Environmental Protection Department
Operations and Regulatory Affairs Division

LLNL NESHAPs
1994 Annual Report

Lawrence Livermore National Laboratory
University of California Livermore, California 94550

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED *BS*

WASILR

This report has been reproduced
directly from the best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LLNL NESHAPs 1994 Annual Report

**Kris A. Surano
Arthur H. Biermann
Robert J. Harrach
Frank J. Gouveia
Robert L. Berger
Barbara C. Fields
Gretchen M. Gallegos
Paula J. Tate**

Contributors:

**P. Althouse
B. Failor**

**J. Clark
J. Kelly**

**U.S. Department of Energy
Radionuclide Air Emission Annual Report
(under Subpart H of 40 CFR Part 61)
Calendar Year 1994**

Site Name: Lawrence Livermore National Laboratory

Operations Office Information

Office: Oakland Operations Office

Address: 1301 Clay Street
Oakland, CA 94612

Contact: Charles A. Taylor Phone: 510-423-3022

Site Information

Operator: University of California

Address: 7000 East Avenue
Livermore, CA 94550

Contact: C. Susi Jackson Phone: 510-423-6577

June 1995

Table of Contents

	Page
SYNOPSIS.....	1
SECTION I. Facilities Information.....	1
Site Description.....	1
Livermore site.....	2
Site 300.....	4
Source Description.....	6
SECTION II. Air-Emission Data.....	7
Sources.....	7
The 1994 Radionuclide Inventory Update and Effective Dose	
Equivalent (EDE) Calculations.....	7
Spreadsheet-Interpretation Guidance (Attachment 1).....	8
Radionuclides.....	8
Radionuclide Inventories.....	8
Physical-State Factors.....	9
Stack Parameters.....	9
Emission-Control Devices.....	9
Control-Device Abatement Factors.....	9
Estimated Annual Emissions.....	9
10 mrem/y Site-Wide Dose Requirement.....	10
0.1 mrem/y Monitoring Requirement.....	11
Source Categories.....	11
SECTION III. Dose Assessment.....	13
Description of Dose Model.....	13
Summary of Model Input Parameters.....	14
General Model Inputs.....	14
Meteorological Data.....	14
Land-Use and Agricultural Inputs.....	14
Population Inputs.....	16
Surrogate Radionuclides.....	17
Emission Source Terms.....	17
Special Modeling Challenges.....	17
Site 300 Explosives Experiments.....	17
Diffuse Sources.....	18
Modeling Documentation.....	18
Compliance Assessment.....	18
SECTION IV. Additional Information.....	19
Construction and Modifications.....	19
Unplanned Releases.....	19

	<u>Page</u>
Diffuse Source Dose Assessments.....	19
Livermore-Site Diffuse Sources.....	20
Building 292.....	20
Building 331.....	20
Building 514.....	20
Building 612 Yard.....	21
Southeast Quadrant.....	21
Site 300 Diffuse Sources.....	21
Pit 7 Complex.....	22
Well 8 Spring.....	22
Building 802.....	23
Building 850.....	23
Building 851.....	23
Resuspension of Depleted Uranium at Site 300.....	23
Total Dose Estimate and Comparison with Previous Years' Data.....	24
SECTION V. Certification.....	25
SECTION VI. Supplemental Information.....	26
Collective Effective Dose Equivalent.....	26
Compliance with 40 CFR 61 Subpart H (61.93).....	28
Status of Compliance with 40 CFR 61 Subpart Q.....	29
Status of Compliance with 40 CFR 61 Subpart T.....	29
Information on Radon-220 and Radon-222 Emissions.....	29
Upgrades to Existing Sampling Systems.....	29
Site Periodic Confirmatory Measurements.....	30
Continuous Monitoring.....	30
Annual Effluent Sampling.....	32
General Surveillance Monitoring.....	33
Site-Specific Surveillance Monitoring.....	33
Status of the NESHAPs QA Program.....	34
Quality Control (QC) on 1994 Inventory and Modeling.....	35
Radiological Inventory QC.....	35
Modeling QC.....	35

ATTACHMENT 1: 1994 LLNL NESHAPs Annual Report Spreadsheet

ATTACHMENT 2: Surrogate Radionuclides List

List of Figures and Tables

	<u>Page</u>
Figure 1. Wind rose showing the frequency of wind speed classes for 16 wind directions at the Livermore Site, 1994.....	3
Figure 2. Wind rose showing the frequency of wind speed classes for 16 wind directions at Site 300, 1994.....	5
Figure 3. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at the Livermore site, 1994.....	12
Figure 4. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 1994.....	13
Figure 5. Comparison of CAP88-PC calculated doses vs. direction from Building 331 stacks corresponding to local, urban, and imported agricultural land-use assumptions.....	16
Table 1. Wind rose for LLNL's Livermore site during 1994 at the 10-m level. Values are frequency of occurrence (in percent).	4
Table 2. Wind rose for LLNL's Site 300 at the 10-m level for 1994. Values are frequency of occurrence (in percent).....	6
Table 3. Radionuclides used at LLNL during 1994.....	6
Table 4. Population distribution for LLNL's Livermore site, based on 1990 census information.....	26
Table 5. Population distribution for LLNL's Site 300, based on 1990 census information.	27
Table 6. Air-effluent sampling locations and systems.....	31

LAWRENCE LIVERMORE LABORATORY 1994 NESHAPs REPORT

This annual report is prepared pursuant to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs; 40 CFR Part 61, Subpart H), that govern radionuclide emissions to air from Department of Energy (DOE) facilities, and in accordance with DOE guidance. In August 1993, the Environmental Protection Agency (EPA) and DOE signed a Federal Facility Compliance Agreement (FFCA) regarding Lawrence Livermore National Laboratory (LLNL) compliance with this regulation. In April 1994, the EPA notified DOE and LLNL that all requirements of the FFCA had been met, and that LLNL had demonstrated compliance with the NESHAPs regulations.

SYNOPSIS

The NESHAPs standard in 40 CFR Part 61, Subpart H limits the emission of radionuclides to the ambient air from DOE facilities to levels resulting in an annual effective dose equivalent (EDE) of 10 mrem (100 μ Sv) to any member of the public. The EDEs to the LLNL site-wide maximally exposed member of the public from 1994 operations were:

- Livermore site: 0.065 mrem (0.65 μ Sv) (65% from stack emissions, 35% from diffuse-source emissions);
- Site 300: 0.081 mrem (0.81 μ Sv) (60% due to emissions from explosives experiments, 40% from diffuse-source emissions).

A complete LLNL-wide radionuclide-inventory update was conducted for 1994. Inventory and site-specific meteorological data, together with results from continuous-monitoring systems, were used as inputs to the EPA-approved CAP88-PC air-dispersion/dose-assessment model to calculate the reported EDEs.

SECTION I. Facilities Information

Site Description

Lawrence Livermore National Laboratory (LLNL) is operated by the University of California for DOE. LLNL was established in 1952 to conduct weapons research and development. LLNL's current mission is to serve as a national resource in science and engineering, with a focus on national security, energy, the environment, biomedicine, economic competitiveness, and science and mathematics education. LLNL's mission is dynamic and over the years has been broadened to meet new national needs.

Livermore site: LLNL's Livermore site occupies an area of 3.3 km² located about 60 km east of San Francisco, California, adjacent to the City of Livermore on the eastern edge of Alameda County. More than 6 million people live within 80 km of LLNL; approximately 61,000 of them live in the City of Livermore.

The Livermore site is located in the southeastern portion of the Livermore Valley, a topographical and structural depression oriented east-west within the Diablo Range of the California Coast Range Province. The Livermore Valley forms an irregularly shaped lowland area approximately 26 km long and an average of 11 km wide. The floor of the valley slopes from an elevation of approximately 200 m at the eastern end to approximately 90 m at its drainage outlet, which is located near the southwestern corner.

The climate of the Livermore Valley is characterized by mild, rainy winters and warm, dry summers. The mean annual temperature is about 15°C. (For 1994, 14.8°C.) Temperatures typically range from -5°C during some pre-dawn hours during the winter, to 35°C on a few summer afternoons. The 1994 annual wind rose for the Livermore site is displayed in Figure 1 with supporting data shown in Table 1. Although winds are variable, the prevailing wind direction is from the southwest, especially during the summer. However, the wind often blows from the northeast, usually during the winter. Most precipitation occurs as rain between October and April with very little rainfall during the summer months. In 1994, the Livermore site received 307 mm of precipitation.

Table 1. Wind rose for LLNL's Livermore site during 1994 at the 10-m level. Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding error.

Direction	Wind Speed Range (m/s)					Total
	0.0-0.4	0.5-2.9	3.0-4.9	5.0-6.9	≥7.0	
NNE	0.84	2.62	1.55	0.21	0.00	5.2
NE	0.84	4.40	2.00	0.01	0.00	7.3
ENE	0.84	2.65	0.01	0.00	0.00	3.5
E	0.84	1.86	0.00	0.00	0.00	2.7
ESE	0.84	1.97	0.01	0.00	0.00	2.8
SE	0.84	1.43	0.00	0.00	0.00	2.3
SSE	0.84	1.65	0.10	0.01	0.00	2.6
S	0.84	5.20	0.72	0.27	0.03	7.1
SSW	0.84	8.02	1.58	0.37	0.06	10.9
SW	0.84	8.32	6.43	3.04	0.45	19.1
WSW	0.84	7.95	5.27	1.11	0.00	15.2
W	0.84	5.11	5.57	1.18	0.00	12.7
WNW	0.84	1.55	0.25	0.06	0.00	2.7
NW	0.84	1.04	0.09	0.00	0.00	2.0
NNW	0.84	0.97	0.20	0.05	0.05	2.1
N	0.84	0.69	0.22	0.10	0.03	1.9
Total	13.5	55.4	24.0	6.4	0.6	100.0

Site 300: Site 300, LLNL's Experimental Test Site, is located 24 km east of the Livermore site in the Altamont Hills of the Diablo Range and occupies an area of 30.3 km². It is close to two other explosives-testing facilities operated by Physics International and SRI International. A State of California vehicular-recreation area is located nearby, and wind-turbine generators line the surrounding hills. The remainder of the surrounding area is in agricultural use, primarily grazing for cattle and sheep. The nearest residential area is the City of Tracy (population 40,000), located 10 km to the northeast.

The topography of Site 300 is much more irregular than that of the Livermore site; it consists of a series of steep hills and ridges, which are oriented along a generally northwest/southeast trend, separated by intervening ravines. The elevation ranges from approximately 540 m in the northwestern portion of the site to 150 m at the southeast corner.

The climate at Site 300 is similar to that of the Livermore site, with mild winters and dry summers. The complex topography of the site significantly influences local wind and temperature patterns, making the temperature range somewhat more extreme than at the Livermore site. The average annual temperature was 15.9°C in 1994. The 1994 annual wind rose is presented in Figure 2 with supporting data shown in Table 2. Prevailing winds are from the west-southwest. As is the case at the Livermore site, precipitation is highly seasonal, with most precipitation occurring between October and April. The average annual rainfall over the past 20 years was 257 mm; Site 300 received 217 mm of precipitation during 1994.

Table 2. Wind rose for LLNL's Site 300 at the 10-m level for 1994.
Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding error.

Direction	Wind Speed Range (m/s)					Total
	0.0-0.4	0.5-4.9	5.0-6.9	7.0-10.9	≥11.0	
NNE	0.14	1.60	0.06	0.06	0.01	1.9
NE	0.14	2.55	0.03	0.05	0.01	2.8
ENE	0.14	2.20	0.01	0.03	0.00	2.4
E	0.14	2.14	0.03	0.08	0.00	2.4
ESE	0.14	2.19	0.14	0.08	0.00	2.6
SE	0.14	2.29	0.16	0.20	0.00	2.8
SSE	0.14	2.33	0.15	0.13	0.00	2.8
S	0.14	3.37	0.42	0.29	0.05	4.3
SSW	0.14	2.07	0.17	0.23	0.00	2.6
SW	0.14	2.21	1.73	2.56	0.42	7.1
WSW	0.14	3.35	5.25	18.42	4.34	31.5
W	0.14	4.15	4.17	2.32	0.02	10.8
WNW	0.14	3.38	1.24	0.49	0.01	5.3
NW	0.14	5.34	1.96	1.95	0.44	9.8
NNW	0.14	3.82	2.56	1.25	0.34	8.1
N	0.14	1.27	1.25	0.34	0.00	3.0
Total	2.3	44.3	19.3	28.5	5.6	100.0

Source Description

Many different radioisotopes are used at LLNL for research purposes, including transuranics, biomedical tracers, tritium, mixed fission products, and others (Table 3). Radioisotope-handling procedures and work enclosures are determined for each project, depending on the isotopes, the quantities being used, and the types of operations being performed. Radioisotope handling and working environments include glove boxes, exhaust hoods, and laboratory bench tops. Exhaust paths to the atmosphere range from triple-HEPA (High-Efficiency-Particulate-Air)-filtered stacks, to roof vents and stacks lacking abatement devices, to direct dispersal of depleted uranium during explosives testing at Site 300, to a variety of diffuse-area sources.

Table 3. Radionuclides used at LLNL during 1994.

H-3	N-13	C-14	O-15	Na-22	P-32	P-33	S-35
K-40	Sc-46	Mn-54	Co-57	Co-58	Fe-59	Co-60	Ni-63
Zn-65	Y-88	Y-90	Sr-90	Y-91	Nb-95	Zr-95	Mo-99
Ru-103	Ru-106	Ag-110m	Sn-113	Sb-120m	Sb-124	I-125	Sb-125
I-129	I-131	Te-132	Ba-133	Cs-134	Cs-136	Cs-137	Ce-139
Ba-140	La-140	Ce-141	Ce-144	Pm-147	Nd-147	Eu-152	Bu-154
Eu-155	Tb-160	Hf-181	Au-195	Hg-203	Bi-207	Pb-214	Bi-214
Po-218	Rn-222	Ra-226	Th-228	Ra-228	Th-230	Pa-231	U-232
Th-232	Pa-233	U-233	U-234	U-235	Pu-236	Np-237	Pu-238
U-237	U-238	Pu-239	Np-239	Pu-240	Am-241	Pu-242	Am-243
Cm-243	Cm-244	Pu-244	Cm-248	Cf-252			

SECTION II. Air-Emission Data

Sources

At LLNL, areas where radioactive materials are used or stored, or where activation products occur, are called Radioactive Materials Management Areas (RMMAs). Sixty-six LLNL facilities contained RMMAs during all or part of 1994; fifty-eight at the Livermore site and eight at Site 300.

Detailed information is given in Attachment 1 for point-source emissions from 41 Livermore-site facilities in which radiological operations took place during 1994 or in which radiological operations previously reported for 1993 ceased. Fifteen Livermore-site facilities containing RMMAs (Buildings 190, 232, 233, 243, 326, 412, 435, 446, 493, 592, 594, 595, 614W, 624 and 625) are not included in Attachment 1 because no operations using radionuclides occurred there during 1993 or 1994, or the radionuclides were encapsulated or sealed for the entire year. An RMAA from Building 514 and four other Livermore-site sources external to buildings (including the RMAA at the Building 612 Hazardous Waste Management Yard) are treated as diffuse-area sources.

Similarly, detailed information is given in Attachment 1 for experiments at three Site 300 explosives-testing facilities (Buildings 801, 850, and 851 and their associated firing tables). The five other Site 300 facilities containing RMMAs (Buildings 804, 810A, 810B, 827A, and 857D) are not included in Attachment 1 because radionuclides were not used there during 1994, or all radionuclides were encapsulated or sealed for the entire year. Six Site 300 sources, including the three firing tables where surface and subsurface contamination exists, are treated as diffuse-area sources.

The 1994 Radionuclide Inventory Update and Effective Dose Equivalent (EDE)

Calculations: For this year's report, covering activities in 1994, the radionuclide inventories in all LLNL facilities were updated. Radionuclide inventory forms, with detailed guidance for completing them, were sent to all unmonitored facilities having the potential for radionuclide emissions to the air. The forms were completed by experimenters, certified by facility managers, and returned. Radionuclide inventories for all Site 300 explosives experiments and assessments of source terms for known diffuse sources at both sites also were updated.

New dose-assessment modeling runs, using CAP88-PC (see Section III), for all facilities with actual or potential radionuclide releases to air during 1994 were conducted using 1994 on-site meteorological data (wind, precipitation, and temperature) along with the 1994 radionuclide inventory or monitoring data. Annual dose is reported as whole-body EDE expressed in units of mrem (μ Sv).

Spreadsheet-Interpretation Guidance (Attachment 1): A generalized description of each facility and its operations is provided on the spreadsheet. In addition, the following information is shown for each listed emission point or stack:

- Building and room number(s)
- Specific stack identification code(s)
- Generalized operations in the room(s) or area(s)
- Radionuclides utilized during 1994
- 1994 annual radionuclide inventory (by isotope, in curies)
- Physical-state factors (by isotope)
- Stack parameters
- Emission-control devices and emission-control-device abatement factors
- Estimated or measured annual emissions (by isotope)
- Distance and direction to the site-wide maximally exposed individual (SW-MEI)
- Calculated EDE to the SW-MEI
- Distance and direction to the maximally exposed individual for that specific source (MEI)
- Calculated EDE to the MEI (source term not adjusted for emission controls)
- Source category

Radionuclides: The radionuclides shown in the spreadsheet are those from specific emission points where air emissions were possible. If radionuclides were present, but encapsulated or sealed for the entire year, radionuclides, annual inventories, and emissions are not listed. In some cases, radionuclide operations occurred at these emission points during 1993, and hence they were reported in last year's report; if, however, no radionuclide operations took place during 1994 at these locations, zero inventory/emission data are recorded in the spreadsheet for the sake of continuity. Similarly, emission points for which zero emissions were reported last year that continued to have zero emissions during 1994 were removed from the spreadsheet.

For Building 231, Room 1128 (a Materials Management vault that is used for receipt, shipment, and storage of sealed radioactive sources), the variety and turnover of radionuclides makes a listing of individual radionuclides and their inventories impractical. This area is continuously monitored, and emissions are therefore directly determined.

Radionuclide Inventories: The annual radionuclide inventories for point-source locations are based on data from facility experimenters and managers. For Buildings 251 (hardened area) and 332, classification issues regarding transuranic-radionuclide inventories make use of the inventory/modeling approach impractical. However, all such affected emission points in these buildings are continuously monitored, and emissions are therefore directly determined.

Physical-State Factors: The physical-state factors listed are EPA potential-release fractions from 40 CFR 61, Appendix D, whereby emissions are estimated from radionuclide inventories depending on their physical states for use in dispersion/dose assessment modeling. A physical-state factor of 1.0×10^{-6} is used for solids, 1.0×10^{-3} is used for liquids and powders, and 1.0 is used for unconfined gases.

Stack Parameters: Engineering surveys conducted from 1990 through 1992 form the basis for the stack physical parameters shown, which were checked and validated by facility experimenters and managers for 1994.

Emission-Control Devices: High-Efficiency-Particulate-Air (HEPA) filters are used in many LLNL facilities to control particulate emissions. For some discharge points, scrubbers and electrostatic precipitators aid the control of emissions. The operational performance of all HEPA filtration systems is routinely tested. The required efficiency of a single-stage HEPA filter is 99.97%. Double-staged filter systems are in place on some discharge points. Triple-stage HEPA filters are used on glove-box ventilation systems in the Building 332 Plutonium Facility and in the hardened portion of Building 251.

Control-Device Abatement Factors: Similar to physical-state factors, control-device abatement factors, from Table 1 in 40 CFR 61, Appendix D, are those associated with the listed emission-control devices, and are used to better estimate actual emissions for use in dispersion and dose models. By regulation, each HEPA filter stage is given a 0.01 factor (even though the required test efficiency that all LLNL HEPA filters must maintain would yield a factor of 0.0003), venturi scrubbers and electrostatic precipitators are each given a 0.05 factor, and each activated-charcoal filter is given a 0.1 factor.

Estimated Annual Emissions: For unmonitored and non-continuously monitored sources, estimated annual emissions for each radionuclide are based on the product of (1) inventory data, (2) EPA potential-release fractions (physical-state factors), and (3) applicable emission-control-device abatement factors.

Actual emission measurements are the basis for reported emissions from continuously monitored facilities. LLNL continuously monitored facilities are Buildings 175, 231-vault, 251, 331, 332, 419, 490, and 491. Many of the monitored facilities show zero emissions. These data are largely based on limit-of-sensitivity (LOS) results from the analysis of air-filter samples. Use of zero values for LOS data can be justified based on facility knowledge, the use of tested multiple-stage HEPA filters in all significant release pathways, and alpha-spectroscopy-based isotopic analyses of selected air-sampling filters. These isotopic analyses demonstrate that detected activity on air-sampling filters comes from naturally occurring radionuclides, such as radon daughters, e.g., polonium. Accordingly, given the level of HEPA filtration, it is likely that actual concentrations are closer to zero than they

are to the LOS. Furthermore, even if the LOS values are substituted in screening dose calculations, an extremely conservative assumption, the total dose attributable to LLNL activities is not significantly affected.

10 mrem/y Site-Wide Dose Requirement: For LLNL to comply with the NESHAPs regulations, the LLNL site-wide maximally exposed individual (SW-MEI; defined as the hypothetical member of the public at a single residence, school, business, or office who receives the greatest LLNL-induced EDE from the combination of all radionuclide source emissions) must receive an EDE no greater than 10 mrem/y (100 μ Sv/y).

To determine the location of the 1994 SW-MEI, CAP88-PC results from multiple sources were combined using an interpolation method. Sources were selected to include those expected to give significant contributions to the EDE. These included Buildings 331, 513, 514, and 612. Because EDE results from CAP88-PC are relative to the location of the specified source, direct summing of results from multiple sources could not easily be accomplished. Instead, the location of each selected source relative to a common location (the Livermore-site center) and a set of receptor locations (where the combined EDEs from the selected sources were to be evaluated), also relative to the site center, were specified in the modeling efforts that supported determination of the SW-MEI. The receptor locations included 48 equally spaced directions from the site center and 4 additional receptor locations along the eastern and southern Livermore-site boundaries. The interpolation method was used to calculate the EDEs for the desired set of receptor locations for each source. These resulting interpolated EDEs for each source, now for the same set of locations, were then summed, and the SW-MEI determined.

At the Livermore site, the SW-MEI for 1994 was located at the U.N.C.L.E. Credit Union, about 10 m outside the controlled eastern perimeter of the site, as shown in Figure 3.

At Site 300, the 1994 SW-MEI was located in an experimental area termed "Bunker 2" operated by Physics International. Bunker 2 lies about 300 m outside the east-central boundary of Site 300, as shown in Figure 4. This bunker is 2.4 km east-southeast of the principal firing table at Building 801.

In Attachment 1, the distance and direction to the respective SW-MEI is shown for each facility at each site. Doses to the site-specific SW-MEIs were evaluated for each source and then totaled for site-specific evaluations against the 10 mrem/y dose standard (See "Compliance Assessment" in Section III).

0.1 mrem/y Monitoring Requirement: To assess compliance with the requirement for continuous monitoring (potential dose greater than 0.1 mrem/y (1.0 μ Sv/y)), emissions must be individually evaluated from each point source; the location of the maximally exposed public individual (MEI) is generally different for each emission point. The maximum dose at a location of unrestricted public access typically occurs at a point on the site perimeter. Therefore, it is often referred to as the maximum "fenceline" dose, although the off-site maximum dose could occur some distance beyond the perimeter. (This could happen, e.g., when the perimeter is close to a stack; however, for all emission points at the Livermore site and Site 300, calculations show that ground-level concentrations of radionuclides decline monotonically beyond LLNL boundaries). As stipulated by the regulations, modeling for assessment of continuous monitoring requirements assumed unabated emissions (i.e., no credit was taken for emission abatement devices, such as filters), but physical-state factors were applied. The spreadsheet attached to this report gives, for each point source, the dose to the MEI and the distance and direction to the LLNL fenceline where the MEI is located.

Source Categories: LLNL radionuclide air-emission sources have been classified into six source categories, indicated by the number in the last column of the spreadsheet: (1) Unmonitored or non-continuously monitored Livermore-site facilities that have had a radionuclide-inventory update for 1994; (2) Unmonitored or non-continuously monitored Livermore site facilities without a current radionuclide-inventory update (used in previous years for small, insignificant sources: no such category was applied for 1994 because a complete site-wide radionuclide-inventory update was performed); (3) Continuously monitored Livermore-site facilities; (4) Site 300 explosives experiments; (5) Diffuse sources where emissions and subsequent doses were estimated using inventory processes; and (6) Diffuse sources where emission and dose estimates were supported by environmental-surveillance measurements.

Figure 3. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at the Livermore site, 1994.

Figure 4. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 1994.

SECTION III. Dose Assessment

Description of Dose Model

Estimates of individual and collective radiological doses to the public from LLNL operations were obtained using the EPA-developed computer code CAP88-PC. New modeling runs were conducted for every emission point, corresponding to the complete radiological-inventory update conducted for all facilities in 1994. The four principal pathways—internal exposures from inhalation of air and ingestion of foodstuffs and drinking water, and external exposures through irradiation from contaminated ground and immersion in contaminated air—are evaluated by

CAP88-PC. The doses are expressed as whole-body effective dose equivalents (EDEs), in units of mrem/y (1 mrem = 10 μ Sv). Separate doses for the Livermore site and Site 300 from point-source emissions (i.e., stack emissions) and diffuse-source emissions at the two sites are reported.

Three potential doses are emphasized: (1) The dose to the SW-MEL, which combines the effects of all emission points, for evaluation under the 10 mrem/y (100 μ Sv/y) standard; (2) the maximum dose to any member of the public (conservatively assumed to be at the LLNL fenceline), in any direction, due to each unabated emission point on the site for evaluation of the need to conduct continuous monitoring; and (3) the collective dose to the populations residing within 80 km of the two LLNL sites, adding the products of individual doses received times the number of people receiving them.

Summary of Model Input Parameters

General Model Inputs: Attachment 1 details the key identifiers and input parameters for the CAP88-PC model runs. These include building number; stack ID; isotope(s); emission rate in curies per year (1 Ci = 3.7×10^{10} Bq); and stack parameters, including height, diameter, and emission velocity.

Meteorological Data: All model runs used actual 1994 Livermore-site and Site 300 meteorological data, collected from the respective on-site meteorological towers. At these towers, wind speed and direction are sampled every few seconds, temperature every minute; and all are averaged into quarter-hour increments, time-tagged, and computer-recorded. The data are converted into a CAP88-PC input wind file using EPA guidelines.

Land-Use and Agricultural Inputs: Options for model inputs regarding agricultural characteristics and land use are established by the EPA, and the particular designation selected can strongly influence the ingestion dose received by the population being evaluated. Following investigation into the use of the various options, the "local-agriculture" option was again selected for the CAP88-PC modeling effort for 1994. This use of the most conservative of the six possibilities available in CAP88-PC (urban, rural, local, regional, imported, and user-entered) assumes all foodstuffs consumed by the exposed population are locally grown and are maximally affected by radionuclide releases from emission points at the site.

In selecting an agricultural-characteristic option, the fractions of vegetable, milk, and beef production that are "home produced", produced in the "assessment area", and imported are specified. (The term "home produced" means produced in the immediate vicinity of the receptor; the "assessment area" is all land lying inside a circle centered on the source, having radius equal to the largest distance specified in the modeling run, up to a maximum allowable value of 80 km.) The local-agriculture option assumes all vegetables, milk, and meat consumed by the receptor are home-

produced, while the imported option assumes all vegetables, milk, and meat come from outside the assessment area. The breakdown for the urban option is 7.6% home vs. 92.4 % from the assessment area for vegetables, 0% vs. 100% for milk, and 0.8% vs. 99.2% for meat. Other options (rural, regional, user-entered) have different breakdowns and were not considered appropriate for use at LLNL.

To illustrate the effect on calculated doses of different agricultural assumptions, a comparison of EDEs at the Livermore-site boundaries due to emissions from the two 30-meter stacks of the Tritium Facility (Building 331) is shown in Figure 5 for the local-, imported-, and urban-agriculture options. Results are displayed for fenceline locations in the 16 compass directions and four other receptor locations (possible locations of the SW-MEI) along the eastern boundary. The local-agriculture option produces a bimodal distribution of dose with direction, with the highest dose occurring in the prevailing downwind direction (to the northeast). This local option produces the highest maximum dose, and is therefore most conservative. The effect of northeasterly winds is apparent by the presence of a second, less dominant peak to the southwest. The peaks are caused by wind direction influences on both ingestion and inhalation doses. By contrast, the urban option produces a "flat" distribution of dose with direction because (1) the ingestion dose dominates over inhalation (though not as greatly as in the local option), and (2) the dose from ingestion of food grown throughout the assessment area is not directionally sensitive. The imported option shows the lowest doses of the three with the bimodal nature again in evidence, driven almost exclusively by inhalation.

Figure 5. Comparison of CAP88-PC calculated doses vs. direction from Building 331 stacks corresponding to local, urban, and imported agricultural land-use assumptions.

The way ingestion dose from "food grown in the assessment area" is handled in CAP88-PC depends on both the maximum receptor distance specified and the number and distribution of receptor distances selected. Depending on the assessment area selected, the ingestion dose derived using the urban option can exceed that using the local option in non-prevailing wind directions. For locations in these directions, home-produced agricultural products (local option) are only slightly affected by radionuclide releases, while the urban option assumes ingestion of both slightly and heavily affected products from throughout the assessment area. In addition, choosing the assessment area by selecting a set of distances clustered near the 80-km value causes the urban EDEs to approach those calculated using the imported option. For these reasons, the conservative, local option was used for modeling.

Population Inputs: Population distributions centered on the two LLNL sites were compiled from 1990 census data. The population data files (distribution of population with distance and direction) used in the 1994 modeling effort are described in Section VI under "Collective Effective Dose Equivalent".

Surrogate Radionuclides: Because the EPA-mandated model CAP88-PC does not contain all the radionuclides in use at LLNL, it was necessary in a few cases to use surrogate radionuclides to estimate EDEs. Attachment 2 shows the surrogate radionuclide lists for CAP88-PC. In selecting the surrogates, the most-restrictive lung class (whether clearance from the lungs takes place in days, weeks, or years) was used. When possible, a surrogate radionuclide with similar chemistry and similar values for "annual limits of intake via inhalation and derived air concentration," as specified in the EPA's Federal Guidance Report No. 11 was used. CAP88-PC contains a library of 265 radionuclides. In some cases, experimenters did not have isotopic analyses of mixtures of radionuclides and could only identify their radionuclide inventory as "gross alpha" or "gross beta." In these cases, ^{239}Pu was used as the surrogate for gross alpha and ^{90}Sr was used as the surrogate for gross beta in modeling efforts to provide conservative dose estimates.

Emission Source Terms: The source term(s) from each emission point in the calculations was determined by one of two methods: For continuously monitored sources, the sampling data (curies released per unit time) for each radionuclide were used directly. For unmonitored facilities, the radionuclide inventories, together with the EPA-specified fractions for potential release to air of materials in different physical states (solid, liquid, powder, or gas), in accordance with 40 CFR Part 61, Appendix D were used. The state-dependent release fraction was used to adjust (by multiplication) the total annual inventory to give the potential annual release to air. If the material was an unconfined gas, then the fraction 1.0 was used; for liquids and powders, 1.0×10^{-3} was used; and for solids, 1.0×10^{-6} was used. In addition, emission-control abatement factors (40 CFR 61, Appendix D), when applicable, were applied. Each HEPA filter stage was given a 0.01 factor, electrostatic precipitators, as well as venturi scrubbers, were each given a 0.05 factor, and each activated-charcoal filter was given a 0.1 factor. The use of actual monitoring data is much more direct, and presumably more accurate, than using assumptions based on inventory, release fractions, and emission-control factors.

Special Modeling Challenges: Among the six source categories defined above, Category 4 (explosives tests using depleted uranium at Site 300) and Categories 5 and 6 (diffuse sources at the two sites) required special attention.

Site 300 Explosives Experiments: During Site 300 explosives experiments, the device containing depleted uranium is placed on an open-air firing table and detonated. Only limited data are available to characterize the initial state of the cloud of explosive decomposition products created by the detonation because properties of the cloud are not routinely measured in the experiments. Empirical scaling laws can be used, however, to define the cloud using the radionuclide and explosives inventories. Isotopic ratios for depleted uranium are used; the three uranium isotopes with atomic weights 238, 235, and 234 occur in the weight percentages 99.8, 0.2, and 5×10^{-4} , respectively. Their masses are multiplied by their respective specific activities to determine the total number of curies for each isotope

in the cloud. It is assumed that all of the uranium is dispersed into the cloud, and the median particle size is assumed to be the CAP88-PC default value of 1 μm . The assumption that all uranium is aerosolized and dispersed as a cloud results in a highly conservative off-site dose estimation—we believe a more realistic release-to-air fraction for the uranium is no greater than 0.2, but we lack sufficient data to use a value other than 1.0. CAP88-PC simulates each shot as a low-level, steady-state, stack-type emission occurring over one year. An alternative modeling methodology for treating these short-duration explosive events was submitted for approval in 1992, but LLNL was directed by EPA to use the CAP88-PC code for these calculations.

Diffuse Sources: Source Categories 5 and 6 are reserved for diffuse emissions, generally area sources external to buildings, as discussed in Section IV. The dose assessments for Category 5 diffuse sources are derived from modeling based on radionuclide-inventory data; those for Category 6 sources are supplemented by environmental-surveillance monitoring data.

Modeling Documentation: Copies of individual model runs, including input parameters and resultant calculated doses, are on file in the Terrestrial & Atmospheric Monitoring & Modeling Group (TAMM) of the Environmental Protection Department at LLNL.

Compliance Assessment

The 1994 calculated EDE to the SW-MEI from Livermore-site point sources was 0.042 mrem (0.42 μSv). Emissions from the two 30-meter stacks at the LLNL Tritium Facility (Building 331) accounted for 0.027 mrem (0.27 μSv), or 64%, and the Stabilization Unit in Hazardous Waste Management's Building 513 produced 0.013 mrem (0.13 μSv), or about 31% of the Livermore-site point-source total. No other point source at the Livermore site contributed as much as 4% to this total.

The calculated EDE to the SW-MEI at Site 300 was calculated to be 0.049 mrem (0.49 μSv) from point-source emissions. All of this EDE resulted from Building 801 and Building 851 firing-table emissions in the course of explosives experiments—41% from the former and 59% from the latter.

All of the dose evaluations from point-source emissions, and those from most diffuse sources discussed below, were made using the EPA-mandated CAP88-PC dispersion model. They result in levels of public exposure well below the EPA standard, which limits the whole-body EDE to members of the public from DOE activities to 10 mrem/y (100 $\mu\text{Sv}/\text{y}$).

SECTION IV. Additional Information

Construction and Modifications

During 1994, no construction projects or modifications were completed for which approval to construct or modify was required or waived under 40 CFR 61.96. Only maintenance, repair, and replacement activities, as well as those considered normal or routine, were conducted. Proposed facilities and significantly modified operations are assessed for NESHAPs requirements during the National Environmental Policy Act (NEPA) process. Under NEPA, all proposed projects or actions that might involve NESHAPs issues or concerns—not just pertaining to radionuclides but to air toxics as well—are reviewed and evaluated. If the proposal includes operations that require a NESHAPs assessment, necessary modeling is conducted. If insufficient information is available for modeling at the time the NEPA documents are prepared, LLNL includes in the NEPA documents a statement that NESHAPs review, modeling, and monitoring requirements will be met. It is the responsibility of the individual project proponent to supply the specific information required for any NESHAPs modeling, analysis, and review that must be completed before operations described in the document are initiated.

Unplanned Releases

There was one spill that could have resulted in an unplanned atmospheric radionuclide release at the Livermore site in 1994, and none from Site 300.

In December 1994, during transfer of boxes containing depleted-uranium ingots, six of the ingots fell out of the boxes onto the sidewalk, curb, and grass area southwest of Building 241, along Avenue B at the Livermore site. The spilled ingots ranged in weight from 95 to 103 kg, and the total spilled quantity was 594 kg, amounting to 0.19 Ci (7×10^9 Bq). Since 0.10 Ci (3.7×10^9 Bq) is a reportable quantity, an Occurrence Report was filed (No. 94-031-IR, dated December 27, 1994). The spilled ingots and associated contamination were promptly cleaned up; less than 0.01 μ Ci (3.7×10^2 Bq) remained as residual contamination in the spill area. Modeling evaluated the resultant dose to the SW-MEI from the residual contamination to be less than 6.8×10^{-13} mrem/y (6.8×10^{-12} μ Sv).

Diffuse Source Dose Assessments

Diffuse, or non-point, sources (Source Categories 5 and 6) are difficult to quantify. There are no EPA-mandated methods for estimation or measurement, although LLNL did review a second draft of EPA guidance on this topic during 1994. At this time, however, dose calculations associated with this type of source remain left to the discretion of the DOE facility. Livermore-site and Site 300 diffuse sources are described separately.

Livermore-Site Diffuse Sources

The dose calculations from 1994 diffuse sources at the Livermore site required four different modeling approaches. Building 292 required a calculation of source term and the use of CAP88-PC; Building 331 and the Building 612 Yard needed facility personnel knowledge and environmental-surveillance data to estimate emissions; Building 514 required radiological-inventory data and CAP88-PC modeling techniques; and in the Southeast Quadrant data from ambient-air monitoring were used to calculate the dose.

Building 292: Elevated tritium concentrations in soil moisture near Building 292 resulted from a historic leak in an underground retention tank. This contamination has resulted in diffuse tritium emissions from evaporation of soil moisture and transpiration from vegetation. Measurements and calculations during 1994 showed transpiration from a single pine tree accounted for the largest amount of tritium released to the atmosphere in this area. The total annual emissions from this pine tree were calculated based on estimated projected area (79 m^2) and collective transpiration rate (190 liter/day), together with average measured concentrations of tritium in transpired water (annual mean of $11,750 \text{ pCi/liter}$ or 435 Bq/liter), producing a 1994 emission of $8.2 \times 10^{-4} \text{ Ci}$ ($3.0 \times 10^7 \text{ Bq}$). The annual tritium release to the atmosphere stemming from evaporation of soil moisture is represented by generous upper-bound estimates. A high value for the measured tritium flux from the ground near the tank is $0.26 \mu\text{Ci}/\text{m}^2/\text{y}$ ($9.6 \times 10^3 \text{ Bq}/\text{m}^2/\text{y}$). Assuming 400 m^2 effective soil area, based on isoactivity contours, this gives an annual soil-evaporation release of $1.7 \times 10^{-5} \text{ Ci}$ ($6.3 \times 10^5 \text{ Bq}$). The total tritium emissions from the Building 292 diffuse source were, therefore, determined to be $8.4 \times 10^{-4} \text{ Ci}$ ($3.1 \times 10^7 \text{ Bq}$) during 1994. The resultant 1994 EDE to the SW-MEI based on CAP88-PC modeling was $2.7 \times 10^{-7} \text{ mrem}$ ($2.7 \times 10^{-6} \mu\text{Sv}$).

Building 331: As the Tritium Facility (Building 331) undergoes both decommissioning/decontamination and redirection of its research and development efforts, tritium-contaminated equipment slated for disposal is removed from the building, packaged in a waste-accumulation area, and sent to Hazardous Waste Management Division (HWM) facilities. During 1994, outgassing from such waste processing released an estimated 3 Ci ($1.1 \times 10^{11} \text{ Bq}$) of tritium to the atmosphere outside of Building 331. The estimated releases were derived from measurements of surface contamination on the material, process and facility knowledge, and environmental-surveillance measurements. The estimated 3 Ci ($1.1 \times 10^{11} \text{ Bq}$) release was modeled in CAP88-PC as a 1 m^2 area source, leading to a calculated 1994 dose to the SW-MEI of $2.8 \times 10^{-3} \text{ mrem}$ ($2.8 \times 10^{-2} \mu\text{Sv}$).

Building 514: Another potential source of diffuse emissions of a variety of radionuclides was HWM waste-storage and treatment operations. Building 514 houses the HWM "tank farm," consisting of six 7,170-liter tanks with ancillary

equipment such as pumps, mixers, probes, and a bulking station. The tanks are used to store and treat liquid and solid radioactive and/or mixed wastes. Treatment is performed on a batch basis. Chemicals and waste are added to the tanks to achieve the desired treatment objectives. A 1994 radionuclide inventory was conducted for the facility to determine the diffuse source term (Attachment 1). CAP88-PC modeling gave a 1994 EDE to the SW-MEI of 4.6×10^{-3} mrem (4.6×10^{-2} μ Sv).

Building 612 Yard: The Building 612 Yard is a potential source of diffuse emissions of tritium. This area is dedicated to hazardous-waste-, radioactive-waste-, and mixed-waste-management activities. The yard consists of several areas where waste containers are stacked outdoors. Many of these containers are not air tight and outgas tritium. A surveillance air monitor has been placed in the Building 612 Yard to provide continuous measurements of tritium near this source. The mean annual concentration of tritium in air for 1994 in this area was 0.018 pCi/L (6.52×10^{-4} Bq/L). These data were used to calculate the total tritium emissions from the area, using a conservative approach that assumed the source to be concentrated 120 m south-southwest of the air sampler. With this assumption, CAP88-PC requires a diffuse source emission of 1.2 Ci/y (4.4×10^{10} Bq/y) to produce the concentrations measured at the air sampler. This source term produced a calculated 1994 dose to the SW-MEI from the Building 612 Yard of 1.3×10^{-2} mrem (1.3×10^{-1} μ Sv).

Southeast Quadrant: The Southeast Quadrant of the Livermore site has elevated levels of ^{239}Pu in the surface soil (from historic waste-management operations) and air (presumably from resuspension). A high-volume air-particulate sampler is located adjacent to the U.N.C.L.E. Credit Union (the location of the SW-MEI) to monitor the ^{239}Pu levels in this area. Monitoring data from this air sampler were used as a direct measurement of potential dose via the air pathway. A mean annual concentration of ^{239}Pu in air of 3.9×10^{-19} μ Ci/mL (1.4×10^{-14} Bq/mL) was used with the dose-conversion factor for ^{239}Pu (0.342 mrem/pCi or 92.3 μ Sv/Bq) and standard-man breathing rates to calculate the estimated 1994 dose of 1.1×10^{-3} mrem (1.1×10^{-2} μ Sv).

Site 300 Diffuse Sources

Diffuse sources at Site 300 involve tritium and uranium. In the course of remediation efforts at Site 300, LLNL completed a contaminant screening to identify potential routes of migration from soil to air and other environmental media of these radionuclides and other contaminants. Information provided in the Final Site Wide Remedial Investigation Report (Webster-Scholten, Ed., 1994, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-108131) was used in the diffuse-source evaluations. In the course of the remedial investigation, the rate of intermediate migration and the exposure-point concentrations of contaminants were evaluated. Tritium and ^{238}U were identified as contaminants of potential concern at six locations.

Tritium contamination is well-characterized at Site 300. Five diffuse tritium sources are discussed individually. Uranium, on the other hand, is not as well characterized, and data are confounded by the naturally occurring high concentrations of uranium in Site 300 soils (Gallegos *et al.*, Environmental Report for 1993, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-93). Diffuse uranium sources were treated collectively in a resuspension calculation, presented following the individual tritium discussions below.

Tritium gas and solid tritium (Li^3H) were components of explosives assemblies tested on the firing tables during past experiments. Most of the gaseous tritium escaped to the atmosphere during the tests, but some of the solid Li^3H remained as residue in the firing table gravel. Rainwater and dust-control rinse water percolated through the gravel, causing the tritium to migrate into the subsurface soil and, in some cases, eventually to the ground water. Tritium-contaminated gravel was removed from the firing tables in 1988 and disposed in the Pit 7 landfill. Tritium in landfills, firing-table soils, and ground water are source terms for diffuse emissions of tritium to the atmosphere at Site 300.

Pit 7 Complex: The Pit 7 Complex is an area where four landfills were established. All of the pits contain gravel and debris generated from explosives tests conducted at the Building 850 and 851 firing tables. Tritium is a known residue in this waste, and tritium contamination in both subsurface soils and ground water in the area has been characterized. Tritium in subsurface moisture can evaporate to the atmosphere. The affected area is estimated at $18,000 \text{ m}^2$. Tritium flux was calculated from tritium activity data obtained from subsurface soil samples collected at depths from 0.15 to 3 m, and was estimated to be 1.0 Ci ($3.7 \times 10^{10} \text{ Bq}$) for 1994. A correction (decrease) in source term from the time the samples were taken accounts for both radioactive decay and loss of the original tritium activities in the soil due to evapotranspiration. In addition, well purge water (water collected from wells and left to evaporate to the atmosphere prior to ground water sampling) in this area often contains elevated levels of tritium. The evaporation of this water to the atmosphere represents another component of the Pit 7 diffuse emission source term; it was estimated to contribute $1.7 \times 10^{-3} \text{ Ci}$ ($6.3 \times 10^7 \text{ Bq}$) during 1994. The 1994 calculated EDE to the SW-MEI from the combined tritium emissions at the Pit 7 Complex was $6.7 \times 10^{-5} \text{ mrem}$ ($6.7 \times 10^{-4} \mu\text{Sv}$).

Well 8 Spring: Tritium released to the soils, and eventually to the ground water, near the Building 850 firing table has been transported to areas where ground water flows near the surface and can evaporate to the atmosphere. Such is the case at the Well 8 Spring, where ground water is very shallow. To estimate tritium flux from this spring, tritium activity data obtained from water samples collected at the spring were used. These data were corrected for radioactive decay, but not for removal by evapotranspiration because the spring was assumed to have a limitless source of tritiated water for the time period in question. The affected area of the spring was estimated at 9.3 m^2 , and the 1994 source term was estimated to be $2.4 \times 10^{-3} \text{ Ci}$

(8.9×10^7 Bq). The 1994 calculated EDE to the SW-MEI from tritium emissions at the Well 8 Spring was 2.4×10^{-7} mrem (2.4×10^{-6} μ Sv).

Building 802: Tritium in the subsurface soils in the vicinity of the Building 802 firing table may evaporate to the atmosphere. The affected area was estimated to be 900 m². Tritium flux was calculated from tritium activity data obtained from subsurface soil samples collected at depths from 0.15 to 3 m. The tritium emission rate from subsurface soils to air was the product of the spatial-average tritium flux, the natural flux of water, the fraction of tritium in the water, and the affected surface area. The 1994 tritium emissions from this source were estimated to be 6.2×10^{-4} Ci (2.3×10^7 Bq). The 1994 calculated EDE to the SW-MEI from tritium emissions at Building 802 was 1.2×10^{-7} mrem (1.2×10^{-6} μ Sv).

Building 850: Approximately 2.1×10^4 Ci (7.8×10^{14} Bq) of tritium was expended in explosives tests at the Building 850 firing table in the past. Although a significant source of tritium (firing-table gravel) was removed from the area during 1988, tritium remains in subsurface soils beneath the Building 850 firing table, sand pile area, and lower corporation yard. Tritium in the subsurface soils in the vicinity can evaporate to the atmosphere. The affected area was estimated to be 20,000 m². The tritium flux and tritium emission rate from subsurface soils to air were calculated as in the Building 802 case above. The 1994 tritium emissions from this source were estimated to be 1.3×10^{-1} Ci (4.8×10^9 Bq). The 1994 calculated EDE to the SW-MEI from tritium emissions at Building 850 was 1.2×10^{-5} mrem (1.2×10^{-4} μ Sv).

Building 851: About 1.0×10^3 Ci (3.7×10^{13} Bq) of tritium were expended during past explosives research conducted at the Building 851 firing table. Although gravel was removed routinely from the area, subsurface soil below the firing table contains residual tritium in soil moisture that can evaporate to the atmosphere. The affected area was estimated to be 470 m². The tritium flux and tritium emission rate from subsurface soils to air were calculated as in the Building 802 case above. The 1994 tritium emissions from this source were estimated to be 3.6×10^{-4} Ci (1.3×10^7 Bq). The 1994 calculated EDE to the SW-MEI from tritium emissions at Building 850 was 3.9×10^{-6} mrem (3.9×10^{-7} μ Sv).

Resuspension of Depleted Uranium at Site 300: Like tritium, depleted uranium has been used as a component of explosives-test assemblies. It remains as a residue in surface soils, especially near the firing tables. Because surface soil is subject to resuspension by the action of wind, rain, and other environmental disturbances, the collective effects of surface soil uranium residuals on off-site doses were evaluated.

Airborne-particulate sampling of uranium isotopes was performed near the firing tables (Buildings 801, 850 and 851) and other facilities. Samples were taken weekly from all eight on-site locations and combined for analysis. Information about this routine environmental-surveillance monitoring network is presented in the Site

Annual Environmental Report (Gallegos *et al.*, Environmental Report for 1993, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-93).

The 1994 monitoring data showed the site-wide annual average airborne concentration of ^{238}U (the principal radioisotope found in the air samples) was $8.82 \times 10^{-11} \text{ g/m}^3$. This included contributions from both naturally occurring uranium and uranium from the Site 300 tests; therefore, use of this concentration gave an upper-bound limit for airborne concentration due to resuspension of surface contamination from historic tests. Depleted uranium includes small fractions of ^{235}U (0.2%) and ^{234}U (0.0005%) and these isotopes were included in the dose calculation. The average concentration of uranium in air for the eight on-site samplers was used to represent the concentration at the location of the SW-MEI. The resultant 1994 dose to the SW-MEI from inhalation of resuspended depleted uranium was thereby estimated to be 0.032 mrem (0.32 μSv).

Total Dose Estimate and Comparison with Previous Years' Data

For the Livermore site, the dose calculated for the SW-MEI from diffuse emissions in 1994 was 0.023 mrem (0.23 μSv). When point and diffuse sources were combined, the total annual dose was 0.065 mrem (0.65 μSv). Therefore, the relative contributions to the total were 35% from diffuse sources and 65% from point source emissions. Compared to data from previous years, the 1994 total EDE of 0.065 mrem (0.65 μSv) was the same as that for 1993, slightly below the 1992 value of 0.079 mrem (0.79 μSv), and is well below the previously reported EDE values of 0.234 mrem (2.34 μSv) and 0.240 mrem (2.40 μSv) for 1991 and 1990, respectively.

The total dose to the Site 300 SW-MEI from Site 300 operations in 1994 was 0.081 mrem (0.81 μSv). Point-source emissions from firing-table explosives experiments accounted for 0.049 mrem (0.49 μSv), or 60%, of this total, while 0.032 mrem (0.32 μSv), or 40%, was contributed by a diffuse source representing resuspension of naturally occurring and LLNL-contributed uranium in surface soils throughout the site. Diffuse-source contributions to dose from tritium emissions remained negligible.

No diffuse emissions were reported at Site 300 for years prior to 1993, so comparison for total dose can only be made with last year's value. The total dose value for 1993 was 0.037 mrem (0.37 μSv), with 0.011 mrem (0.11 μSv) from point sources and 0.026 mrem (0.26 μSv) from diffuse sources. The total dose in 1994 increased over that in 1993 because of normal variations in firing-table experiments that resulted in increased emissions. These increased emissions, however, resulted in doses which remain significantly below any NESHAPs thresholds. Variation in doses from firing-table experiments are apparent when comparing them over the past 5 years: 0.049 mrem (0.49 μSv) in 1994, 0.011 mrem (0.11 μSv) in 1993, 0.021 mrem (0.21 μSv) in 1992, 0.044 mrem (0.44 μSv) in 1991, and 0.057 mrem (0.57 μSv) in 1990.

SECTION V. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Name: Michael K. Hooper
U.S. Department of Energy,
Oakland Operations Office
1301 Clay Street, Room 700N
Oakland, Ca 94612

Signature: _____ Date: _____
Michael K. Hooper

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: Dennis K. Fisher
Associate Director
Plant Operations
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore CA 94551

Signature: _____ Date: _____
Dennis K. Fisher

SECTION VI. Supplemental Information

Collective Effective Dose Equivalent

Population doses, or collective EDEs, for both LLNL sites were calculated out to a distance of 80 km in all directions from the site-centers using CAP88-PC. As noted earlier, CAP88-PC evaluates the four principal exposure pathways: ingestion through food and water consumption, inhalation, air immersion, and irradiation by contaminated ground surface.

Population distributions centered on the two LLNL sites were compiled from 1990 census data. Key population centers affected by LLNL emissions are the relatively nearby communities of Livermore and Tracy, and the more distant metropolitan areas of Oakland, San Francisco, and San Jose, as well as the San Joaquin Valley communities of Modesto and Stockton. Within the 80 km outer distance specified by the EPA, there are 6.3 million residents included for the Livermore site collective dose determination, and 5.4 million for Site 300. Our population data files (distribution of population with distance and direction) are shown in Tables 4 and 5 for the Livermore site and Site 300, respectively.

Table 4. Population distribution for LLNL's Livermore site, based on 1990 census information. Values are population (in thousands) in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5-degree-sector directions.

Direction	Distance Range from Site (km)					Total
	0-16	16-32	32-48	48-64	64-80	
N	17	15	121	25	15	193
NNW	17	16	173	149	46	401
NW	17	53	136	291	17	514
WNW	27	13	509	715	232	1496
W	28	167	146	211	3	555
WSW	27	222	319	19	7	594
SW	27	58	199	50	49	383
SSW	7	44	700	82	99	932
S	7	6	7	111	47	178
SSE	7	10	7	10	11	45
SE	7	7	6	10	18	48
ESE	7	9	8	74	145	243
E	7	8	82	22	38	157
ENE	7	7	48	169	16	247
NE	7	11	10	63	78	169
NNE	17	22	6	7	74	126
Total	233	668	2477	2008	895	6281

Table 5. Population distribution for LLNL's Site 300, based on 1990 census information. Values are population (in thousands) in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5-degree sector directions.

Direction	Distance Range from Site (km)									Total
	0-15	15-24	24-32	32-42	42-50	50-57	57-63	63-74	74-80	
N	2.3	1	10	1	3.5	3.5	38	36	1	96.3
NNW	2.3	10	22	6	81	40	25	8	7	201.3
NW	2.3	1	8	33	13	80	80	149	23	389.3
WNW	3.5	32	32	33	33	70	220	400	510	1333.5
W	3.5	14	54	55	83	84	73	73	105	544.5
WSW	3.5	14	14	30	250	100	320	125	42	898.5
SW	3.5	1	1	28	22	350	350	82	50	887.5
SSW	2	1	10	7	4	3	55	55	47	184
S	2	1	4	2	1	10	5	6	1	32
SSE	2	1	5	3	8	6	12	1	1	39
SE	0.1	5	23	54	1	1	1	1	1	87.1
ESE	0.1	1	1	1	73	72	1	1	1	151.1
E	0.1	72	11	11	38	1	1	1	1	136.1
ENE	0.1	10	1	1	8	8	1	1	1	31.1
NE	0.1	30	18	169	1	1	1	1	1	222.1
NNE	1	1	1	32	31	1	78	1	1	147
Total	28.4	195	215	466	650.5	830.5	1261	941	793	5380.4

The collective EDE due to 1994 Livermore-site operations was 0.76 person-rem (0.0076 person-Sv), of which 0.50 person-rem (0.0050 person-Sv), or 66%, was from point-source emissions, and the remaining 34% from diffuse sources. This value is down slightly from the 1993 result of 0.98 person-rem (0.0098 person-Sv).

The corresponding collective EDE from Site 300 operations in 1994 was 17 person-rem (0.17 person-Sv), comprised of 14 person-rem (0.14 person-Sv), or 82%, due to point-source emissions, and 2.8 person-rem (0.028 person-Sv) from diffuse-source emissions. This total is more than twice the value of 6.9 person-rem (0.069 person-Sv) calculated for 1993 because of differences in the amounts of high explosives and depleted uranium used in explosives experiments.

The larger value for Site 300 relative to the Livermore site in both years is traceable primarily to the highly conservative assumptions about the Site 300 explosives experiments, especially regarding the fraction of radioactive material that is aerosolized and the height and trajectory of the explosive-debris cloud. This conservative modeling methodology over-predicts the quantity of radionuclides released to air by at least a factor of five, we believe, and over-estimates the long-range dispersal of material in these experiments. In 1992 we submitted to EPA a modeling protocol designed to treat the transient explosive experiments more realistically than does CAP88-PC, but this protocol was not accepted.

We note that the diffuse sources influence the individual dose to the SW-MEI more than they impact the population dose. The reason is the relatively less dynamic nature of the diffuse-source emissions, originating low to the ground at low initial velocity. Stacks release effluents at considerable speed high above the ground, and the explosives experiments force the effluent high into the air, allowing contaminants to be more readily transported toward population centers downwind.

Compliance with 40 CFR 61 Subpart H (61.93)

Calculations of effective dose equivalents for all Livermore-site and Site 300 facilities having the potential to release radionuclides to the atmosphere have been completed. Annual doses from actual total emissions of all facilities during 1994 were found to be well below the 10 mrem (100 μ Sv) NESHAPs dose standard. Tritium accounted for most of the Livermore-site calculated dose, while at Site 300 practically the entire calculated dose was due to the isotopes ^{238}U , ^{235}U , and ^{234}U , in depleted uranium.

Based on potential emissions without control devices and agreements with the EPA, 17 emission points in three facilities at the Livermore site will maintain continuous monitoring systems in compliance with NESHAPs requirements. Continuous monitoring will be maintained in Building 332 and the hardened area of Building 251 in lieu of a modeling or measurement effort to demonstrate the actual need for monitoring. Continuous monitoring is being continued at Building 331 even though the EDEs that result from measured emissions do not require monitoring under 40 CFR 61.93(b).

Several other Livermore-site facilities also will maintain continuous-monitoring systems; however, calculations using unabated potential emissions resulted in EDEs of less than 0.1 mrem/y (1 μ Sv/y) for the emissions from each of these facilities. While this monitoring also will be continued, it is not required under NESHAPs.

For facilities having discharge points without continuous monitoring, the requirement for continuous monitoring was individually evaluated. The evaluation was based on unabated emissions, even if emission-control systems existed. No additional facilities at either LLNL site were found to require continuous monitoring.

In August 1993, the EPA and DOE signed a Federal Facility Compliance Agreement (FFCA) regarding LLNL's compliance with 40 CFR 61, Subpart H. In April 1994, the EPA notified DOE and LLNL that all requirements of the FFCA had been met, and that LLNL had demonstrated compliance with the NESHAPs regulations.

Status of compliance with 40 CFR 61 Subpart Q - National Emission Standards for Radon Emissions From Department of Energy Facilities

LLNL does not have storage and disposal facilities for radium-containing materials that would be a significant source of radon.

Status of compliance with 40 CFR 61 Subpart T - National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings

LLNL does not have or store any uranium mill tailings.

Information on Radon-220 and Radon-222 Emissions

The majority of radon sources at LLNL occur naturally by emanation from the earth. Radon-222 emissions from research experiments during 1994 were estimated to be 20 μCi ($7.4 \times 10^5 \text{ Bq}$) with a corresponding EDE of $3 \times 10^{-9} \text{ mrem}$ ($3 \times 10^{-8} \mu\text{Sv}$). These ^{222}Rn emissions are less than one-millionth of that expected for naturally occurring ^{222}Rn emanation from the soil of the LLNL site.

Upgrades to Existing Sampling Systems

Progress has been made on upgrading existing sampling systems located in facilities that have been identified as requiring monitoring of discharge points according to NESHAPs (Buildings 331, 332, and the hardened portion of Building 251). The sampling systems in these facilities have been previously described in the NESHAPs June 1992 quarterly progress report to EPA Region IX. In our March 1993 quarterly progress report to EPA Region IX, we reported on operational changes made to the existing monitoring systems to ensure the extraction of representative samples. Although LLNL has stated that the existing systems satisfy or exceed the NESHAPs requirements regarding air sampling of radionuclide effluents, upgrades that proceeded in 1994 (which are scheduled for completion during 1995) will improve these sampling systems with regard to specific ANSI standards.

Requirements that are being addressed in these upgrades are continuous measurement of stack velocity, installation of multi-port aerosol extraction probes, minimization of sample transport line length, and relocation or installation of samplers to meet location requirements for extraction of samples. The upgraded particulate-sampling systems will ensure the extraction of representative samples as specified by the ANSI N13.1-1969 guidelines.

In all, the monitoring of 17 discharge locations is involved. Currently, 17 of 21 probe systems have been installed. Eight velocity probes have been calibrated using the traverse methodology prescribed in Method 2 of Appendix A to 40 CFR 60. Costs of these upgrades is estimated to be \$800,000 to \$900,000.

Site Periodic Confirmatory Measurements

LLNL uses a graded approach to determine the required level of periodic confirmatory measurements. The greater the calculated EDE, the more intensive the measurements will be. LLNL proposes a four-tier approach: (1) continuous monitoring at selected facilities, (2) annual effluent sampling, (3) general surveillance monitoring, and (4) site-specific surveillance monitoring, as described below.

Continuous Monitoring: There are currently eight buildings (Buildings 175, 231, 251, 331, 332, 419, 490, and 491) at the LLNL site that have radionuclide air-monitoring systems. These buildings are listed in Table 6, along with the number of samplers, the types of samplers, the analytes of interest, and the number of monitored discharge points at the building. In all, there are 94 samplers operating continuously. Many would operate from emergency power systems in the event of loss of normal power.

Air samples for particulate emissions are extracted downstream of High-Efficiency-Particulate-Air (HEPA) filters and prior to the discharge point to the atmosphere. Particles are collected on membrane filters. The sample filters are removed and analyzed for gross alpha and beta activity on a weekly or bi-weekly frequency depending on the facility. In most cases, simple filter-type aerosol collection systems are used. However, in some facilities, alpha continuous-air monitors (CAMs) are used for sampling. In addition to collecting a sample of particles, the CAM units provide an alarm capability for the facility in the event of a release of alpha activity.

Detection of gross alpha and beta activity resulting from particles collected on the air filters is accomplished using gas-flow-proportional counters. Analysis is delayed for at least four days from sample termination to allow for the decay of naturally occurring radon daughters. For verification of the operation of the counting system, calibration sources, as well as background samples, are intermixed with the sample filters for analysis. Analysis is performed by the Radiological Measurements Laboratory (RML) in the Hazards Control Department (HCD).

Table 6. Air-effluent sampling locations and systems.

Building	Facility	Analytes	Sample type	Number of samplers	Number of discharge points
175	Mars	Gross α,β on particles	Filters	6	6
231	Vault	Gross α,β on particles	Filter	1	1
251	Heavy Elements				
	Unhardened area	Gross α,β on particles	Filters	44	55 ^a
	Hardened area	Gross α,β on particles	CAM ^b	4	4
331	Tritium	Tritium	Ionization Chamber ^b	4	4
		Gaseous tritium/ tritiated water vapor	Molecular sieves	4	2
332	Plutonium	Gross α,β on particles	CAM ^b	12	11
		Gross α,β on particles	Filters	12	11
419	Decontamination	Gross α,β on particles	Filters	2	2
490	Laser Isotope Separation	Gross α,β on particles	Filters	4	4
491	Laser Isotope Separation	Gross α,β on particles	Filters	1	1

Note: "CAM" denotes Eberline continuous air monitors.

^a Alternate blower system measured by the same sampler.

^b Alarmed systems.

Each stack of the Tritium Facility (Building 331) is monitored for tritium release by both a continuous-monitoring alarm system and continuous molecular-sieve samplers. The alarmed samplers, Overhoff ion chambers, provide real-time tritium concentration release levels (HT and HTO). The sieve samplers, which can discriminate between tritiated-water (HTO) vapor and molecular tritium (HT), provide the values used for environmental reporting and are exchanged weekly or bi-weekly depending on the rate of tritium releases expected from planned work. Each sieve sampler (unalarmed) is in parallel with an alarmed monitor and consists of two molecular sieves. The first sieve collects tritiated water vapor; then a palladium-coated catalyst converts molecular tritium to tritiated water which is collected on a second sieve. The molecular sieve samples are submitted to the Hazards Control Analytical Laboratory where they are installed into a recovery system for the bake-out of tritiated-water vapor and subsequent condensation and

collection of the water. The retrieved tritiated water is analyzed by RML using liquid-scintillation counting techniques. New continuous air-effluent-flow-measurement systems are being installed in the stacks of the Tritium Facility.

Data from air-particulate-sampling filter and molecular-sieve analyses are reviewed by both a Hazards Control Department Health Physicist responsible for each facility and an Environmental Protection Department Environmental Analyst.

Annual Effluent Sampling: For point sources where the EDE is between 0.1% and 1% of the NESHAPs emission standard of 10 mrem/y (100 μ Sv/y) (between 0.01 and 0.1 mrem/y or 0.1 and 1.0 μ Sv/y), and no existing monitoring system is in place, LLNL strives to perform annual confirmatory sampling. Measurements of the effluent from such sources are planned for the year following the annual dose assessment. These measurements are planned to be taken downstream of any emission control devices and when operations are being performed. However, no facilities at LLNL fit into this EDE range during 1993, and therefore no requirement for confirmatory monitoring existed during 1994.

Nevertheless, during 1994, confirmatory effluent sampling was performed at two facilities (Buildings 321 and 298) that did not have existing monitoring systems. Results of CAP88-PC modeling, using source terms based on these sampling results, confirmed that continuous monitoring is not required. Furthermore, this also demonstrates that the inventory-modeling approach for these emissions (Attachment 1) is conservative.

At Building 321, sampling was conducted for an operation having the potential to emit uranium particles. The sampling was located after the HEPA filters in the stack venting an operation in Room 1351. The air sampling was conducted in accordance with EPA Method 5 (40 CFR 60) "Sampling for Particulate Emissions From Stationary Sources." The sampling system, an Andersen Universal Stack Sampler, extracted an air sample through an isokinetic sample probe placed in the ventilation duct, collected particles from the extracted air on a filter, controlled the air sample rate, and metered the air sample volume. Stack-gas temperature and velocity were measured with a manufacturer-calibrated anemometer. Control of the air sample rate was performed to ensure that the sampling was isokinetic; the sample taken was 104% of isokinetic. A 5.0 mm-pore-diameter Millipore filter housed in a 47-mm filter-holder attached to the end of the probe was used for particle collection. Filter and probe wash were analyzed for gross alpha and beta radiation. Results indicated alpha and beta activity concentrations to be less than 7.9×10^{-16} μ Ci/mL (2.9×10^{-11} Bq/mL) and 2.6×10^{-15} μ Ci/mL (9.6×10^{-11} Bq/mL), respectively. Conservatively, the source used for CAP88-PC modeling in support of these measurements projected these operations to be taking place during the entire year. This would result in an EDE to the SW-MEI of less than 9.6×10^{-6} mrem (9.6×10^{-5} μ Sv) for the year.

At Building 298, sampling was performed in a laboratory workplace (Room 181) that has the potential to release tritium to the workplace and environment. Ventilation is provided through the building air conditioning and heating system. That is, there is no stack. The tritium sampler, operated at 0.7 liters per minute, used silica gel to capture tritiated-water vapor from the room air. Results indicated tritium-in-room-air concentrations of 8.0×10^{-11} $\mu\text{Ci/mL}$ (3.0×10^{-6} Bq/mL). This concentration leads to a calculated effective dose equivalent to the SW-MEI of 2.2×10^{-8} mrem (2.2×10^{-7} μSv) for the year.

The 1994 dose assessments (Attachment 1) showed that rooms in three facilities (Buildings 177, 231, and 513) will require periodic confirmatory measurements during 1995. Periodic confirmatory sampling will take place if and when operations are in progress. Site 300 Firing Tables are considered exempt from this type of monitoring as a practical matter.

General Surveillance Monitoring: Surveillance air monitoring for tritium and radioactive particles has been in place since the 1970s and will continue. LLNL currently maintains eight continuously operating, high-volume, air-particulate samplers on the Livermore site, ten in the Livermore Valley, eight at Site 300, and one in Tracy. LLNL also maintains 11 continuously operating airborne-tritium samplers on the Livermore site and five samplers in the Livermore Valley. The samplers are positioned to ensure reasonable probability that any significant concentration of particulate and tritium effluents resulting from LLNL operations will be detected. The data from this monitoring network provide continuous measurements of the concentrations of radionuclides present in the air at the Livermore site, Site 300, and in the surrounding areas. This network allows for direct measurements of the overall impact of LLNL operations. Data from this network are presented in the Site Annual Environmental Report (Gallegos *et al.*, Environmental Report for 1993, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-93).

Site-Specific Surveillance Monitoring: Surveillance air monitors are placed in the vicinity of diffuse emission sources, such as those associated with Buildings 292, 331, 514, and 612, as well as in and around the Southeast Quadrant of the Livermore site. The data from these monitoring networks provide continuous measurements of the concentrations of specific radionuclides present in the air near these sources and allow a direct and accurate determination of their environmental impact. This practice will continue at these locations. It has been determined that the use of site-specific surveillance monitoring for Site 300 diffuse sources of tritium is unnecessary because of the low emissions and resultant dose values displayed in Attachment 1.

Status of the NESHAPs QA Program

The LLNL NESHAPs Quality Assurance (QA) Program is a multi-organizational effort that relies on the Quality Assurance/Quality Control programs that are in place at the LLNL facilities with continuous air-monitoring systems, the Radiological Measurements Laboratory (RML) of the Hazards Control Department, and the Environmental Protection Department (EPD).

Facility Safety Procedures (FSPs), Safety Analysis Reports (SARs) and QA Manuals for each monitored facility describe its organizational structure, responsibilities for sampling locations used for continuous air monitoring, and the procedures to be followed in the case of unplanned radionuclide releases. For example, the FSP for the Plutonium Facility (Building 332) describes in detail the procedure for responding to detection of radioactive materials in a release from the stacks. These documents also describe the sample-collection systems for both continuous and passive (i.e., not alarmed) air-monitoring systems (CAM and PAM, respectively), including sampling probes and procedures to be used for measuring flow rates, sampling, and calibration. Similarly, the FSP for the Tritium Facility (Building 331) describes its stack monitoring system, which includes molecular-sieve detectors for tritiated water (HTO) and elemental tritium gas (HT).

The RML Quality Assurance Program describes laboratory-analysis procedures, precision, accuracy and completeness objectives, sample-tracking procedures, quality-control (QC) sampling, sample handling, and data reporting. For example, the Gross Alpha-Beta Procedures Manual of the RML describes operational procedures for analyzing the CAM and PAM filters for radioactivity.

EPD, which is responsible for NESHAPs modeling and reporting, also operates under a Quality Assurance Management Plan and associated procedures. Detailed records are kept of all measurements, model runs, and calculations, and selected model runs are validated. The Terrestrial and Atmospheric Monitoring and Modeling Group (TAMM) of EPD is responsible for modeling and reporting radionuclide emissions for the purpose of NESHAPs compliance. TAMM members continue to refine mechanisms that ensure they are informed whenever new operations are proposed, significant changes in radionuclide inventories occur, or existing operations are modified so that NESHAPs modeling can be performed and appropriate action taken. All NESHAPs calculations are archived with the supporting information used to make the calculations.

LLNL is continuing to upgrade its NESHAPs QA program. This process involves an assessment of LLNL's compliance with requirements of 40 CFR Part 61, Appendix B, Method 114, Section 4. In this regard, FSPs, SARs and QA Manuals for the three continuously monitored facilities have been collected. In addition, the QA Plan, Health and Safety Manual, Laboratory Procedures Manual, and Calibration Procedures Manual for RML, as well as the Quality Assurance Plan and Quality Implementing Procedures of the Environmental Protection Department have been

collected and reviewed. Furthermore, a detailed NESHAPs QA Plan has been obtained from the Hanford Site. It is currently being reviewed and compared with the LLNL NESHAPs QA Program.

Quality Control (QC) on 1994 Radiological Inventory Update and Modeling

Radiological Inventory Update QC: Approximately 15% of the Livermore-site facilities that completed radiological-inventory updates in 1994 were randomly selected for validation. For this QC check, radiological inventories from four emission points were selected for validation in Building 151, two in Buildings 235, 253, and 361, and one each in Buildings 175, 177, 222, 226, 227, 231, 241, 281, 292, 321, 341, 364, 378, and 391. In addition, radiological inventories from all rooms in Buildings 254 and 513 were validated, as was the radiological inventory from the Building 514 Tank Farm. An EPD Environmental Analyst contacted the responsible party who signed the NESHAPs Inventory Forms and physically visited and inspected the facilities to verify inventory data. The responsible party was asked to demonstrate how he/she arrived at the data submitted on the original inventory form. Stack parameters also were verified. The QC data were compared to the original data. The accuracy of the inventory data was confirmed.

Modeling QC: Fifteen percent of the CAP88-PC modeling runs were selected for validation by a second analyst using a different computer and copy of CAP88-PC. The analyst performing this QC effort ran the model following independent gathering of radionuclide inventories and stack data from the NESHAPs Inventory Forms and pertinent distances from site maps. This independent QC modeling exercise did result in some minor adjustments to the EDEs shown for the SW-MEI for a few facilities. In general, however, the QC modeling verified the values from the original CAP88-PC modeling runs. In any event, the data that are presented in the attached spreadsheet are as accurate as possible, demonstrating that quality objectives are being met.

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	D
NOTE: CAPS-PC requires activity rates of curies/year and gives doses in mrem/year. To convert curies to becquerels use 1 Ci=3.7E+10 Bq and to convert mrem to s								
OVERMORE SITE POINT SOURCES								
Building 131 complex is a large office/laboratory facility housing both Mechanical Engineering and Electrical Engineering Division.								
131	Vault	Room Air	Temporary Storage	U-238	3.5E-07	1.0E-06	NA	
				U-235	4.8E-09	1.0E-06		
				U-234	3.3E-08	1.0E-06		
131	1221	Room Air	Temporary Storage	U-238	8.3E-02	1.0E-06	NA	
				U-235	1.1E-03	1.0E-06		
				U-234	7.7E-03	1.0E-06		
131	H-Bay Rooms 1331, 1341 1341A, 1345 1345A, 1349	131-H-Bay-FEV	No Operations	None	None	NA	19.7	
131	2250	Room Air	Processing systems	U-238	3.3E-01	1.0E-06	NA	
				U-235	4.3E-03	1.0E-06		
				U-234	3.1E-02	1.0E-06		
Building 151 houses the Isotope Sciences Division which processes samples generated by the nuclear test program. The radionuclides in these samples are fission products and								
Building 151 contains the Radiation Analytical Sciences laboratory (room 2117) where samples of waste streams and environmental media (air, water, soil etc.) are analyzed to								
151	1038	FHE-04	Aliquot Extraction	Sr-90	2.0E-08	1.0E-03	19.2	
				Ru-106	3.0E-10	1.0E-03		
				Ce-137	3.0E-08	1.0E-03		
				Ce-144	3.0E-10	1.0E-03		
				Pm-147	1.0E-09	1.0E-03		
151	1043	FGE-10/20	Core Dissolution	Sr-90	2.7E-08	1.0E-03	8.4	
				Ru-106	3.2E-10	1.0E-03		
				Ce-137	3.4E-08	1.0E-03		
				Ce-144	3.2E-10	1.0E-03		
				Pm-147	1.0E-08	1.0E-03		
151	1139	FHE-08	Sample Analysis	Am-241	1.8E-10	1.0E-03	19.2	
				Pu-239	3.0E-09	1.0E-03		
				Pu-240	8.0E-10	1.0E-03		
				U-235	3.0E-11	1.0E-03		
				U-238	3.0E-10	1.0E-03		
				Pm-231	3.0E-09	1.0E-03		
151	1318	FHE-06	Sample Preparation	Pu-239	1.0E-09	1.0E-03	19.2	
				Am-241	2.0E-10	1.0E-03		
				Cm-244	1.0E-10	1.0E-03		
				B-129	8.0E-11	1.0E-03		
151	1322	FHE-04	Sample Processing	Sr-90	2.0E-09	1.0E-03	19.2	
				Ru-106	3.0E-11	1.0E-03		
				Ce-137	3.0E-09	1.0E-03		
				Ce-144	3.0E-11	1.0E-03		
				Pm-147	1.0E-09	1.0E-03		
				Pu-239	2.0E-07	1.0E-03		
				Am-241	2.0E-07	1.0E-03		
151	1326	FHE-03	Sample Analysis	Sr-90	2.0E-09	1.0E-03	19.2	
				Ru-106	3.0E-11	1.0E-03		
				Ce-137	3.0E-09	1.0E-03		
				Ce-144	3.0E-11	1.0E-03		
				Pm-147	1.0E-09	1.0E-03		
				Pu-239	2.0E-07	1.0E-03		
151	1330	FHE-04	Sample Preparation	U-238	8.0E-09	1.0E-03	19.2	

3 Annual Report Spreadsheet

sk	Stack	Control	Control Device	Estimated	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source
water	Velocity	Device(s)	Abatement	Annual Emissions	Distance to	Direction	RDE	Distance to MBI	Direction	Unabated	Category
(m)	(m/s)		Factor	(Ci)	SWMBI (m)	to SWMBI	(mrem)	to MBI (m)	to MBI	EDE (mrem)	
with use of 5x10E+05 intem.											
A	NA	None	1	3.8E-13 4.6E-15 3.3E-14	1326	E	1.6E-11	552	SW	8.0E-11	1
IA	NA	None	1	8.3E-08 1.1E-09 7.7E-09	1326	E	4.6E-06	383	SWW	9.7E-05	1
DO	3.0	HEPA	0.01	0.0E+00	1326	E	0.0E+00	NA	NA	0.0E+00	1
IA	NA	None	1	3.0E-07 4.3E-09 3.1E-08	1326	E	1.0E-05	383	SWW	3.8E-04	1
ed in debris from drillback cores.											
eir radioactive content.											
41	16.4	None	1	2.0E-11 3.0E-13 3.0E-17 3.0E-13 1.8E-11	1308	E	3.4E-11	1125	NNE	8.7E-11	1
21	13.1	Scrubber and Precipitator	0.0025	9.8E-14 8.0E-16 8.6E-14 8.0E-16 2.5E-14	1308	E	1.3E-13	686	WNN	1.7E-10	1
141	4.7	None	1	1.0E-13 3.0E-12 6.0E-13 3.0E-14 3.0E-13 3.0E-12	1308	E	7.2E-10	1125	NNE	2.1E-09	1
341	4.9	None	1	1.0E-12 2.0E-13 1.0E-13 6.0E-14	1308	E	1.8E-10	1125	NNE	3.6E-10	1
041	4.7	None	1	2.0E-12 3.0E-14 3.0E-12 3.0E-14 1.8E-12 2.0E-10 2.0E-10	1308	E	4.6E-08	1125	NNE	1.3E-07	1
041	5.8	None	1	2.0E-12 3.0E-14 3.0E-12 3.0E-14 1.0E-12 2.0E-10 2.0E-10	1308	E	4.5E-08	1125	NNE	1.3E-07	1
041	4.9	None	1	8.0E-11	1308	E	2.4E-09	1125	NNE	5.8E-09	1

Building	Room/Area	Stack #	Operation	Radionuclides	Annual Inventory (Ci)	Physical State	Stack Height (m)	Stack Diam. (in)
151	1334	FHE-61	Sample Processing	Sr-90	1.0E-09	1.0E-03	19.2	0.4
				Po-106	1.5E-11	1.0E-03		
				Cs-137	1.5E-09	1.0E-03		
				Cs-144	1.5E-11	1.0E-03		
				Pm-147	5.0E-10	1.0E-03		
				Pu-239	1.0E-07	1.0E-03		
				Am-241	1.0E-07	1.0E-03		
151	2103	FHE-7	Sample Preparation	Co-60	4.0E-06	1.0E-03	19.2	0.4
151	2107	FHE-14	Tracer Preparation	Pu-239	3.4E-14	1.0E-03	19.2	0.4
				H-3	1.3E-11	1.0E-03		
				Cs-137	3.6E-14	1.0E-03		
				Sr-90	2.0E-12	1.0E-03		
				Eu-152	3.4E-11	1.0E-03		
				Eu-154	3.4E-11	1.0E-03		
				Ra-226	1.7E-12	1.0E-03		
				Co-60	2.3E-12	1.0E-03		
				Th-232	2.0E-14	1.0E-03		
				Ga-133	4.0E-13	1.0E-03		
				U-238	1.5E-09	1.0E-03		
151	2109	FHE-18	Sample Processing	Sr-90	2.0E-09	1.0E-03	19.2	0.4
				Au-106	3.0E-11	1.0E-03		
				Cs-137	3.0E-09	1.0E-03		
				Cs-144	3.0E-11	1.0E-03		
				Pm-147	1.0E-09	1.0E-03		
151	2117	FHE-28	Preparing Calibration Standards	H-3	2.0E-06	1.0E-03	19.2	0.4
				C-14	2.2E-06	1.0E-03		
				U-235	4.5E-09	1.0E-03		
				U-238	6.2E-09	1.0E-03		
				Pu-239	1.0E-07	1.0E-03		
				Am-241	4.5E-09	1.0E-03		
				Am-243	4.5E-09	1.0E-03		
				Sr-90	1.0E-07	1.0E-03		
				Y-90	1.0E-07	1.0E-03		
				Cs-137	4.5E-09	1.0E-03		
				Co-57	3.7E-09	1.0E-03		
				Co-60	3.7E-09	1.0E-03		
				Mn-54	3.7E-09	1.0E-03		
				Cs-144	3.7E-09	1.0E-03		
151	2121	FHE-29	Preparation of Calibration Standards	H-3	1.0E-06	1.0E-03	19.2	0.4
				C-14	1.0E-07	1.0E-03		
				U-235	5.0E-09	1.0E-03		
				U-238	7.2E-09	1.0E-03		
				Pu-239	2.0E-07	1.0E-03		
				Am-241	6.0E-09	1.0E-03		
				Am-243	6.0E-09	1.0E-03		
				Sr-90	3.1E-07	1.0E-03		
				Y-90	3.1E-07	1.0E-03		
				Cs-137	6.0E-09	1.0E-03		
				Co-57	4.3E-09	1.0E-03		
				Co-60	4.3E-09	1.0E-03		
				Mn-54	4.3E-09	1.0E-03		
				Cs-144	1.0E-07	1.0E-03		
151	2125	FHE-46	Alcohol Extraction	Bi-207	6.0E-08	1.0E-03	19.2	0.4
				Pu-239	3.0E-10	1.0E-03		
				Po-214	3.0E-10	1.0E-03		
				H-3	3.0E-10	1.0E-03		
				C-14	1.0E-06	1.0E-03		
151	2131	FHE-56	No Operations	None	None	NA	NA	
151	2143	FHE-63	No Operations	None	None	NA	NA	

Annual Report Spreadsheet

Stack	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (t)	10 ppmv 8-hr Wide Area Requirement Distance to SWMEI (m)	Direction to SWMEI	8DE (ppmv)	0.1 ppmv Monitoring Requirement Distance to MEI (m)	Direction to MEI	Unabated 8DE (ppmv)	Source Category
5.5	None	1	1.0E-12 1.5E-14 1.5E-12 1.5E-14 5.0E-13 1.0E-10 1.0E-10	1308	E	2.3E-08	1125	NNE	6.5E-08	1
6.2	None	1	4.0E-09	1308	E	8.8E-08	1125	NNE	1.0E-08	1
6.9	None	1	3.4E-17 1.3E-14 3.6E-17 2.0E-15 3.4E-14 3.4E-14 1.7E-15 2.3E-16 2.8E-17 4.0E-16 1.5E-12	1308	E	4.4E-11	1125	NNE	1.3E-10	1
5.3	None	1	2.0E-12 3.0E-14 3.0E-12 3.0E-14 1.0E-12	1308	E	3.8E-12	1125	NNE	8.6E-12	1
7.3	None	1	2.5E-08 2.2E-09 4.6E-12 6.2E-12 1.8E-10 4.8E-12 4.8E-12 1.8E-10 1.8E-10 4.6E-12 3.7E-12 3.7E-12 3.7E-12 3.7E-12	1308	E	1.8E-08	1125	NNE	5.0E-08	1
6.9	None	1	1.8E-09 1.8E-10 5.0E-12 7.2E-12 2.2E-10 6.8E-12 6.0E-12 3.1E-10 3.1E-10 6.0E-12 4.3E-12 4.3E-12 4.3E-12 1.0E-20	1308	E	2.2E-08	1125	NNE	6.2E-08	1
6.2	None	1	8.0E-09 3.0E-13 3.0E-13 3.0E-13 1.0E-12	1308	E	5.4E-11	1125	NNE	1.5E-10	1
NA	None	1	0.0E+00	1308	E	0.0E+00	NA	NA	0.0E+00	1
NA	None	1	0.0E+00	1308	E	0.0E+00	NA	NA	0.0E+00	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	St. Dia.
151	2149	FHE-78	Tracer Preparation	Pu-238 Pu-239 Pu-240 Pu-242 U-232 U-233 U-236	2.0E-14 4.0E-14 4.0E-14 3.0E-12 1.0E-12 9.0E-13 4.0E-15	1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03	19.2	0
151	2302 and 2302A	FHE-09	Process and Weigh Samples	Ce-144 Pr-147	3.0E-11 1.0E-09	1.0E-03 1.0E-03	19.2	0
151	2318	FHE-22	Sample Preparation	C-14	1.2E-09	1.0E-03	19.2	0
Building 175 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).								
175	103	FHE-1/2	Cleaning & Refurbishment of Parts	U-238 U-235 U-234	4.1E-01 5.0E-03 1.7E-01	1.0E-03 1.0E-03 1.0E-03	9.1	0
175	128	FHE-1000/2000	Cleaning Parts	U-238 U-235 U-234	6.0E-03 8.0E-04 2.0E-02	1.0E-03 1.0E-03 1.0E-03	10.7	0
Building 177 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).								
177	1014	FHE-10	Cleaning Parts and Process Uranium Oxide Powders	U-238 U-235 U-234	1.0E-04 2.2E-05 4.0E-04	1.0E-03 1.0E-03 1.0E-03	5.8	0
177	1015	FHE-27	Sample Preparation	U-238 U-235 U-234	2.5E-06 7.0E-07 1.7E-06	1.0E-06 1.0E-06 1.0E-06	7.0	0
177	1020	FHE-22	Cleaning & Refurbishment of Parts	U-238 U-235 U-234	3.3E-02 4.0E-04 1.4E-02	1.0E-03 1.0E-03 1.0E-03	8.4	0
177	1021	FHE-24/25	Sample Preparation	U-238 U-235 U-234	1.3E-04 4.0E-05 8.0E-04	1.0E-03 1.0E-03 1.0E-03	11.0	0
Building 179 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).								
179	1000	179-1000-RA1	No Operations	None	None	NA	NA	
179	1020	179-1020-RA1	No Operations	None	None	NA	NA	
Building 194 is operated by the Physics and Space Technology Directorate Center for Accelerator and Mass Spectrometry (CAMS) and E-Division. The complex houses a high energy linear accelerator and research laboratories. The accelerator beam can produce small quantities of short-lived activation products.								
194	Target Exhaust	TE-PE4	Positron Beam Generation	O-16 N-13	2.3E+00 4.4E+00	1.0E+00 1.0E+00	30.5	
194	1131	1131-RA	Positron Lifetime Experiments	Na-22	2.0E-03	1.0E-06	8.5	
194	8124A	TE-PE4	No Operations	None	None	NA	30.5	
Building 212 is administered by the Physics and Space Technology Directorate (formerly the Physical Sciences Directorate) for miscellaneous physics experiments. The current radionuclide emissions are due to contamination from past operations of the rotating target neutron source, which is no longer in operation.								
212	174	FHE-7	Contamination	H-3	1.1E-02	1.0E-06	4.3	
212	184	212-184-RA	Contamination	H-3	1.1E-02	1.0E-06	4.3	

Annual Report Spreadsheet

ID	Stack	Control	Control Device	Estimator	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source
	Velocity (m/s)	Device(s)	Abatement Factor	Annual Emissions (Ci)	Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Category
	5.9	None	1	2.0E-17 4.0E-17 3.0E-15 1.0E-15 9.0E-16 4.0E-18	1308	E	4.1E-13	1125	NNE	1.2E-12	1
	7.3	None	1	3.0E-14 1.0E-12	1308	E	1.6E-14	1125	NNE	4.5E-14	1
	6.2	None	1	1.2E-12	1308	E	1.5E-14	1125	NNE	4.3E-14	1
	4.0	HEPA	0.01	0.0E+00 0.0E+00 0.0E+00	1332	ESE	0.0E+00	821	NNE	0.0E+00	3
	4.0	HEPA	0.01	0.0E+00 0.0E+00 0.0E+00	1332	ESE	0.0E+00	821	NNE	0.0E+00	3
	2.4	HEPA	0.01	1.0E-09 3.2E-10 4.0E-09	1350	ESE	1.3E-07	764	NNE	1.5E-04	1
	12.9	HEPA	0.01	2.5E-13 7.0E-15 1.7E-13	1350	ESE	3.0E-12	764	NNE	8.1E-09	1
	6.0	HEPA	0.01	3.3E-07 4.0E-08 1.4E-07	1350	ESE	6.5E-06	764	NNE	1.1E-02	1
	7.8	HEPA	0.01	1.3E-09 4.3E-10 8.0E-09	1360	ESE	8.2E-08	764	NNE	2.0E-04	1
	NA	None	1	0.0E+00	1288	ESE	0.0E+00	NA	NA	0.0E+00	1
	NA	None	1	0.0E+00	1296	ESE	0.0E+00	NA	NA	0.0E+00	1
5	4.5	None	1	2.3E+00 4.4E+00	1524	ESE	2.5E-05	838	NE	2.4E-03	1
6	0.5	None	1	2.0E-08	1524	ESE	1.0E-09	412	NNE	3.1E-06	1
7	4.5	None	1	0.0E+00	1524	ESE	0.0E+00	NA	NA	0.0E+00	1
9	0.5	None	1	1.1E-08	1278	ESE	8.0E-12	38	SW	4.1E-10	1
10	0.5	None	1	1.1E-08	1278	ESE	8.0E-12	38	SW	4.1E-10	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	SI Class
Building 222 is part of the Chemistry and Material Sciences Directorate. Many of the laboratories either store or used depleted uranium. The depleted uranium usually exists as a solid, either as metal pieces or in chemical reagents such as oxide powders. The other sources of radionuclides in Building 222 is from analysis.								
222	1020B	FHE-4000	Gas Transfer	H-3	1.0E-02	1.0E+00	28.0	0
222	1020B	FHE-3000	No Operations	None	None	NA	12.8	1
222	1106	FHE-66	Cleaning of Equipment	Tb-232 U-238	2.1E-08 6.4E-08	1.0E-06 1.0E-06	5.5	0
222	1110B	FHE-6	No Operations	None	None	NA	9.8	0
222	1161	FHE-129	Chemical Analysis	Ni-63 Gross Alpha Gross Beta	1.4E-02 1.0E-06 1.0E-06	1.0E-06 1.0E-03 1.0E-03	6.1	0
222	1169	FHE-1000	Chemical Analysis	Gross Alpha Gross Beta	1.0E-08 1.0E-08	1.0E-09 1.0E-09	10.7	0
222	1216B	FHE-1000	Chemical Analysis	Gross Alpha Gross Beta Ni-63	1.0E-06 1.0E-06 7.5E-02	1.0E-03 1.0E-03 1.0E-06	10.7	0
222	1223A/B	FHE-1000	No Operations	None	None	NA	10.7	0
222	1228B	FHE-1000	Chemical analysis of waste	Gross Alpha Gross Beta	2.5E-06 2.5E-06	1.0E-03 1.0E-03	10.7	0
222	1405	Room Air	Chemical analysis	Gross Alpha Gross Beta	4.0E-07 4.0E-07	1.0E-03 1.0E-03	NA	1
222	1421	FHE-2000	Chemical analysis	U-234 U-235 U-238	1.3E-14 1.4E-15 1.2E-14	1.0E-03 1.0E-03 1.0E-03	10.7	0
222	1428	FHE-2000	Chemical analysis	Ni-63	2.9E-02	1.0E+00	10.7	0
222	1506	FHE-108	Gas chromatography	H-3	3.1E-01	1.0E+00	5.0	0
222	1511B	FHE-114	Chemical analysis	U-234 U-235 U-238	2.4E-12 1.1E-13 2.4E-12	1.0E-03 1.0E-03 1.0E-03	6.1	0
222	1518B	FHE-73	Chemical analysis	Gross Alpha Gross Beta	2.0E-08 2.0E-08	1.0E-03 1.0E-03	5.0	0
222	1520	FHE-116	Optical emission spectroscopy	U-234 U-235 U-238	3.2E-09 1.4E-10 3.0E-09	1.0E-06 1.0E-06 1.0E-06	4.4	0
222	1520B	FHE-75	Sample preparation	U-234 U-235 U-238	3.2E-09 1.4E-10 3.0E-09	1.0E-06 1.0E-06 1.0E-06	4.0	0
222	1520C	Room Air	Gravimetric	U-234 U-235 U-238	3.2E-09 1.4E-10 3.0E-09	1.0E-06 1.0E-06 1.0E-06	NA	0
222	1523C	FHE-94	Chemical extraction	Gross Alpha Gross Beta	1.2E-08 1.2E-08	1.0E-03 1.0E-03	6.1	0

Annual Report Spreadsheet

Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Cr)	10 mrem/y Site-Wide Dose Requirement Distance to SWMEI (m)	Direction to SWMEI	EDR (mrem)	0.1 mrem/y Monitoring Requirement Distance to MEI (m)	Direction to MEI	Unbased EDR (mrem)	Source Category
of hazardous-waste samples.										
12.8	None	1	1.0E-02	1239	ENE	2.9E-05	253	SW	5.1E-06	1
15.6	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	1
3.1	HEPA	0.01	2.1E-16 6.4E-18	1239	ENE	1.0E-13	253	SW	9.4E-11	1
5.2	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	1
10.2	None	1	1.4E-08 1.0E-09 1.0E-09	1239	ENE	2.1E-07	253	SW	1.0E-08	1
10.4	None	1	1.0E-11 1.0E-11	1239	ENE	1.4E-09	253	SW	4.4E-09	1
19.4	None	1	1.0E-09 1.0E-09 7.5E-08	1239	ENE	1.4E-07	253	SW	4.4E-07	1
19.4	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	1
19.4	None	1	2.5E-09 2.5E-09	1239	ENE	3.4E-07	253	SW	1.1E-06	1
NA	None	1	4.0E-10 4.0E-10	1239	ENE	1.1E-07	253	SW	3.1E-08	1
13.7	None	1	1.3E-17 1.4E-18 1.2E-17	1239	ENE	1.4E-15	253	SW	5.5E-15	1
13.7	None	1	2.9E-02	1239	ENE	1.0E-04	253	SW	6.5E-04	1
8.3	None	1	3.1E-01	1239	ENE	1.7E-04	253	SW	1.6E-03	1
4.8	None	1	2.6E-18 1.1E-18 2.4E-15	1239	ENE	2.0E-13	253	SW	3.8E-12	1
9.3	None	1	2.0E-06 2.0E-06	1239	ENE	4.4E-07	253	SW	4.2E-06	1
7.4	None	1	3.2E-15 1.4E-16 3.0E-15	1239	ENE	5.0E-13	253	SW	4.9E-12	1
6.5	None	1	3.2E-15 1.4E-16 3.0E-15	1239	ENE	5.0E-13	253	SW	4.9E-12	1
NA	None	1	3.2E-15 1.4E-16 3.0E-15	1239	ENE	5.1E-13	253	SW	1.7E-11	1
11.5	None	1	1.2E-08 1.2E-08	1239	ENE	2.4E-07	253	SW	2.2E-06	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	SSR Diameter (m)
Building 224 is operated by the Chemistry and Materials Science Directorate. The facility houses laboratories that perform digestion and analysis of waste samples.								
224	110	FHE-1000	Sample digestion/chemical analysis	Gross Alpha Gross Beta	2.5E-04 2.5E-04	1.0E-03 1.0E-03	2.6	0
224	114	FHE-5	Waste collection	Gross Alpha Gross Beta	5.0E-05 5.0E-05	1.0E-03 1.0E-03	5.6	0
224	115	FHE-4	Chemical analysis	Gross Alpha Gross Beta	5.0E-08 5.0E-08	1.0E-03 1.0E-03	6.7	0
224	117	FHE-3	Chemical analysis	Gross Alpha Gross Beta	1.0E-07 1.0E-07	1.0E-03 1.0E-03	5.9	0
Building 226 is operated by the Chemistry and Materials Science Directorate. The facility houses chemistry laboratories that prepare and analyze various media such as soil, vegetation. Radioactive material can exist in this facility, either in the samples or in the prepared standards.								
226	108	FE-4	Borelation counting	Gross Alpha Gross Beta	2.5E-11 2.5E-11	1.0E-03 1.0E-03	6.4	0
226	109	FHE-2	Sample preparation	Gross Alpha Gross Beta	2.5E-09 2.5E-09	1.0E-03 1.0E-03	5.9	0
Building 227 is part of the Chemistry and Materials Science Directorate. In room 1063, liquid samples containing very small amounts of depleted uranium are studied to determine the leaching properties of natural waters.								
227	1036	Room Air	No Operations	None	None	NA	NA	0
227	1044	Room Air	No Operations	None	None	NA	NA	0
227	1063	Room Air	Leaching studies	U-234 U-235 U-238	1.1E-06 4.7E-09 1.0E-06	1.0E-03 1.0E-03 1.0E-03	NA	0
227	1064	Room Air	Leaching studies	U-234 U-235 U-238	3.2E-08 1.4E-09 3.0E-08	1.0E-03 1.0E-03 1.0E-03	NA	0
The 231 complex houses research and development activities conducted by the Chemistry and Materials Science Directorate, Engineering, Nuclear Test Engineering, Weapons Engineering. Management oversight for Building 231 is provided by the Engineering Directorate through the Engineering Sciences Division.								
231	1128	FHE-31-1,2	Storage of Radionuclides	See Text	See Text	1.0E-06	9.1	0
231	1330	FHE-63N4	Repackaging	U-234 U-235 U-238	2.9E-01 1.3E-01 1.0E+01	1.0E-06 1.0E-06 1.0E-06	10.6	0
231	1351	FHE-63N4	Verification of packaging	U-234 U-235 U-238	6.3E+00 1.3E+00 1.0E+02	1.0E-06 1.0E-06 1.0E-06	10.6	0
231	1737	FHE-54	Electron beam welding	Th-232	3.2E-06	1.0E-06	10.5	0
231	1737A	FHE-54	No Operations	None	None	NA	10.5	0
231	1800HB	FGB-778	Storage	U-234 U-235 U-238	1.0E-10 2.6E-11 2.0E-09	1.0E-06 1.0E-06 1.0E-06	2.4	0
231	1844	FHE-42	Heat treatment studies	U-234 U-235 U-238	1.9E-10 2.6E-11 2.0E-09	1.0E-06 1.0E-06 1.0E-06	2.4	0
231	1846	FHE-40	Sample preparation	U-234 U-235 U-238	1.9E-10 2.6E-11 2.0E-09	1.0E-06 1.0E-06 1.0E-06	10.7	0

Annual Report Spreadsheet

ID	Stack	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/yr Site-Wide Dose Requirement			0.1 mrem/yr Monitor Room Requirement			Source Category
	Velocity (m/s)				Distance to SWMS (m)	Direction to SWMS	EDE (mrem)	Distance to MBI (m)	Direction to MBI	Unabated EDE (mrem)	
	11.0	None	1	2.5E-07 2.5E-07	1170	ENE	4.0E-05	255	SW	3.5E-04	1
	3.6	None	1	5.0E-08 5.0E-08	1170	ENE	1.3E-05	255	SW	1.1E-04	1
	6.6	None	1	5.0E-11 5.0E-11	1170	ENE	1.1E-08	255	SW	8.9E-08	1
	9.3	None	1	1.0E-10 1.0E-10	1170	ENE	2.2E-08	255	SW	1.9E-07	1
and waste samples for toxic chemical and radioactivity analysis.											
	11.1	None	1	2.5E-14 2.5E-14	1155	ENE	6.3E-12	244	SW	4.3E-11	1
	7.5	None	1	2.5E-12 2.5E-12	1155	ENE	5.8E-10	244	SW	4.1E-09	1
	NA	None	1	0.0E+00	1155	ENE	0.0E+00	244	SW	0.0E+00	1
	NA	None	1	0.0E+00	1155	ENE	0.0E+00	244	SW	0.0E+00	1
	NA	None	1	1.1E-08 4.7E-11 1.0E-09	1155	ENE	2.4E-07	244	SW	3.0E-06	1
	NA	None	1	3.2E-11 1.4E-12 3.0E-11	1155	ENE	7.0E-09	244	SW	1.1E-07	1
mg, and Safeguards and Security Materials Management Division.											
	12.0	HEPA	0.01	0.0E+00	1167	ENE	0.0E+00	NA	NA	0.0E+00	3
	6.0	HEPA	0.01	9.3E-09 1.3E-09 1.0E-07	1167	ENE	6.7E-06	568	SW	1.8E-03	1
	6.0	HEPA	0.01	8.3E-08 1.3E-08 1.0E-06	1167	ENE	6.7E-05	568	SW	1.8E-02	1
	2.0	HEPA	0.01	3.2E-14	1167	ENE	8.1E-12	568	SW	1.8E-09	1
	2.0	None	1	0.0E+00	1167	ENE	0.0E+00	NA	NA	0.0E+00	1
	14.4	None	1	1.8E-16 2.6E-17 2.0E-15	1157	ENE	2.0E-13	568	SW	5.5E-13	1
	40.4	HEPA	0.01	1.9E-18 2.6E-19 2.6E-17	1167	ENE	1.3E-15	568	SW	2.9E-13	1
	3.8	None	1	1.9E-16 2.6E-17 2.0E-15	1167	ENE	1.4E-13	568	SW	4.1E-13	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	DI
231	1945A	Room Air	Scanning electron microscopy	U-234 U-235 U-238	1.9E-13 2.6E-14 2.0E-12	1.0E-06 1.0E-06 1.0E-06	NA	
231	1945B	FHE-40	Micrography sample preparation	U-234 U-235 U-238	8.8E-03 1.5E-04 1.2E-02	1.0E-03 1.0E-03 1.0E-03	10.7	
231	1945C	Room Air	Microscopy	U-234 U-235 U-238	1.9E-13 2.6E-14 2.0E-12	1.0E-06 1.0E-06 1.0E-06	NA	
231	1945D	Room Air	Metallurgical analysis	U-234 U-235 U-238	1.9E-10 2.6E-11 2.0E-09	1.0E-06 1.0E-06 1.0E-06	NA	
231	1945E	Room Air	Wet grinding/polishing	U-234 U-235 U-238	1.9E-07 2.6E-08 2.0E-06	1.0E-03 1.0E-03 1.0E-03	NA	
231	1958A	FGE-78	Metal casting	U-234 U-235 U-238	9.2E-06 1.3E-06 9.8E-05	1.0E-06 1.0E-06 1.0E-06	2.4	
231	1958A	FHE-43	Metal casting	U-234 U-235 U-238	9.2E-06 1.3E-06 9.8E-05	1.0E-06 1.0E-06 1.0E-06	8.8	
231	2034	FHE-23	Lapping/finishing/polishing	U-234 U-235 U-238	3.7E-07 5.1E-08 4.0E-06	1.0E-03 1.0E-03 1.0E-03	12.6	
Building 235 is part of the Chemistry and Materials Sciences Directorate. Operations in the facility include examination of material structure, surface, and subsurface; precision metal of the depleted uranium in this building is there for characterization studies; some is used for ion beam implantation experiments. Chemical characterization studies follow up to 500 grams each of depleted uranium and thorium might be present in each of these rooms.								
235	1109	FHE-2001	No Operations	None	None	NA	11.1	
235	1121	Room Air	Scanning electron microscopy	U-234 U-235 U-238	1.1E-08 4.7E-10 1.0E-08	1.0E-06 1.0E-06 1.0E-06	NA	
235	1123	Room Air	No Operations	None	None	NA	NA	
235	1125	Room Air	Scanning electron microscopy	U-234 U-235 U-238	6.4E-10 2.6E-11 6.0E-10	1.0E-06 1.0E-06 1.0E-06	NA	
235	1131	FHE-2	Metallurgical sample preparation	U-234 U-235 U-238	1.8E-04 7.8E-08 1.7E-04	1.0E-06 1.0E-06 1.0E-06	8.2	
235	1133	Room Air	Microstructure examination	U-234 U-235 U-238	5.3E-08 2.3E-07 5.0E-06	1.0E-06 1.0E-06 1.0E-06	NA	
235	1138	FHE-1001/HD-13	Sample preparation	U-234 U-235 U-238	1.1E-08 4.7E-10 1.0E-08	1.0E-06 1.0E-06 1.0E-06	8.8	
235	1224	FHE-1001/HD-21	Sputter coating	U-234 U-235 U-238	1.7E-05 2.4E-05 1.9E-04	1.0E-06 1.0E-06 1.0E-06	9.6	
235	1226	FHE-1001/HD-22	Target cleaning	U-234 U-235 U-238	1.7E-05 2.4E-05 1.9E-04	1.0E-06 1.0E-06 1.0E-06	9.8	
235	1251	FHE-2001	No Operations	None	None	NA	11.1	

Annual Report Spreadsheet

R pt	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mSv/yr. Site-Wide Dose Requirement			0.1 mSv/yr. Monitoring Requirement		Source Category	
					Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unfiltered EDE (mrem)	
1	NA	None	1	1.8E-19 2.8E-20 2.0E-18	1167	ENE	2.3E-16	438	SW	1.7E-15	1
6	3.8	None	1	6.8E-08 3.5E-07 1.2E-05	1167	ENE	1.3E-03	568	SW	3.7E-03	1
	NA	None	1	1.9E-19 2.8E-20 2.0E-18	1167	ENE	2.3E-16	438	SW	1.7E-15	1
1	NA	None	1	1.9E-18 2.8E-17 2.0E-16	1167	ENE	2.3E-13	438	SW	1.7E-12	1
1	NA	None	1	1.9E-10 2.8E-11 2.0E-09	1167	ENE	2.3E-07	438	SW	1.7E-08	1
10	14.3	None	1	9.2E-12 1.3E-12 8.8E-11	1167	ENE	9.8E-09	568	SW	2.7E-08	1
50	7.2	HEPA	0.01	9.2E-14 1.3E-14 8.8E-13	1167	ENE	8.8E-11	568	SW	1.9E-08	1
35	1.7	None	1	3.7E-10 5.1E-11 4.0E-09	1167	ENE	2.8E-07	568	SW	7.8E-07	1
ng. Ion Implanting, and metallurgical studies in rooms 1100, 1224, and 1226.											
30	0.2	HEPA	0.01	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	1
11	NA	None	1	1.1E-14 4.7E-16 1.0E-14	1065	ENE	2.7E-12	556	SW	1.7E-11	1
1A	NA	None	1	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	1
1A	NA	None	1	4.4E-16 2.8E-17 6.0E-16	1065	ENE	1.6E-13	556	SW	1.0E-12	1
31	12.3	None	1	1.8E-10 7.8E-12 1.7E-10	1065	ENE	2.7E-08	556	SW	7.0E-08	1
NA	NA	None	1	5.3E-12 2.3E-13 5.0E-12	1065	ENE	1.3E-08	556	SW	8.5E-09	1
30	2.4	HEPA	0.01	1.1E-16 4.7E-18 1.0E-16	1065	ENE	1.5E-14	556	SW	3.5E-12	1
130	2.4	HEPA	0.01	1.7E-13 2.4E-14 1.9E-12	1065	ENE	1.4E-10	556	SW	3.1E-09	1
230	2.4	HEPA	0.01	1.7E-13 2.4E-14 1.9E-12	1065	ENE	1.4E-10	556	SW	3.1E-08	1
230	0.2	HEPA	0.01	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	S or D
Building 241 is administered by the Chemistry and Material Sciences Directorate for material properties research and testing.					Radionuclide emissions result from contamination from			
241	1808	FGBE-45	Oxidation of uranium	U-238	1.0E-06	1.0E-06	12.5	0
241	1829	Room Air	X-ray diffraction analysis	U-238	6.0E-11	1.0E-03	NA	
241	1822	Room Air	X-ray diffraction analysis	U-238	2.0E-08	1.0E-06	NA	
241	1841	FHE-53	Reaction of uranium oxide with chlorine	U-238	7.5E-07	1.0E-03	7.0	0
241	1887	FGBE-27	No Operations	None	None	NA	11.3	C
241	1896	FHE-27	UV spectroscopy	U-238	3.0E-11	1.0E-03	7.0	C
Building 251, the Heavy Element Facility, is operated by the Nuclear Test-Experimental Sciences Directorate as a facility for handling radioactive materials, especially transuramics. One area of the facility has been "hardened" to resist damage from earthquakes. Room exhausts from this hardened area are double HEPA filtered, glove box exhausts are triple HEPA filtered. Exhausts from the hardened area are continuously monitored by alpha alarm detectors (CAADs). Exhausts from the unhardened area, also HEPA filtered, are continuously sampled by air exhausts of the Building 251 hardened area are required to have continuous monitoring; measured emissions, rather than the inventory approach, are used to determine annual								
251	1027, 1035, 1047, 1048, 1052 & 1053 (Hardened Area) Room Exhaust	FFE-1000, 2000	Transuranic Research	Transuranics	*	NA	7.8	C
251	Hardened Area Glove Boxes	FGBE-1000, 2000	Transuranic Research	Transuranics	*	NA	7.8	C
251	1117	FGBE-25/26	Preparation of targets	Cm-244 Ci-252	4.6E-04 5.7E-06	1.0E-03 1.0E-03	9.5	C
251	1142	FHE-09	No Operations	None	None	NA	2.5	I
251	1150	FGBE-33/34	Preparation of targets	Cm-244 Ci-252	2.3E-04 5.7E-06	1.0E-06 1.0E-03	8.0	C
251	1251	FHE-57	General Chemistry	Ci-252	5.7E-08	1.0E-03	6.4	
251	1232	FGBE-38/39	No Operations	None	None	NA	7.2	
251	1314	FGBE-44/45	Solidification of liquids	Am-241 Cm-244 Pu-238 Pu-239 Pu-242 U-233	4.1E-03 5.5E-03 2.7E-04 8.9E-11 4.1E-09 8.2E-11	1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03	10.2	
251	1383	FHE-13	General Chemistry	Pu-242 Cm-243 Cm-248 Cm-244	1.4E-08 2.1E-03 5.2E-07 6.0E-05	1.0E-03 1.0E-09 1.0E-03 1.0E-06	1.5	
Building 253 houses the Hazards Control Department, and the facility includes laboratories for the chemical analysis and counting of radioactive samples.								
253	1722A	FHE-24	Liquid scintillation counting	H-3	2.5E-11	1.0E-03	2.6	
253	1732	FHE-23	HNO3 digestion of samples above 100 deg. C.	Pu-239 Sr-90 Th-230 Cs-137	1.1E-12 1.9E-12 1.1E-13 1.0E-13	1.0E-03 1.0E-03 1.0E-03 1.0E-03	10.2	
253	1734	Room Air	Oxidation of spikes and other samples	H-3 Pu-239 Sr-90	9.0E-10 2.8E-12 1.2E-11	1.0E-03 1.0E-03 1.0E-03	NA	
253	1734A	FGBE-42	Sieve soil samples	Pu-239 Sr-90	2.7E-10 4.6E-10	1.0E-06 1.0E-06	6.1	

Annual Report Spreadsheet

#	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (kg)	10 yearly Site Wide Dose Requirement			0.1 yearly Monitoring Requirement			Source Category
					Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unfiltered EDE (mrem)	
all operations that have been discontinued.											
	5.5	HEPA	0.01	1.0E-16	1140	E	4.2E-15	821	SW	1.0E-12	1
	NA	None	1	5.0E-14	1140	E	4.2E-12	697	W	3.5E-11	1
	NA	None	1	2.0E-14	1140	E	1.4E-12	597	W	1.2E-11	1
	11.2	HEPA	0.01	7.5E-12	1140	E	3.5E-10	821	SW	8.7E-08	1
	21.7	HEPA	0.01	0.0E+00	1140	E	0.0E+00	NA	NA	0.0E+00	1
	14.9	None	1	3.0E-14	1140	E	1.3E-12	821	SW	3.4E-12	1
45. Filtered. Triple filter systems. nationals.											
	11.7	Double HEPA	0.0001	0.0E+00	1189	E	0.0E+00	NA	NA	0.0E+00	3
	4.8	Triple HEPA	0.000001	0.0E+00	1188	E	0.0E+00	NA	NA	0.0E+00	3
	12.8	HEPA	0.01	4.8E-09	1188	E	5.1E-07	714 1150	WSW NNE	1.4E-04 1.4E-04	1
	5.1	HEPA	0.01	0.0E+00	1188	E	0.0E+00	NA	NA	0.0E+00	1
	12.8	HEPA	0.01	2.3E-12	1189	E	2.8E-10	1150	NNE	7.4E-08	1
	8.0	HEPA	0.01	3.7E-13	1188	E	3.5E-11	714	WSW	9.7E-09	1
	5.1	HEPA	0.01	0.0E+00	1188	E	0.0E+00	NA	NA	0.0E+00	1
	10.2	HEPA	0.01	4.1E-08 5.5E-08 2.7E-11 8.0E-16 4.1E-14 8.2E-16	1188	E	1.4E-05	1150	NNE	3.5E-03	1
	6.2	HEPA	0.01	1.4E-13 2.1E-04 5.2E-12 6.0E-13	1188	E	3.0E-04	713 714	WNW WSW	1.5E-03 1.5E-03	1
16	5.8	None	1	2.5E-14	1116	E	3.7E-17	1079	NNE	1.0E-16	1
18	8.5	None	1	1.1E-15 1.9E-15 1.1E-16 1.0E-16	1116	E	1.5E-13	1079	NNE	4.0E-13	1
1	NA	None	1	9.9E-13 2.8E-15 1.2E-14	1116	E	8.9E-13	736	W	4.7E-12	1
10	23.6	HEPA	0.01	2.7E-18 4.8E-18	1116	E	4.2E-16	1079	NNE	1.1E-13	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	St Over
253	1734B	FE-2	Samples and standards plated and flamed	Cs-137	1.7E-11	1.0E-03	6.4	0.
				Tl-230	2.2E-12	1.0E-03		
				Pu-239	1.2E-11	1.0E-03		
				Sr-90	1.7E-12	1.0E-03		
				Y-90	7.8E-13	1.0E-03		
				Np-237	6.4E-13	1.0E-03		
				H-3	4.3E-12	1.0E-03		
253	1734C	FE-4	Quality control sample aliquoting	H-3	2.2E-14	1.0E-03	6.4	0.
				Np-237	3.0E-12	1.0E-03		
				Sr-90	2.5E-12	1.0E-03		
				Y-90	2.5E-12	1.0E-03		
				Cs-137	3.7E-12	1.0E-03		
				Tl-230	4.0E-13	1.0E-03		
				Pu-239	7.5E-12	1.0E-03		
253	1734D	FE-11	Acid digestion for gross alpha/beta	H-3	6.8E-06	1.0E-03	10.4	0
				Pu-239	5.3E-11	1.0E-03		
				Sr-90	2.6E-10	1.0E-03		
				Y-90	2.8E-12	1.0E-03		
				Np-237	3.1E-12	1.0E-03		
253	1813	Room Air	Analysis of radon daughter samples	Po-218	7.8E-07	1.0E-03	NA	1
				Pb-214	7.8E-07	1.0E-03		
				Bi-214	7.8E-07	1.0E-03		
				Ra-226	4.6E-08	1.0E-06		
253	1814	FEY-1	Aerosol attachment to radon daughter products	Ra-226	3.5E-06	1.0E-03	9.5	0
253	1814A	GLV-1	Aerosol attachment to radon daughter products	Po-218	7.8E-05	1.0E+00	5.4	0
				Pb-214	7.8E-05	1.0E+00		
				Bi-214	7.8E-05	1.0E+00		
Building 254 is run by Hazard Control for the purpose of conducting bioassays and providing analytical services.								
254	105	Room Air	Analysis of urine for radionuclides	U-238	5.5E-17	1.0E-03	NA	
				U-235	2.6E-18	1.0E-03		
				U-234	8.9E-17	1.0E-03		
254	109	FE-5	Analysis of urine for radionuclides	U-238	1.3E-16	1.0E-03	6.9	0
				U-235	5.8E-18	1.0E-03		
				U-234	1.4E-16	1.0E-03		
254	113	FE-2	Analysis of urine for radionuclides	Am-243	1.1E-13	1.0E-03	6.9	0
				Pu-242	1.4E-12	1.0E-03		
				Pu-239	2.3E-13	1.0E-03		
254	113A	FE-3	Analysis of urine for radionuclides	Am-241	8.6E-14	1.0E-03	6.9	0
				Am-243	2.4E-12	1.0E-03		
				Cm-244	8.1E-13	1.0E-03		
				Np-237	8.5E-12	1.0E-03		
				Th-230	9.4E-12	1.0E-03		
				Cl-242	8.4E-12	1.0E-03		
				U-233	2.8E-14	1.0E-03		
				U-234	1.1E-12	1.0E-03		
				U-235	2.8E-14	1.0E-03		
				U-236	8.8E-12	1.0E-03		
				U-238	6.6E-16	1.0E-03		
254	113B	FE-4	Analysis of urine for radionuclides	P-32	5.6E-12	1.0E-03	6.9	
				S-35	1.1E-10	1.0E-03		
				C-14	3.8E-11	1.0E-03		
				P-33	1.1E-09	1.0E-03		
				I-125	1.7E-10	1.0E-03		
				H-3	1.2E-10	1.0E-03		
				Sr-90	2.7E-10	1.0E-03		
				Y-90	2.7E-10	1.0E-03		

Annual Report Spreadsheet

ID	Stack Velocity (m/s)	Control Device(s)	Control Device Adjustment Factor	Estimated Annual Emissions (Ci)	10 yearly Site-Wide Dose Requirement			0.1 yearly Monitoring Requirement			Source Category
					Distance to SWMGI (m)	Direction to SWMGI	GEC (mrem)	Distance to MGI (m)	Direction to MGI	Unabated GEC (mrem)	
	8.7	None	1	1.7E-14	1116	E	2.1E-12	1079	NNE	5.5E-12	1
				2.2E-15							
				1.2E-14							
				1.7E-15							
				7.8E-16							
				6.4E-16							
				4.3E-15							
	7.2	None	1	2.2E-17	1116	E	1.8E-12	1079	NNE	5.0E-12	1
				3.0E-16							
				2.5E-15							
				2.6E-15							
				3.7E-15							
				4.8E-16							
				7.5E-15							
	12.3	None	1	6.8E-12	1116	E	7.7E-12	1079	NNE	2.0E-11	1
				8.3E-14							
				2.6E-13							
				2.6E-15							
				3.1E-15							
	74A	None	1	7.8E-10	1116	E	5.5E-10	736	W	4.0E-09	1
				7.8E-10							
				7.8E-10							
				4.6E-14							
	13.7	4 stage HEPA	0.0000001	3.5E-17	1116	E	2.6E-16	1079	NNE	6.6E-08	1
	3.5	HEPA	0.01	7.8E-07	1116	E	7.3E-10	736	W	2.6E-07	1
				7.8E-07				800	WSW	2.6E-07	
				7.8E-07							
	NA	None	1	5.5E-20	1032	E	1.1E-17	817	W	4.5E-17	1
				2.6E-21							
				5.8E-20							
	8.3	None	1	1.3E-19	1032	E	1.6E-17	1070	NNE	3.7E-17	1
				5.0E-21							
				1.4E-19							
	8.3	None	1	1.1E-16	1032	E	2.8E-13	1070	NNE	6.8E-13	1
				1.4E-15							
				2.3E-16							
	5.1	None	1	8.8E-17	1032	E	5.6E-12	1070	NNE	1.4E-11	1
				2.4E-16							
				9.1E-18							
				8.5E-15							
				9.4E-15							
				8.4E-15							
				2.8E-17							
				1.1E-15							
				2.0E-17							
				8.8E-15							
				6.8E-19							
	8.3	None	1	5.6E-15	1032	E	9.7E-13	1070	NNE	2.1E-12	1
				1.1E-13							
				3.5E-14							
				1.1E-12							
				1.7E-13							
				1.2E-13							
				2.7E-13							
				2.7E-13							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	SI
Building 255 is shared by Hazards Control and L-Division and houses a radiation calibration and standards laboratory. Most operations involve the use of sealed sources.								
255	100	FHE-2	H-3 gas monitor calibrations	H-3	2.5E-02	1.0E+00	8.1	0.
Facility 2581 is operated by Hazards Control and had no operations in CY94.								
2581	AI	None	No Operations	None	None	NA	3.1	0.
Building 281 is part of the Chemistry and Material Sciences Directorate. In rooms 1311 and 1318, there are a number of sources, both as solids and in solution, which are kept on. There are HEPA filters between the glove boxes and the vent stack. Room 1323 is used for collection of Nuclear Test Site groundwater samples. These samples contain some U-238.								
281	1164	FHE-22	Solution chemistry of the actinides	Pu-242 Am-241	3.7E-07 3.7E-07	1.0E-03	6.7	0.
281	1174	FHE-13	Synthesis of expanded porphyrins with actinides	U-238 Th-232	4.0E-11 1.0E-11	1.0E-03	6.7	0.
281	1184	Room Air	No Operations	None	None	NA	NA	0.
281	1311	FHE-12	Wet Chemistry Laboratory	U-233	4.5E-11	1.0E-03	6.1	0.
281	1311A	FHE-3	Wet Chemistry Laboratory	Th-232 Pu-242	2.5E-10 1.0E-06	1.0E-03	4.9	0.
281	1311B	FHE-3	Wet Chemistry Laboratory	Pu-242	4.0E-06	1.0E-03	4.9	0.
281	1314	FHE-9	Experimental Laboratory with Glove Boxes	Pu-242 U-233	2.0E-06 1.0E-09	1.0E-03	5.0	0.
281	1319	FHE-1	Experimental Laboratory with Glove Boxes	Th-232 Np-237 Pu-242	3.0E-10 7.0E-05 5.0E-07	1.0E-03	5.2	0.
Building 282 is operated by the Isotope Sciences Division of the Chemistry and Material Sciences Directorate. Experimental work involves neutron particle maps and related studies. Gaseous tritium is absorbed on a "getter" material to which it is tightly bound at room temperature.								
282	1004	Room Air	No Operations	None	None	NA	NA	0.
Building 292 is administered by the Physics and Space Technologies Directorate. Residual contamination exists throughout the facility from the past operation of a rotating target. Also, neutron mass experiments have been conducted since 1993.								
292	1200/1202	Room Air	No Operations	H-3	1.8E+06	1.0E-03	NA	0.
292	1204	Room Air	No Operations	H-3	2.3E+01	1.0E-03	NA	0.
292	1402, 1402A, 1404, 1406, 1407	Room Air	No Operations	H-3	1.8E+00	1.0E-03	NA	0.
Building 299 is part of the Laser Fusion Program. Small amounts of tritium are used in this facility in conjunction with laser target research and development.								
299	169	FHE-34	Laser fusion target research and development	U-238	5.0E-10	1.0E-06	6.4	0.
299	Various	Room Air	Laser fusion target research and development	H-3	3.0E-02	1.0E+00	NA	0.
Buildings 321, 321A, 321B, and 321C are the Material Fabrication Shops and are part of the Mechanical Engineering Department. Operations in this complex include milling, shaping. Uranium pieces may be worked on in a single location, or may be moved from machine to machine. In addition, depleted uranium parts occasionally undergo heat treatment. The on programmatic demands and varies from month to month. NOTE: Machining only occurs in 321C.								
321	1001A	FHE-24	No Operations	None	None	NA	9.9	0.
321	1153	FHE-9	Forming	U-238	5.8E-01	1.0E-06	8.5	0.
321	1351	FEV-1000	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	12.5	0.
321	1437	FHE-15	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	11.2	0.
321	1437A	FHE-11	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	11.3	0.

Annual Report Spreadsheet

ID	Stack	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mSv/yr Site-Wide Dose Requirement			0.1 mSv/yr Monitoring Requirement			Source Category
	Velocity (m/s)				Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unshielded EDE (mrem)	
	5.2	None	1	2.5E-02	1056	E	1.0E-05	1156	NNE	2.3E-05	1
	5.0	HEPA	0.01	0.0E+00	1104	E	0.0E+00	NA	NA	0.0E+00	1
ed in glove boxes, 1 water.											
	7.1	Double HEPA	0.0001	3.7E-14 3.7E-14	1332	ENE	4.1E-12	579	NNE	9.2E-07	1
	6.1	None	1	4.0E-14 1.0E-14	1332	ENE	1.1E-12	579	NNE	2.3E-11	1
	NA	None	1	0.0E+00	1332	ENE	0.0E+00	NA	NA	0.0E+00	1
	4.0	None	1	4.5E-14	1332	ENE	9.5E-13	579	NNE	1.8E-11	1
	10.0	None	1	2.5E-13 1.0E-11	1332	ENE	5.0E-10	579	NNE	1.0E-08	1
	10.3	Double HEPA	0.0001	4.0E-15	1332	ENE	1.9E-13	579	NNE	4.0E-08	1
	2.5	Double HEPA	0.0001	2.0E-15 1.0E-16	1332	ENE	1.3E-13	579	NNE	2.2E-08	1
	9.2	Double HEPA	0.0001	3.0E-17 7.0E-12 5.0E-14	1332	ENE	4.8E-10	579	NNE	1.0E-04	1
	NA	HEPA	0.01	0.0E+00	~ 1332	ENE	0.0E+00	NA	NA	0.0E+00	1
ion source, that is no longer in operation.											
	NA	None	1	1.8E-03	1380	ENE	5.7E-07	493	NNE	1.3E-05	1
	NA	None	1	2.3E-02	1380	ENE	7.3E-06	493	NNE	1.7E-04	1
	NA	None	1	1.9E-03	1380	ENE	5.7E-07	493	NNE	1.3E-05	1
	15.1	HEPA	0.01	5.0E-18	1398	SE	3.3E-17	344	NE	3.2E-13	1
	NA	None	1	3.9E-02	1398	SE	1.3E-05	264	NNE	5.8E-04	1
id machining of depleted uranium.											
unt of depleted uranium that is handled depends											
	5.8	HEPA	0.01	0.0E+00	1032	ENE	0.0E+00	NA	NA	0.0E+00	1
	16.1	HEPA	0.01	5.8E-09	1032	ENE	4.2E-07	326	SW	1.7E-04	1
	6.0	HEPA	0.01	5.8E-09	1032	ENE	4.0E-07	326	SW	1.4E-04	1
	19.4	HEPA	0.01	5.8E-09	1032	ENE	4.2E-07	326	SW	1.8E-04	1
	6.5	HEPA	0.01	5.8E-09	1032	ENE	4.0E-07	326	SW	1.3E-04	1

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	Q
Building 331 is operated by the Defense and Nuclear Technologies Program. The building houses the plutonium research facility and associated laboratories. The facility is underground. Tritium HT and HTO emissions are continuously monitored from the two 30 meter tall stacks in compliance with NESHA's regulations. Monitoring data, rather than the inventory, is used.								
331	All	Stack 1	Tritium R&D, Decontamination and Decommissioning of Facility	H-3	-	1.0E+00	30.0	1
331	All	Stack 2	Tritium R&D, Decontamination and Decommissioning of Facility	H-3	-	1.0E+00	30.0	1
Building 332 is operated by the Defense Sciences Program for plutonium research. Exhausts from glove box operations and the workplace are highly filtered by high efficiency particulate air (HEPA) filters. Exhausts are monitored with both continuous filter sampling (PAMs) and plutonium-specific, continuous real-time monitors. Because building plutonium inventory and the plutonium associated with specific tasks is classified, the standard NESHA's approach, based on inventory, cannot be utilized with show no detectable released plutonium activity, i.e. at or below the limit of sensitivity of the analytical analysis.								
332	Increment 1 Room	FHE-1000/2000	Plutonium research	Transuranics	-	NA	8.6	0.
332	Increment 1 Glove boxes	FGBE-1000/2000	Plutonium research	Transuranics	-	NA	11	
332	Downdraft	FHE-45	Plutonium research	Transuranics	-	NA	11	
332	Left	FE-4 FE-5	Plutonium research Plutonium research	Transuranics Transuranics	- -	NA NA	11 11	B, 0.
332	Increment 1 Glove boxes	FGBE-3000/4000	Plutonium research	Transuranics	-	NA	11	
332	Increment 3 Room	FHE-1000/2000	Plutonium research	Transuranics	-	NA	10.1	
	Increment 3 Glove boxes	FGBE-7000/9000						
Building 341 is a Physics and Space Technologies Directorate research facility. The experimental studies within the facility include the use of high-energy electron systems, exotic and development and testing of optics, laser systems, flash x-ray generators, and hydro-diagnostics equipment.								
341	1015	None	Storage for D-38 (DU) components	None	None	NA	10.0	
The biomedical research complex includes buildings 361, 362, 363, 364, 365 and 366. Buildings 363 and 366 have discontinued the use of radionuclides. Building 365 contains small amounts of tritium, carbon-14 and sulfur-35 incorporated in animal carcasses stored frozen pending disposal. No chemical operations are done in Building 365, and the built at least two HEPA filters and one charcoal filter before being exhausted. Most of the organs that contained radionuclides have been removed from the animals for examination. The radionuclide sources in building 361 include tritium, carbon-14, phosphorus-32, and sulfur-35, mostly incorporated as constituent atoms (tracers) in organic compounds.								
361	1014	FHE-4	DNA Labeling and Sequencing	P-32	3.5E-03	1.0E-03	1.7	
361	1020	FHE-6	DNA Hybridization	P-32	3.0E-03	1.0E-03	1.7	
361	1242	FHE-24	Phosphorus 32 Labeling	P-32	3.5E-03	1.0E-03	1.7	
361	1245	FHE-20,21	Human Genome	P-32 S-35	4.0E-02 2.0E-03	1.0E-03 1.0E-03	1.7	
361	1342	FHE-18	Enzyme Assay	C-14	1.0E-03	1.0E-03	7.0	
361	1348	Room Air	DNA Labeling and Hybridization	P-32	2.8E-02	1.0E-03	NA	
361	1346	FHE-17	No Operations	None	None	NA	7.0	
361	1347	FHE-16	DNA Labeling and Hybridization	P-32	2.0E-02	1.0E-03	1.7	
361	1442	FHE-31	No Operations	None	None	NA	7.0	
361	1445	FHE-14	DNA Repack and Chromatin	P-32 S-35	1.8E-03 1.0E-02	1.0E-03 1.0E-03	1.7	
361	1446	FHE-15	No Operations	None	None	NA	7.0	
361	1542	FHE-12	DNA Labeling	P-32 S-35	6.0E-03 0.0E+00	1.0E-03 1.0E-03	7.0	

Annual Report Spreadsheet

#1	Stack	Control	Control Device	Estimated	10 nearest Site-Wide Down Requirements			9.1 nearest Montana Requirements			Source
	Velocity (m/s)	Device(s)	Abatement Factor	Annual Emissions (Ci)	Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Category
significant reduction in future work and inventory down along each, are used to determine emissions.											
	7.8	None	1	2.2E+01	957	ENE	8.3E-03	1284	NE	8.6E-03	3
	10.5	None	1	5.4E+01	957	ENE	1.9E-02	1384	NE	2.0E-02	3
work (CAH/s)											
including this report The gas monitoring data for all emission points											
1	17.3	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
	6.9	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
	14.2	Double HEPA	0.0001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
4.9	4.6	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
19	4.6	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
	2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
	12.2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	NA	NA	0.0E+00	3
15. high-velocity armor impact experiments.											
9	9.0	None	1	0.0E+00	870	E	0.0E+00	NA	NA	0.0E+00	1
air is drawn through											
11	0.5	None	1	3.0E-06	918	ENE	7.8E-08	979	W	4.1E-07	1
11	0.5	None	1	3.0E-06	918	ENE	7.8E-08	976	W	4.1E-07	1
13	0.5	None	1	3.5E-06	918	ENE	9.1E-08	976	W	4.8E-07	1
11	0.5	None	1	4.0E-06	918	ENE	1.1E-06	976	W	5.6E-06	1
				2.0E-08							
41	4.4	None	1	1.0E-06	918	ENE	4.5E-09	953	NNE	6.9E-09	1
A	NA	None	1	2.0E-05	918	ENE	4.7E-07	976	W	2.5E-06	1
41	4.4	None	1	0.0E+00	918	ENE	0.0E+00	NA	NA	0.0E+00	1
41	0.5	None	1	2.0E-06	918	ENE	5.2E-07	976	W	2.7E-06	1
26	3.6	None	1	0.0E+00	918	ENE	0.0E+00	NA	NA	0.0E+00	1
41	0.4	None	1	1.0E-06	918	ENE	1.2E-07	976	W	6.3E-07	1
				1.0E-05							
41	4.4	None	1	0.0E+00	918	ENE	0.0E+00	NA	NA	0.0E+00	1
41	4.4	None	1	6.0E-06	918	ENE	6.7E-08	953	NNE	4.4E-07	1
				0.0E+00							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)
361	1546	FHE-10	DNA Labeling	P-32	1.0E-03	1.0E-03	1.7	0.4
361	1564	FHE-2000	No Operations	None	None	NA	7.6	0.6
361	1568	FHE-2000	Biological Dosimetry	P-32	4.5E-04	1.0E-03	1.7	0.4
				P-33	1.2E-04	1.0E-03		
361	1635	Room Air	DNA Sequencing	P-32	2.0E-04	1.0E-03	NA	NA
361	1642	FHE-11	EMSA/HNA Hybridization	P-32	1.0E-03	1.0E-03	7.0	0.4
361	1649	FHE-4	Biological Dosimetry	P-33	3.0E-03	1.0E-03	7.0	0.4
				S-35	5.0E-04	1.0E-03		
361	1658	FHE-1000	No Operations	None	None	NA	7.6	0.6
361	1688C	FHE-1000	Radioactive Probes	P-32	8.8E-03	1.0E-03	7.6	0.6
361	1684	FHE-2000	Human Genome	None	None	NA	7.0	0.4
361	1742	FHE-8	Biological Dosimetry	P-32	2.9E-03	1.0E-03	7.0	0.4
361	1745	FHE-7	No Operations	None	None	NA	7.0	0.4
361	1848	Room Air	Human Genome	P-32	4.0E-02	1.0E-03	NA	NA
				S-35	2.0E-03	1.0E-03		
Building 362								
362	113	Room Air	Dose Preparation	C-14	1.0E-03	1.0E-03	NA	NA
Building 363								
363	1005	FHE-2000	Dispensing Samples	H-3	3.0E-02	1.0E-03	1.7	0.4
Building 364								
364	1507	Room Air	DNA Labeling	P-32	3.0E-01	1.0E-03	NA	NA
364	1510	Room Air	Isolation and Purification	C-14	5.0E-04	1.0E-03	NA	NA
Building 365								
365	109	FHE-5	Research Animals Housed	C-14	1.3E-04	1.0E-03	1.7	0.4
				H-3	5.6E-07	1.0E-03		
Building 366								
366	103	FHE-1	Metabolic Heterocyclic Aromatics	H-3	4.0E-03	1.0E-03	1.7	0.4
366	111	FHE-4	DNA Sequencing	P-33	5.0E-04	1.0E-03	1.7	0.4
Building 377 is operated by the Health and Ecological Assessment Division. The major activities in this facility are associated with chemical and radiological sample preparation for water, vegetation, etc., samples.								
377	1003	Stack FHE-6 removed	No Operations	None	None	NA	NA	NA
377	1005	Stack FHE-7 removed	No Operations	None	None	NA	NA	NA
377	1028	FHE-1000	No Operations	None	None	NA	8.2	0.6
Building 378 is operated by the Health and Ecological Assessment Division. The major activities in this facility are associated with chemical and radiological sample preparation for water, vegetation, etc., samples.								
378	120	378-120-FHE-1,2,3,4,5,8,9,10	Environmental analysis	Am-241	7.2E-10	1.0E-03	8.5	0.6
				Pu-238	3.6E-10	1.0E-03		
				Pu-242	1.8E-09	1.0E-03		
378	120	378-120-FHE-6,7	Environmental analysis	Am-241	1.8E-10	1.0E-03	8.5	0.6
				Pu-238	9.0E-11	1.0E-03		
				Pu-242	4.5E-10	1.0E-03		

Annual Report Spreadsheet

Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (t/a)	10 m/s or 100 m/s Downwind Dispersion			0.1 m/s or 100 m/s Downwind Dispersion			Source Category
				Distance to SWMEH (m)	Direction to SWMEH	EDE (m/s)	Distance to MEH (m)	Direction to MEH	Unabated EDE (m/s)	
2.5	None	1	4.0E-08	918	ESE	1.0E-07	976	W	5.5E-07	1
3.6	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	1
0.4	None	1	4.5E-07 1.2E-07	918	ESE	1.5E-08	976	W	7.8E-08	1
NA	None	1	2.0E-07	918	ESE	4.7E-09	976	W	2.5E-08	1
4.4	None	1	1.0E-08	918	ESE	9.6E-09	953	NNE	7.4E-08	1
4.4	None	1	3.0E-05 5.0E-07	918	ESE	7.5E-08	976	W	4.0E-07	1
2.8	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	1
2.8	None	1	8.8E-04	918	ESE	2.3E-07	976	W	1.2E-06	1
4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	1
4.4	None	1	2.0E-05	918	ESE	5.2E-07	976	W	2.7E-06	1
4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	1
NA	None	1	4.0E-06 2.0E-09	918	ESE	9.6E-07	976	W	6.1E-06	1
NA	None	1	1.0E-06	890	ESE	2.2E-06	885	W	1.5E-07	1
8.4	HEPA	1	3.6E-05	998	ESE	1.0E-06	892	W	1.8E-07	1
NA	None	1	3.0E-04	998	ESE	8.3E-06	904	W	4.2E-05	1
NA	None	1	5.0E-07	986	ESE	1.1E-08	884	W	7.4E-09	1
0.6	Double HEPA	0.0001 1	1.3E-11 3.0E-10	1002	ESE	6.4E-13	802	W	2.0E-06	1
0.5	None	1	4.0E-06	912	ESE	2.5E-09	998	W	1.4E-08	1
0.4	Bioablate/HEPA	0.01	5.0E-09	912	ESE	1.3E-10	998	W	6.4E-09	1
Horizontal analysis, and analysis of SO2										
NA	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	1
NA	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	1
20.8	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	1
Horizontal analysis, and analysis of SO2										
5.9	None	1	7.2E-13 3.6E-13 1.0E-12	888	ESE	1.5E-10	857	NNE	1.5E-09	1
8.7	None	1	1.8E-13 9.0E-14 4.5E-13	888	ESE	3.0E-11	857	NNE	3.0E-10	1

Building	Floor/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	SLD
Building 381 is part of the Laser Fusion Program. Small quantities of bismuth are handled in support of laser target research and development.								
381	B158	381-B158-FHE-1	Tritium handling for laser target R&D	H-3	4.0E-04	1.0E-06	11.3	0
Building 391 is part of the Laser Fusion Program. The high energy laser is located in this facility. Small amounts of lithium are handled in support of laser target research and development.								
391	Target Chamber	391-FHE-1	Fusion Target Irradiation Area	H-3	2.1E-01	1.0E+00	6.1	0
Building 419 has been used previously for the decontamination of equipment. However, it is now undergoing closure and no activities were conducted during 1994. Exhausts from the facility are continuously sampled.								
419	124	FHE-2	No Operations	None	None	NA	12.1	0
419	155	FHE-4	No Operations	None	None	NA	10.9	0
Building 490 & 491 are part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC). The facility which vaporizes uranium for enrichment, is located in building 490. Stack sampling at both facilities is continuous. Both facilities operate with two in-series high efficiency particulate air emissions are continuously sampled at the post-HEPA-filter atmospheric discharge points, although emissions are low enough that stack monitoring is not required per the NESHAP.								
490	1061	490 Stack	No Operations	None	None	NA	13.7	0
Building 491								
491	Air	FPE-1	No Operations	None	None	NA	11.6	0
Building 513 is operated by the Hazardous Waste Management Division. The Stabilization Unit is a mechanized mixing device used to make homogeneous mixtures of waste. Solids. The Microfiltration Unit filters out waste radioactive particles. In the Laboratory, small quantities of waste materials are sampled, treated, and stored. No releases are assumed to occur.								
513	Stabilization	Room Air	Stabilizes sludges to solids	Am-241	3.0E-03	1.0E-03	NA	
				Ce-60	4.2E-05	1.0E-03		
				Cs-137	3.2E-05	1.0E-03		
				U-238	8.0E-03	1.0E-03		
				U-235	1.2E-04	1.0E-03		
				U-234	8.7E-04	1.0E-03		
				H-3	1.0E-02	1.0E-03		
				K-40	2.3E-03	1.0E-03		
				Sr-90	3.1E-04	1.0E-03		
				Th-232	2.6E-04	1.0E-03		
513	Microfiltration	Room Air	Filters radioactive waste particles	U-238	8.2E-05	1.0E-03	NA	
				U-235	1.2E-06	1.0E-03		
				U-234	8.5E-06	1.0E-03		
513	Laboratory	513 Stack	Sample, treat, and store waste materials used in treatment processes	Am-241	1.9E-03	1.0E-03	8.5	
				Ce-144	5.0E-05	1.0E-03		
				Ce-60	1.2E-04	1.0E-03		
				Cs-134	2.7E-05	1.0E-03		
				Cs-137	1.1E-04	1.0E-03		
				U-238	9.5E-03	1.0E-03		
				U-235	1.5E-04	1.0E-03		
				U-234	8.5E-04	1.0E-03		
				H-3	1.0E-02	1.0E-03		
				K-40	1.5E-03	1.0E-03		
				Mn-54	5.5E-05	1.0E-03		
				Nb-95	5.5E-05	1.0E-03		
				Sr-90	3.6E-04	1.0E-03		
				Zr-95	8.2E-05	1.0E-03		
Building 514 - See Diffuse Sources Section below.								

Annual Report Spreadsheet

Stack	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 Annual Site-Wide Dose Requirement Distance to SVMEI (m)	Direction to SVMEI	EDR (mrem)	0.1 Annual Monitoring Requirement Distance to MBI (m)	Direction to MBI	Unabated EDE (mrem)	Source Category
20.6	None	1	4.0E-04	1092	SE	2.7E-14	560	NE	6.9E-07	1
9.9	None	1	2.1E-01	1149	SE	2.9E-05	403	NE	9.0E-04	1
12.6	Double HEPA	0.0001	0.0E+00	640	NE	0.0E+00	NA	NA	0.0E+00	3
5.4	HEPA	0.01	0.0E+00	640	NE	0.0E+00	NA	NA	0.0E+00	3
Separator Demonstration Facility (SDF), HEPA filter bank to control emissions. 40 CFR 61 regulations.										
5.7	Double HEPA	0.0001	0.0E+00	900	SE	0.0E+00	NA	NA	0.0E+00	3
20.4	Double HEPA	0.0001	0.0E+00	1000	SW	0.0E+00	NA	NA	0.0E+00	3
Airborne agents are added during moving to transfer sludge to solids, air from waste storage because the wastes are fully contained										
NA	None	1	3.0E-06	579	NNE	1.3E-02	128	SW	6.1E-02	1
			4.2E-06							
			3.2E-06							
			9.9E-06							
			1.2E-07							
			8.7E-07							
			1.8E-05							
			2.3E-06							
			3.4E-07							
			2.5E-07							
NA	None	1	0.2E-08	579	NNE	6.2E-05	128	SW	2.5E-04	1
			1.2E-09							
			8.6E-08							
8.0	HEPA	0.01	1.9E-08	579	NE	8.4E-05	128	SW	1.4E-02	1
		0.01	5.9E-10							
		0.01	1.2E-09							
		0.01	2.7E-10							
		0.01	1.1E-09							
		0.01	9.5E-08							
		0.01	1.5E-08							
		0.01	8.5E-09							
		1	1.8E-05							
		0.01	1.5E-08							
		0.01	5.5E-10							
		0.01	5.5E-10							
		0.01	3.5E-09							
		0.01	8.2E-10							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State	Stack Height (m)	SI Class
SITE 300 POINT SOURCES								
Site 300 - Explosive tests are conducted on open-air firing tables located at Buildings 801, 850, and 851. These tests have depleted uranium material as part of the material inventory. A total for 1994 is shown here. The radionuclides in Buildings 804, 810A, 810B, 822B, and 854F are encapsulated or sealed and are not used.								
801	Firing Table	None	Explosive tests	U-238	5.9E-02	1.0E+00	NA	1
				U-235	7.6E-04	1.0E+00		
				U-234	5.5E-03	1.0E+00		
850	Firing Table	None	No Operations	None	None	NA	NA	1
851	Firing Table	None	Explosive tests	U-238	1.7E-02	1.0E+00	NA	1
				U-235	2.1E-04	1.0E+00		
				U-234	1.6E-03	1.0E+00		
LIVERMORE SITE DIFFUSE SOURCES								
Building 292 - Gaseous emissions result from tritium-contaminated water which leaked from an underground storage tank. Vegetation in the area transpires water with elevated tritium.								
292	Spill Area	None	Evaporation and Transpiration	H-3	NA	1.0E+00	NA	1
Building 331 - As part of D&D operations contaminated equipment outside the facility is awaiting transport and storage by Hazardous Waste Management.								
331	Outside	None	Storage of Contaminated Parts	H-3	NA	1.0E+00	NA	1
Building 514 is operated by the Hazardous Waste Management Division. The wastewater treatment tank farm and storage tank area processes the liquid waste from facilities on site consisting of neutralization, flocculation, oxidation, reduction, separation, and filtration. Areas used for storage are not considered to release radionuclides because the								
514	Tank Farm	Area Source	Processes liquid hazardous mixed and radioactive wastes in open topped tanks.	Am-241	7.7E-05	1.0E-03	NA	1
				Ba-140	1.5E-06	1.0E-03		
				Ce-141	4.4E-05	1.0E-03		
				Ce-144	9.2E-05	1.0E-03		
				Ce-137	2.2E-06	1.0E-03		
				Co-60	7.7E-06	1.0E-03		
				Co-60	2.9E-05	1.0E-03		
				Co-134	1.9E-06	1.0E-03		
				Co-137	1.5E-05	1.0E-03		
				Fe-59	2.3E-05	1.0E-03		
				H-3	1.3E-01	1.0E-03		
				Mn-54	3.0E-05	1.0E-03		
				Na-22	6.0E-06	1.0E-03		
				Nb-95	4.3E-06	1.0E-03		
				Ag-110m	1.3E-06	1.0E-03		
				C-14	5.3E-04	1.0E-03		
				Co-136	1.4E-06	1.0E-03		
				Eu-152	2.4E-07	1.0E-03		
				Eu-154	3.9E-08	1.0E-03		
				Eu-155	5.7E-08	1.0E-03		
				Eu-181	4.0E-05	1.0E-03		
				Hg-203	4.6E-05	1.0E-03		
				I-125	2.0E-05	1.0E-03		
				I-131	1.6E-05	1.0E-03		
				K-40	1.7E-06	1.0E-03		
				Nb-147	6.7E-06	1.0E-03		
				Np-238	1.5E-04	1.0E-03		
				P-32	6.7E-02	1.0E-03		
				Pm-233	2.4E-08	1.0E-03		
				Pm-147	2.6E-08	1.0E-03		
				Pu-239	9.2E-05	1.0E-03		
				Pu-242	5.0E-06	1.0E-03		
				Ra-226	1.7E-04	1.0E-03		
				Ra-228	6.4E-06	1.0E-03		
				Ra-103	9.1E-07	1.0E-03		
				Ra-106	5.8E-08	1.0E-03		
				S-35	2.9E-03	1.0E-03		
				Sb-124	6.4E-05	1.0E-03		
				Sb-125	7.6E-06	1.0E-03		
				Se-46	1.4E-06	1.0E-03		
				Sn-113	7.0E-09	1.0E-03		
				Sn-90	7.6E-06	1.0E-03		
				Tb-150	1.6E-08	1.0E-03		

Annual Report Spreadsheet

Stack	Control Device(s)	Control Device	Estimated Annual Emissions (C)	10 nearest Site-Wide Down Requirements	Distance to SWMEI (m)	Direction to SWMEI	DE (m/yr)	Distance to MEI (m)	Direction to MEI	Unabated EDE (m/yr)	Source Category
Velocity (m/s)		Abatement Factor									
There are multiple tests per year.											
NA	None	1	5.8E-02	2380	WSE	2.0E-02	1685	E	4.1E-02	4	
			7.6E-04								
			5.4E-03								
NA	None	1	0.0E+00	4206	ENE	0.0E+00	NA	NA	0.0E+00	4	
NA	None	1	1.7E-02	3870	E	2.0E-02	3836	ENE	6.9E-02	4	
			2.1E-04								
			1.6E-03								
concentrations.											
NA	None	1	8.4E-04	1390	ENE	2.7E-07	493	NNE	6.8E-06	9	
NA	None	1	3.0E+00	860	E	4.1E-03	441	SSW	2.4E-02	5	
The treatment process may involve batch chemical treatment steps are fully contained.											
NA	None	1	7.7E-08	530	NE	4.6E-03	217	SN	1.2E-02	6	
			1.5E-09								
			4.4E-08								
			9.2E-08								
			2.2E-08								
			7.7E-08								
			2.9E-08								
			1.8E-09								
			1.6E-04								
			2.8E-09								
			1.3E-04								
			3.0E-08								
			0.0E+00								
			4.3E-08								
			1.3E-09								
			5.3E-07								
			1.4E-09								
			2.4E-10								
			3.8E-09								
			5.7E-09								
			4.0E-09								
			4.6E-23								
			2.0E-08								
			1.6E-08								
			1.7E-08								
			6.7E-08								
			1.5E-07								
			6.7E-05								
			2.4E-11								
			2.0E-09								
			3.2E-08								
			5.0E-11								
			1.7E-07								
			6.4E-09								
			9.1E-10								
			5.8E-09								
			2.9E-08								
			8.4E-09								
			7.6E-06								
			1.4E-09								
			7.0E-12								
			7.6E-09								
			1.8E-11								

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)
514	Tank Farm (continued)			Ta-132	3.0E-07	1.0E-03	
				Th-232	1.3E-04	1.0E-03	
				U-233	3.2E-06	1.0E-03	
				U-234	5.8E-04	1.0E-03	
				U-235	8.1E-04	1.0E-03	
				U-237	5.2E-04	1.0E-03	
				U-238	7.4E-03	1.0E-03	
				Y-91	8.5E-06	1.0E-03	
				Zr-95	1.4E-06	1.0E-03	
				Zr-96	2.1E-03	1.0E-03	
				Mo-99	1.2E-05	1.0E-03	
				La-140	3.0E-08	1.0E-03	
				Ce-137	1.0E-03	1.0E-03	
				Am-185	6.4E-06	1.0E-03	
				Ce-139	6.0E-09	1.0E-03	
				Sr-120m	1.1E-06	1.0E-03	
				Y-96	1.4E-05	1.0E-03	
The Building 612 Yard is operated by the Hazardous Waste Management Division. The Yard consists of several areas where containers having radioactive wastes are stacked out.							
612	Yard	Area Source	Storage of low level waste	H-3	1.2E+00	1.0E+00	NA
The Southeast Quadrant of the Livermore Site has slightly elevated levels of Pu-239 in the surface soil and air (presumably from resuspension). The source of the Pu-239 was:							
Southeast Quadrant	Area Source	Resuspension		Pu-239	NA	NA	NA
SITE 300 DIFFUSE SOURCES							
Diffuse sources consist of evapotranspiration of tritiated water and resuspension of depleted uranium. Tritiated water sources include land areas where water purged from wells has been dumped, an open artesian spring, and evaporation of water from soils due to migration from contaminated ground water.							
Pt 7 complex	Area Source	Evaporation from Soil and purge water		H-3	1.0E+00	1.0E+00	NA
802	Area Source	Evaporation from Soil		H-3	6.2E-04	1.0E+00	NA
850	Area Source	Evaporation from Soil		H-3	1.3E-01	1.0E+00	NA
851	Area Source	Evaporation from Soil		H-3	3.5E-04	1.0E+00	NA
Well 8 Spring	Area Source	Evaporation from Spring Water		H-3	2.4E-03	1.0E+00	NA
Site 300	All	Area Source	Soil Resuspension	U-238	NA	NA	NA
				U-235	NA	NA	NA
				U-234	NA	NA	NA

Annual Report Spreadsheet

ST	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (t)	10 m/s (m/s) Stack-Wide Disp. Requirement Distance to SWMB (m)	Direction to SWMB	EE (m/min)	9.1 m/s (m/s) Dispensing Requirement Distance to MB (m)	Direction to MB	Unabated SOE (m/min)	Source Category
				3.0E-10							
				1.3E-07							
				3.2E-08							
				5.9E-07							
				8.7E-07							
				5.2E-07							
				7.4E-08							
				6.5E-09							
				1.4E-09							
				2.1E-06							
				1.2E-08							
				3.0E-11							
				1.0E-06							
				6.4E-09							
				6.0E-12							
				1.1E-09							
				1.4E-09							
The containers, which are not all tight, can outgas helium.											
	NA	None	1	1.2E+00	420	NNE	1.3E-02	236	SSW	3.1E-02	6
acid management operations.											
	NA	None	1	NA	0	NA	1.1E-03	NA	NA	NA	6
	NA	None	1	1.0E+00	4882	ENE	6.7E-03	853	NNE	1.2E-03	5
	NA	None	1	6.2E-04	2380	ENE	1.2E-07	1337	N	3.4E-07	6
	NA	None	1	1.7E-04	4206	E	1.2E-05	1402	N	6.3E-05	6
	NA	None	1	3.5E-04	3970	E	3.9E-08	1285	W	1.0E-07	5
	NA	None	1	2.4E-03	4884	E	2.4E-07	732	N	3.7E-06	6
	NA	None	1	NA	0	NA	3.2E-02	NA	NA	NA	6
				NA							
				NA							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)
EMISSIONS WHICH CONTRIBUTE TO MORE THAN 10% OF THE POTENTIAL EFFECTIVE DOSE EQUIVALENT AT EACH SITE.								
LIVERMORE SITE SOURCES								
331	All	Stack 1	Tritium R&D; Decontamination and Decommissioning of Facility	H-3	2.2E+01	1.0E+00	30.0	1.2
331	All	Stack 2	Tritium R&D; Decontamination and Decommissioning of Facility	H-3	5.4E+01	1.0E+00	30.0	1.2
513	Stabilization	Room Air	Stabilizer sludges to solids	Am-241	3.0E-03	1.0E-03	NA	NA
				Co-60	4.2E-06	1.0E-03		
				Cs-137	3.2E-05	1.0E-03		
				U-238	0.0E-03	1.0E-03		
				U-235	1.2E-04	1.0E-03		
				U-234	8.7E-04	1.0E-03		
				H-3	1.0E-02	1.0E-03		
				K-40	2.3E-03	1.0E-03		
				Sr-90	3.4E-04	1.0E-03		
				Th-232	2.6E-04	1.0E-03		
612	Yard	Area Source	Storage of low level waste	H-3	1.2E+00	1.0E+00	NA	NA
SITE 300 SOURCES								
801	Filing Table	None	Explosive Tests	U-238	5.9E-02	1.0E+00	NA	NA
				U-235	7.0E-04	1.0E+00		
				U-234	5.5E-03	1.0E+00		
851	Filing Table	None	Explosive Tests	U-238	1.7E-02	1.0E+00	NA	NA
				U-235	2.1E-04	1.0E+00		
				U-234	1.0E-03	1.0E+00		
Site 300	All	Area Source	Soil Resuspension	U-238	NA	NA	NA	NA
				U-235	NA	NA		
				U-234	NA	NA		

Annual Report Spreadsheet

	Stack	Control	Control Device	Estimated	10 mg/m ³ Std-Wide Dose Requirement			0.1 mg/m ³ Monitoring Requirement			Source
N	Velocity (m/s)	Device(s)	Abatement Factor	Annual Emissions (Cl)	Distance to SWMEI(m)	Direction to SWMEI	EDE (mrem)	Distance to NEI (m)	Direction to NEI	Unabated EDE (mrem)	Category
	7.6	None	1	2.2E+00	957	ENE	8.3E-03	1384	NE	8.6E-03	3
	10.5	None	1	5.4E+01	957	ENE	1.9E-02	1384	NE	2.0E-02	3
	NA	None	1	3.0E-06 4.2E-06 3.2E-06 0.9E-06 1.2E-07 0.7E-07 1.8E-06 2.3E-06 3.4E-07 2.8E-07	570	NNE	1.3E-02	128	SW	6.1E-02	1
	NA	None	1	1.2E+00	420	NNE	1.3E-02	216	SSW	3.1E-02	6
	NA	None	1	5.9E-02 7.6E-04 5.6E-03	2380	ENE	2.0E-02	1666	E	4.1E-02	4
	NA	None	1	1.7E-02 2.1E-04 1.8E-03	3870	E	2.9E-02	3836	ENE	6.8E-02	4
	NA	None	1	NA NA NA	0	NA	3.2E-02	NA	NA	NA	6

Attachment 2: Surrogate Radionuclides List

Available in CAP88- PC	Radio- nuclide	Half-life	Lung Class ^a	ALI (inh), μCi	DAC, μCi/m ³	Surrogate	Correction Factor ^b
	^{108m} Ag	127 y	Y	20	1×10^{-8}	⁶⁰ Co	
y	^{110m} Ag	250 d	Y	90	4×10^{-8}	⁶⁰ Co	
y	¹¹¹ Ag	7.45 d	Y	900	4×10^{-7}	⁶⁰ Co	
y	²⁴³ Am	7380 y	W	0.006	3×10^{-12}	²⁴¹ Am	
	²⁰⁷ Pb	38 y	W	400	1×10^{-7}	²¹⁴ Pb	
y	¹³³ Ba	10.7 y	D	700	3×10^{-7}	¹⁴⁰ Ba	
	⁴⁵ Ca	163 d	W	800	4×10^{-7}	⁹⁰ Sr	
	¹⁰⁹ Cd	464 d	D	40	1×10^{-8}	⁶⁰ Co	
y	¹⁴¹ Ce	32.5 d	Y	600	2×10^{-7}	¹⁴⁰ La	
y	¹⁴⁴ Ce	284 d	Y	10	6×10^{-9}	¹⁴⁰ La	100
	²⁴⁹ Cf	351 y	Y	0.01	4×10^{-12}	²⁴¹ Am	
	²⁵⁰ Cf	13.1 y	W	0.009	4×10^{-12}	²⁴¹ Am	
	³⁶ Cl	3.01×10^5 y	W	200	1×10^{-7}	¹³⁷ Cs	
y	²⁴⁴ Cm	18.1 y	W	0.01	5×10^{-12}	²⁴¹ Am	
y	⁵⁷ Co	271 d	Y	700	3×10^{-7}	⁶⁰ Co	
y	⁵⁸ Co	70.8 d	Y	700	3×10^{-7}	⁶⁰ Co	
y	¹³⁴ Cs	2.06 y	D	100	4×10^{-8}	¹³⁷ Cs	
y	¹³⁶ Cs	13.1 d	D	700	3×10^{-7}	¹³⁷ Cs	
	²³⁴ Es	276 d	W	0.07	3×10^{-11}	²³⁹ Pu	
y	¹⁵² Eu	13.33 y	W	20	1×10^{-8}	¹⁴⁰ La	50
y	¹⁵⁴ Eu	8.8 y	W	20	8×10^{-9}	¹⁴⁰ La	50
y	¹⁵⁵ Eu	4.96 y	W	90	4×10^{-8}	¹⁴⁰ La	10
y	¹⁵⁶ Eu	15.2 d	W	500	2×10^{-7}	¹⁴⁰ La	
y	⁵⁵ Fe	2.7 y	D	2000	8×10^{-7}	⁶⁰ Co	
	¹⁴⁸ Gd	93 y	D	0.008	3×10^{-12}	¹⁴⁰ La	1×10^5
y	¹⁶⁶ Ho	26.80 h	W	2000	7×10^{-7}	¹⁴⁰ La	
y	¹⁹² Ir	74.02 d	Y	200	9×10^{-8}	⁶⁰ Co	
y	⁵⁴ Mn	313 d	W	800	3×10^{-7}	⁹⁰ Y	
y	²² Na	2.60 y	D	600	3×10^{-7}	¹³⁷ Cs	
y	⁹⁴ Nb	2.03×10^4 y	Y	20	6×10^{-9}	⁹⁹ Mo	50
y	⁹⁵ Nb	35.2 d	Y	1000	5×10^{-7}	⁹⁹ Mo	
y	¹⁴⁷ Nd	11 d	Y	800	4×10^{-7}	¹⁴⁰ La	

(See next page for footnotes.)

Attachment 2: (continued)

Available in CAP88- PC	Radio- nuclide	Half-life	Lung Class ^a	ALI (inh), μCi	DAC, μCi/m ³	Surrogate	Correction Factor ^b
y	⁶³ Ni	96 y	W	3000	1 × 10 ⁻⁶	⁶⁰ Co	
y	²³⁷ Np	2.14 × 10 ⁶ y	W	0.004	2 × 10 ⁻¹²	²⁴¹ Am	
	¹⁸⁵ Os	94 d	D	500	2 × 10 ⁻⁷	⁹⁹ Mo	
y	²³¹ Pa	3.28 × 10 ⁴ y	W	0.002	6 × 10 ⁻¹³	²³⁹ Pu	
y	¹⁴⁷ Pm	2.62 y	W	100	6 × 10 ⁻⁸	¹⁴⁰ La	10
y	²³⁸ Pu	87.7 y	W	0.007	3 × 10 ⁻¹²	²³⁹ Pu	
y	²⁴² Pu	3.76 × 10 ⁵ y	W	0.007	3 × 10 ⁻¹²	²³⁹ Pu	
y	²⁴⁴ Pu	8.26 × 10 ⁷ y	W	0.007	3 × 10 ⁻¹²	²³⁹ Pu	
	¹⁸⁶ Re	38.0 d	W	1000	6 × 10 ⁻⁷	⁹⁹ Mo	
y	¹⁸³ Ru	39.3 d	Y	600	3 × 10 ⁻⁷	⁶⁰ Co	
y	¹⁸⁵ Ru	4.44 h	Y	10000	5 × 10 ⁻⁶	⁶⁰ Co	
y	¹⁸⁶ Ru	368 d	Y	10	5 × 10 ⁻⁹	⁶⁰ Co	10
y	³⁵ S	87.4 d	W	2000	9 × 10 ⁻⁷	³² P	
y	¹²⁵ Sb	2.77 y	W	500	2 × 10 ⁻⁷	²¹⁴ Bi	
y	¹²⁶ Sb	12.4 d	W	500	2 × 10 ⁻⁷	²¹⁴ Bi	
y	¹²⁷ Sb	3.85 d	W	900	4 × 10 ⁻⁷	²¹⁴ Bi	
	⁷⁵ Se	120 d	W	600	3 × 10 ⁻⁷	³² P	
	⁸⁵ Sr	64.8 d	Y	2000	6 × 10 ⁻⁷	⁹⁰ Sr	
y	⁸⁹ Sr	50.5 d	Y	100	6 × 10 ⁻⁸	⁹⁰ Sr	
	¹⁸² Ta	115 d	Y	100	6 × 10 ⁻⁸	⁹⁹ Mo	
	¹⁸⁷ Tb	150 y	W	300	1 × 10 ⁻⁷	¹⁴⁰ La	
	¹⁸⁸ Tb	150 y	W	20	8 × 10 ⁻⁹	¹⁴⁰ La	50
y	¹⁶⁰ Tb	72.3 d	W	200	9 × 10 ⁻⁸	¹⁴⁰ La	5
y	⁹⁹ Tc	2.13 × 10 ⁵ y	W	700	3 × 10 ⁻⁷	^{99m} Tc	1000
y	¹³² Te	78.2 h	D	200	9 × 10 ⁻⁸	¹²⁵ I	
	²⁰⁴ Tl	3.78 y	D	2000	9 × 10 ⁻⁷	²¹⁴ Pb	
	¹⁶⁸ Tm ^c	85 d	W	2000	8 × 10 ⁻⁷	¹⁴⁰ La	
	¹⁷¹ Tm	1.92 y	W	300	1 × 10 ⁻⁷	¹⁴⁰ La	5
y	²³² U	72 y	Y	0.008	3 × 10 ⁻¹²	²³⁸ U	10
y	²³³ U	1.59 × 10 ⁵ y	Y	0.04	2 × 10 ⁻¹¹	²³⁸ U	
y	²³⁶ U	2.34 × 10 ⁷ y	Y	0.04	2 × 10 ⁻¹¹	²³⁸ U	
y	^{133m} Xe	2.19 d	None		1 × 10 ⁻⁴	¹³³ Xe	
y	¹³⁵ Xe	9.09 h	None		1 × 10 ⁻⁵	¹³³ Xe	10
y	⁹¹ Y	58.5 d	Y	100	5 × 10 ⁻⁸	⁹⁰ Y	6
y	⁶⁵ Zn	244 d	Y	300	1 × 10 ⁻⁷	⁶⁰ Co	
y	⁹⁵ Zr	64.0 d	D	100	5 × 10 ⁻⁸	⁹⁰ Y	6

a D = days, W = weeks, Y = years.

b The annual inventory is multiplied by the correction factor, and a resulting surrogate equivalency is used for the modeling calculation.

c Data on lung class and ALIs for ¹⁶⁷Tm were used. The nuclides have similar decay and energy characteristics.

Source: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency, 1988.