comprise the majority of DOE collective dose. See *Exhibit 5-1* below for summary data.

The collective TED for all DOE facilities increased by more than 124 person rem (1,240 person mSv) from 2014 to 2015. This year marks the first time during the 5-year period 2011-2015, that collective dose in the DOE complex increased. Much of the increase in collective dose has been attributed to an increase in D&D activities in reducing the radioactive source term and spent fuel treatments.

The collective dose at DOE facilities has experienced a dramatic (93 percent) decrease since 1986. This decrease coincides with the end of the Cold War era, which shifted the DOE mission from weapons production to stabilization, waste management, and environmental remediation activities, along with the consolidation and remediation of facilities across the complex to meet the new mission. As DOE has become more involved in the new mission, collective and average doses have been relatively low. Also, in alignment with the change in mission, regulations and requirements have been modified (see Section 2) that reinforce DOE's focus on ALARA practices and risk reduction that contribute to continued lower occupational radiation dose.

Exhibit 5-1:
2015 Radiation Exposure Summary.

- The collective TED was 20 percent higher in 2015, at 744.7 person-rem (7,447 person-mSv) compared with 620.1 person-rem (6,201 person-mSv) in 2014.
- Sites contributing significantly to collective TED were (in descending order of collective TED) Idaho, Oak Ridge, Hanford, LANL, and SRS. These sites accounted for 73 percent of the collective TED at DOE in 2015
- The collective TED increased at four of the five sites with the largest collective TED, i.e., Idaho, Hanford, LANL, and SRS. At Idaho, the increase was due to an increase in Homeland Security training exercises, maintenance at the analytical and radiochemistry laboratories, spent fuel treatment product handling, TRU waste retrieval and characterization, and maintenance and upgrade of the sodium distillation system. At Hanford, the increase was due to work at the plutonium finishing plant facility. This work included the dismantlement of two large glove boxes in the process lines and the cleanout of the plutonium recovery facility canyon. The slight increase at LANL was due to the TA-55 plutonium facility operations—historically consistent for LANL. Occupational dose was accrued from weapons manufacturing, Pu-238 work, and repackaging materials. At SRS, a minor increase of occupational dose was attributed to resuming process operations in portions of the H Canyon to allow for continued spent nuclear fuel dissolution.
- The collective CED (internal exposure) decreased by 5 percent from 54.1 person-rem (541 person-mSv) in 2014 to 51.4 person-rem (514 person-mSv) in 2015, due to small decreases in internal doses across the DOE complex including Y-12.
- U-234 accounted for the largest percentage of the collective CED, with over 99 percent of this dose accrued at Y-12.
- The collective TED for transient workers increased by 6 percent from 21.7 person-rem (217 person-mSv) in 2014 to 22.9 person-rem (229 person-mSv) in 2015.

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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 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.

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. In this report, average measurable dose is calculated for TED and CED.

collective dose
As used in this report, the term "collective dose" is the sum of doses to all individuals in a population for a period of time. The general term "collective dose" is used whenever the dose may refer to more than one type of dose. In cases where the type of dose is specified, the term "collective" is followed by the type of dose such as the TED, CED, or photon. In all cases, the population is the group of DOE workers that were monitored for occupational radiation exposure, and the period of time is the monitoring year. Collective dose is expressed in units of person-rem.

committed effective dose (CED) (H_E,50)
The sum of the committed equivalent doses to various tissues or organs in the body (H_T,50), each multiplied by the appropriate tissue weighting factor (w_T) (i.e., $H_E,50 = w_T H_T,50$). CED is expressed in units of rem.

committed equivalent dose (CEqD) (H_T,50)
The equivalent dose 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. CEqD is expressed in units of rem.

DOE site
A geographic location operated under the authority of the DOE.

Effective Dose
The summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (w_T) –that is, Effective dose = $\Sigma\, w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with this part, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose is expressed in units of rem (or Sievert [Sv]).

equivalent dose (EqD)
The product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (w_R). For external dose, the EqD to the whole body is assessed at a depth of 1 cm in tissue; the EqD to the lens of the eye is assessed at a depth of 0.3 cm in tissue; and the EqD to the extremity and skin is assessed at a depth of 0.007 cm in tissue. The mathematical term is H_T, while the abbreviation EqD is used in this report and in the REMS reporting requirements for this data element. EqD is expressed in units of rem (or Sv).

exposure
Occupational exposure means an individual's exposure to ionizing radiation (external and internal) as a result of that individual's work assignment.

Occupational exposure does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

Hanford
This term is used to describe the entire reservation and all activities at this geographic location. It includes all cleanup activities at the reactors at the "Hanford Site," ORP, and PNNL. This term is used when we are *including* Hanford Site, ORP, and PNNL.

Hanford Site
All activities at, and cleanup of, the reactors and 100 – 400 areas at the reservation. Does not include ORP and PNNL.

Office of River Protection (ORP)
Tank farm and liquid waste cleanup to protect the Columbia River.

Pacific Northwest National Laboratory (PNNL)
The national laboratory involved in a broad range of scientific research.

measurable dose
A dose greater than zero rem (not including doses reported as "not detectable").

member of the public
Any individual not occupationally exposed to radiation or radioactive material, which either is not a DOE general employee or is an off duty DOE general employee. The definition of general employee is specified in 10 CFR 835.

number of individuals with measurable dose
The subset of all monitored individuals who receive a measurable dose (greater than the 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
Occupational dose is an individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational exposure does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

person-rem
The unit of measurement used for the collective dose to all DOE employees, contractors and subcontractors.

rem
A unit of dose derived from the phrase roentgen equivalent man. The rem is equal to 0.01 sievert, which is the international unit of measurement for radiation exposure.

total effective dose (TED)
The sum of the effective dose from external sources and the CED from intakes of radionuclides during the monitoring period. The internal dose component of TED changed from the annual effective dose equivalent to the committed effective dose equivalent (CEDE) in 1993 and from CEDE to CED in 2007.

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.

total organ dose
The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye.

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

urinalysis
The technique of determining the amount of radioactive material in the urine excreted from the body.

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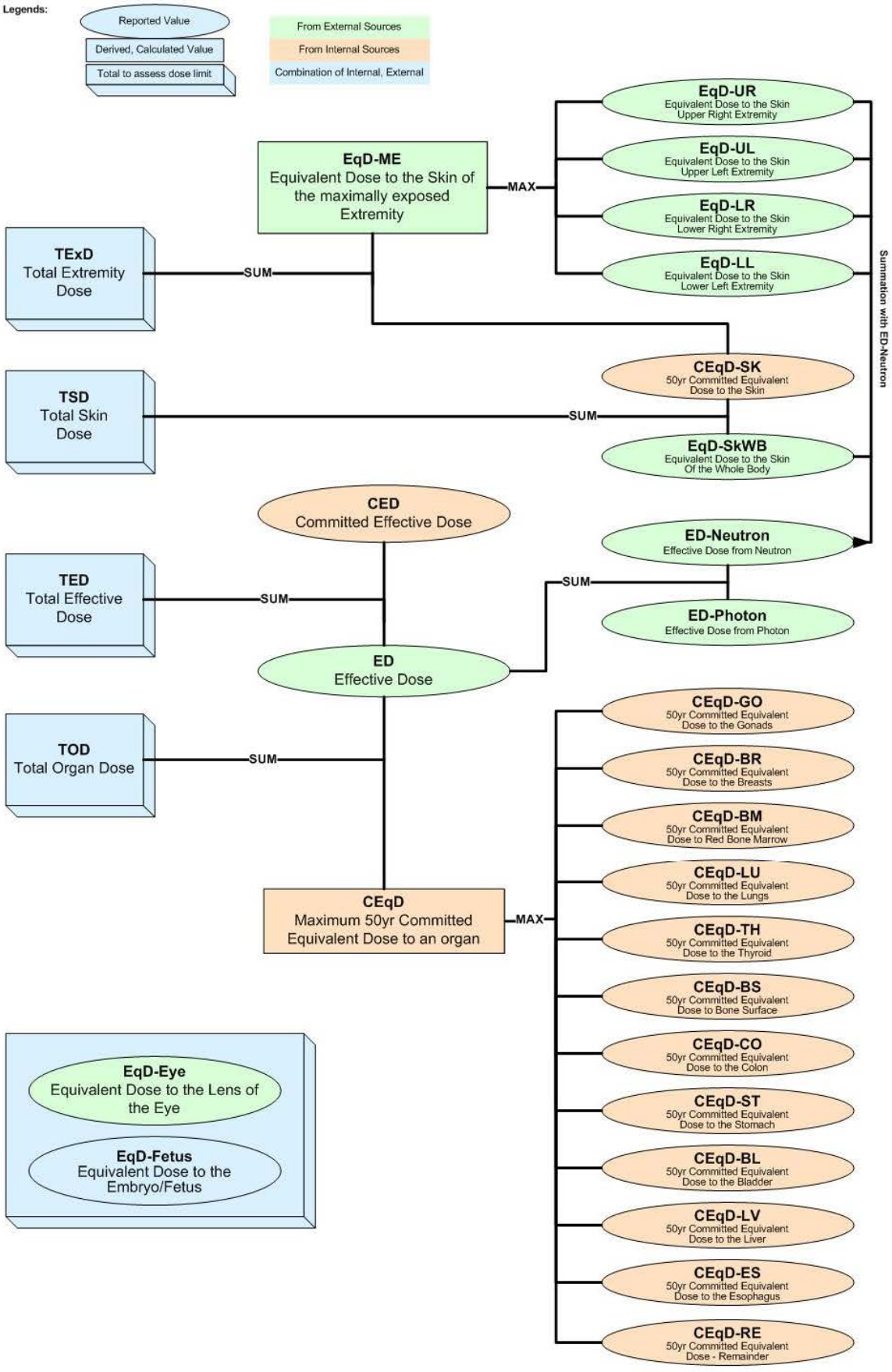
DOE Radiation Exposure Management System (REMS)
Dose Abbreviations, Definitions, and Relationships



User Survey

DOE Occupational Radiation Exposure Report
User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the *DOE 2015 Occupational Radiation Exposure Report*. **Your feedback is important**. Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to:

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

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Doses in Excess of ACL limit (2 rem)	1	2	3	4	5
Intakes of Radioactive Material	1	2	3	4	5
Analysis of Site Data	1	2	3	4	5
Collective TED by Site	1	2	3	4	5
Activities Significantly Contributing to Collective Dose	1	2	3	4	5
Additional Site Descriptions	1	2	3	4	5
Summary by Program Office	1	2	3	4	5
Transient Individuals	1	2	3	4	5
Historical Data	1	2	3	4	5
DOE Occupational Dose in Relation to Other Activities	1	2	3	4	5
ALARA Activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

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Please provide any additional input or comments on the report.

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