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Environmental Protection Department

Operations and Regulatory Affairs Division

LLNL NESHAPs
1999 Annual Report

Lawrence Livermore National Laboratory
University of California Livermore, California 94550

DISCLAIMER

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LLNL NESHAPs 1999Annual Report

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Lawrence Livermore National Laboratory NESHAPs 1999 Annual Report

This annual report is prepared pursuant to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) 40 CFR Part 61, Subpart H; Subpart H governs radionuclide emissions to air from Department of Energy (DOE) facilities.

SYNOPSIS

NESHAPs 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 μSv) to any member of the public. The EDEs for the Lawrence Livermore National Laboratory (LLNL) site-wide maximally exposed members of the public from 1999 operations are summarized here.

- Livermore site: 0.12 mrem (1.2 μSv) (77% from point-source emissions, 23% from diffuse-source emissions). The point-source emissions include gaseous tritium modeled as tritiated water vapor as directed by EPA Region IX, and the resulting dose is used for compliance purposes. LLNL believes a more accurate evaluation of dose for compliance evaluation at the Livermore site is 0.10 mrem (1.0 μSv) (72% from point-source emissions, 28% from diffuse-source emissions); see discussion beginning on page 11.

- Site 300: 0.035 mrem (0.35 μSv) (97% from point-source emissions, 3% from diffuse-source emissions).

The EDEs were generally calculated using the EPA-approved CAP88-PC air-dispersion/dose-assessment model. Site-specific meteorological data, stack flow data, and emissions estimates based on radionuclide usage inventory data or continuous stack monitoring data were the specific input to CAP88-PC for each modeled source.

SECTION I. Facilities Information

Site Description

LLNL was established in 1952 to conduct nuclear weapons research and development, still its primary responsibility. The Laboratory's mission is dynamic and has been broadened over the years to meet new national needs. LLNL serves as a national resource in science and engineering; its activities focus on global security, energy, global ecology, biomedicine, economic competitiveness, and science and mathematics education. LLNL consists of two sites—the main laboratory site located in Livermore, California (Livermore site), and the Experimental Test Facility (Site 300) located near Tracy, California. Figure 1 shows the locations of the sites. The University of California operates LLNL for DOE.

Livermore Site

LLNL's Livermore site occupies an area of 3.3 km^2 located about 60 km east of San Francisco, California, adjacent to the City of Livermore in the eastern part of Alameda County. More than 6 million people live within 80 km of the Livermore site; approximately 73,600 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 the southwest 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. Temperatures typically range from –5°C during some pre-dawn hours in the winter, to 40°C on a few summer afternoons. The 1999 annual wind data for the Livermore site are shown in Table 1 and displayed as a wind rose in Figure 2. Although winds are variable, the prevailing wind direction is from the southwest, especially during the summer. However, during the winter, the wind often blows from the northeast. Most precipitation occurs as rain between October and April with very little rainfall during the summer months. In 1999, the Livermore site received 245 mm of precipitation.

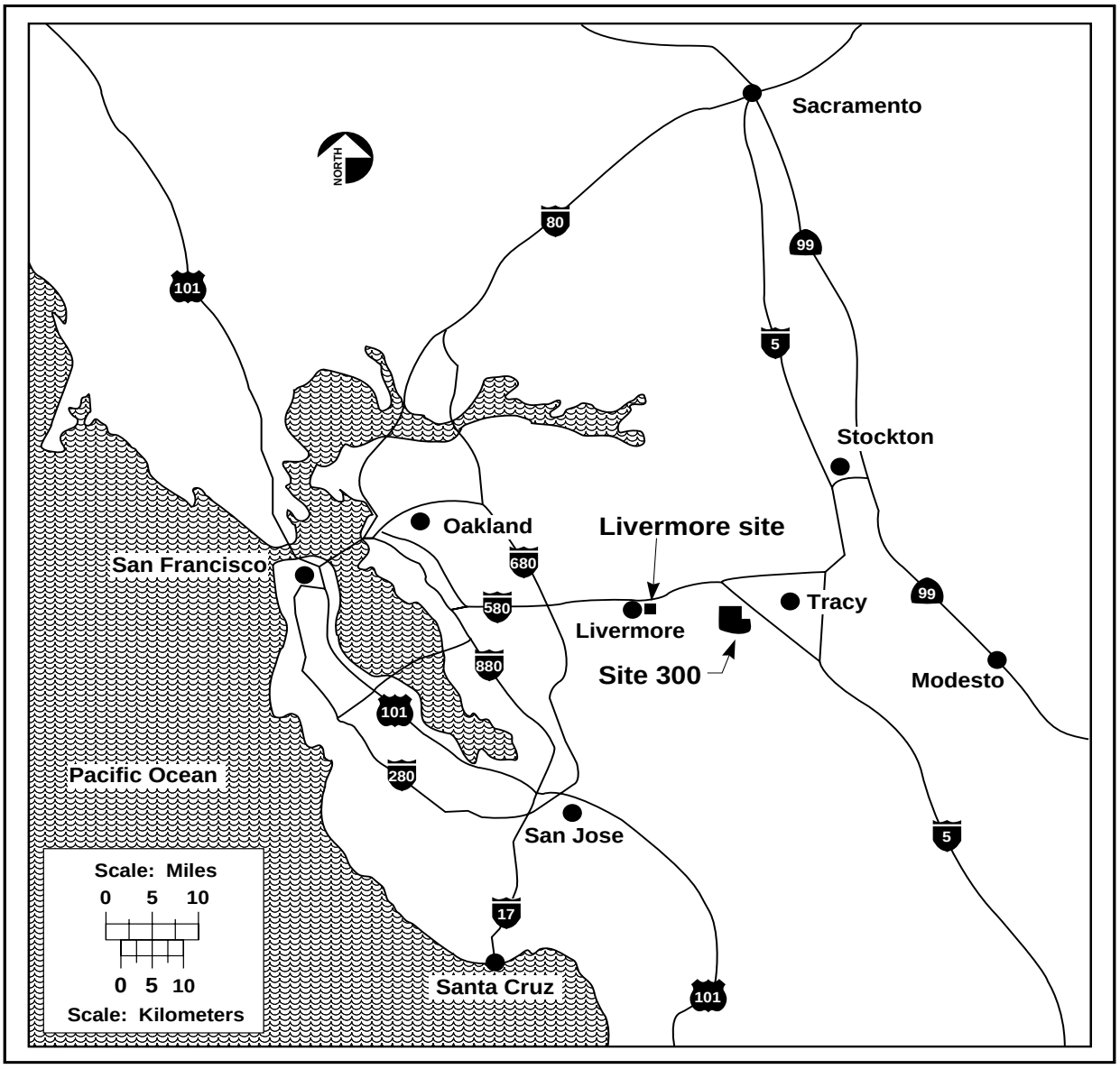

Figure 1. Locations of LLNL Livermore site and Site 300.

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 km^2. It is close to two other explosives-testing facilities; one operated by Primex Physics International, the other by 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,

Table 1. Wind rose for LLNL's Livermore site at the 10-m level for 1999**.**

	Wind Speed Range (m/s)					
Direction	0.0-0.40	0.50-2.90	3.00-4.90	5.00-6.90	≥7.00	Total
NNE	0.58	2.11	1.66	0.46	0.05	4.9
NE	0.58	2.84	1.83	0.14	0.00	5.4
ENE	0.58	2.92	0.08	0.00	0.00	3.6
E	0.58	2.41	0.03	0.00	0.00	3.0
ESE	0.58	2.61	0.02	0.00	0.00	3.2
SE	0.58	2.00	0.00	0.00	0.00	2.6
SSE	0.58	1.65	0.00	0.03	0.00	2.3
S	0.58	4.95	0.81	0.29	0.11	6.7
SSW	0.58	5.96	1.89	0.90	0.23	9.6
SW	0.58	7.71	7.72	3.51	0.65	20.2
WSW	0.58	8.44	5.48	0.97	0.16	15.6
W	0.58	5.43	6.52	0.96	0.05	13.5
WNW	0.58	1.86	0.74	0.26	0.00	3.4
NW	0.58	1.31	0.09	0.02	0.00	2.0
NNW	0.58	1.26	0.14	0.03	0.03	2.0
N	0.58	0.76	0.23	0.14	0.27	2.0
Total	**9.2**	**54.2**	**27.3**	**7.7**	**1.6**	**100.0**

Note: Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding.

Table 2. Wind rose for LLNL's Site 300 at the 10-m level for 1999.

	Wind Speed Range (m/s)					
Direction	0.0-0.4	0.5-4.9	5.0-6.9	7.0-10.9	≥11.0	Total
NNE	0.16	1.69	0.05	0.00	0.00	1.9
NE	0.16	1.91	0.03	0.00	0.00	2.1
ENE	0.16	1.91	0.00	0.00	0.00	2.2
E	0.16	1.53	0.05	0.00	0.00	1.7
ESE	0.16	1.62	0.03	0.03	0.00	1.8
SE	0.16	1.50	0.19	0.07	0.00	1.9
SSE	0.16	2.04	0.17	0.10	0.00	2.5
S	0.16	3.77	0.56	0.06	0.00	4.6
SSW	0.16	2.06	0.16	0.03	0.00	2.4
SW	0.16	2.09	0.33	0.38	0.05	3.0
WSW	0.16	3.78	4.56	16.24	5.46	30.2
W	0.16	5.20	5.33	4.09	0.25	15.0
WNW	0.16	4.04	1.21	0.45	0.00	5.9
NW	0.16	6.08	1.20	1.46	0.06	9.0
NNW	0.16	5.65	2.56	2.47	1.12	12.0
N	0.16	1.94	1.29	0.37	0.17	3.9
Total	**2.6**	**46.8**	**17.7**	**25.8**	**7.1**	**100.0**

Note: Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding.

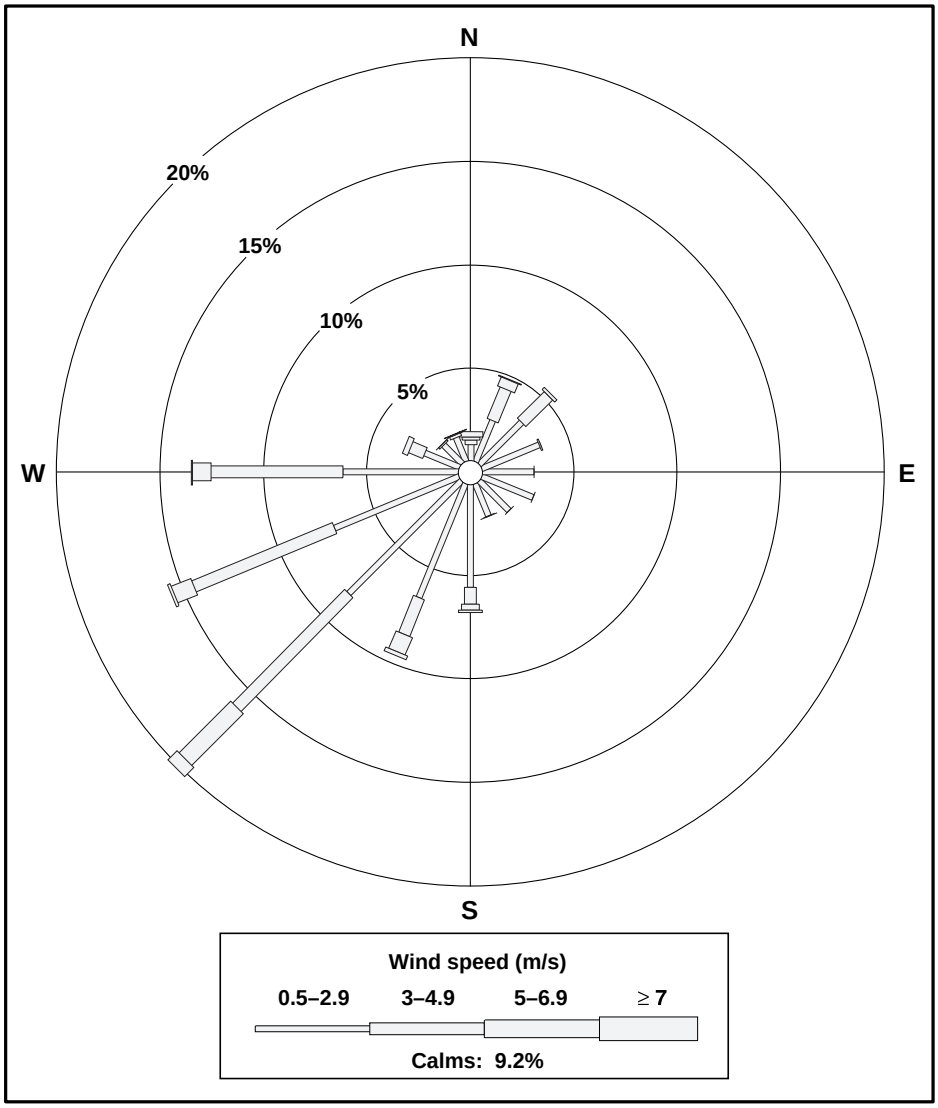

Figure 2. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at the Livermore site, 1999.

primarily pasture land for cattle and sheep. The nearest residential area is the city of Tracy (population approximately 48,000), 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

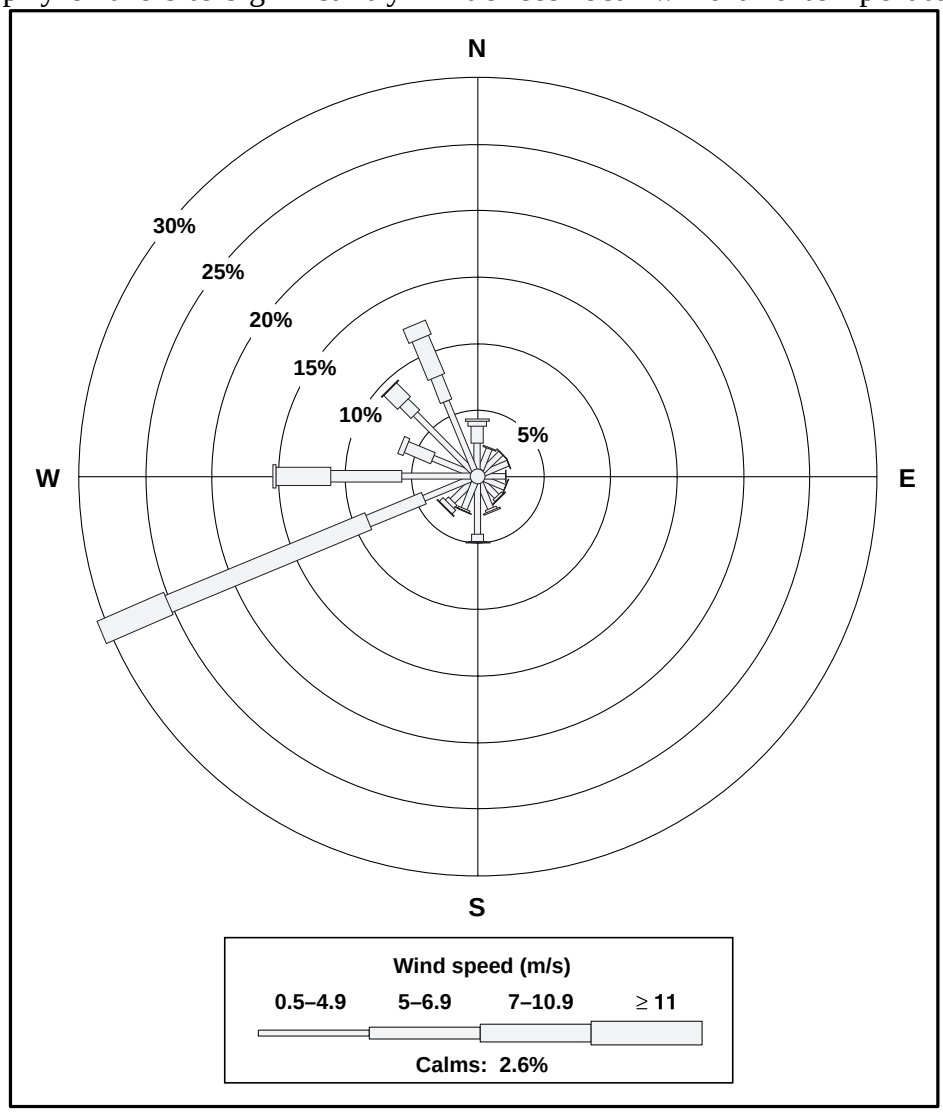

Figure 3. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at Site 300, 1999.

patterns, making the temperature range somewhat more extreme than at the Livermore site. The 1999 annual wind data for Site 300 are shown in Table 2 and displayed as a wind rose in Figure 3. 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. Site 300 received

198 mm of precipitation during 1999. The mean annual temperature is about 16°C.

Source Description

Many different radioisotopes are used at LLNL for research purposes, including transuranic isotopes, 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 ventilation systems, 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 1999.

^{3}H	^{54}Mn	^{99}Tc	^{147}Nd	^{228}Th	^{238}U
^{7}Be	^{55}Fe	^{103}Ru	^{147}Pm	^{229}Th	^{239}Np
^{13}N	^{57}Co	^{106}Ru	^{151}Pm	^{230}Th	^{239}Pu
^{14}C	^{59}Ni	^{109}Cd	^{151}Sm	^{232}Th	^{240}Pu
^{15}O	^{60}Co	^{125}I	^{152}Eu	^{232}U	^{241}Am
^{22}Na	^{63}Ni	^{125}Sb	^{154}Eu	^{233}U	^{241}Pu
^{32}P	^{88}Y	^{131}I	^{155}Eu	^{234}U	^{242}Pu
^{33}P	^{90}Sr	^{133}Ba	^{195}Au	^{235}U	^{243}Am
^{35}S	^{90}Y	^{134}Cs	^{195m}Pt	^{236}Pu	^{244}Cm
^{36}Cl	^{94}Nb	^{137}Cs	^{207}Bi	^{236}U	^{249}Cf
^{40}K	^{95}Nb	^{140}Ba	^{209}Po	^{237}Np	^{250}Cf
^{41}Ar	^{95}Zr	^{141}Ce	^{223}Ra	^{237}U	^{252}Cf
^{51}Cr	^{99}Mo	^{144}Ce	^{226}Ra	^{238}Pu	

SECTION II. Air-Emission Data

Sources

At LLNL, there are emissions from point sources, such as stacks and roof vents, and diffuse-area sources, including areas of known contamination. Hazardous Waste Management operations at Building 514 and at the Building 612 Yard and other Livermore-site sources external to buildings are treated as diffuse-area sources. Detailed information is given in Attachment 1 for emissions from the Livermore-site radiological operations that took place during 1999.

Similarly, detailed information is given in Attachment 1 for experiments at two Site 300 explosives-testing facilities (Buildings 801 and 851 and their associated firing tables). Explosives tests are treated as point sources for demonstration of NESHAPs compliance. Site 300 is also treated as a diffuse-area source of residual tritium and depleted uranium contamination.

1999 Radionuclide Usage Inventory Update and Effective Dose Equivalent (EDE) Calculations

For this year's report, covering activities in 1999, we updated the radionuclide usage inventories in key facilities, defined as those that accounted for 90% or more of the 1998 Livermore site radiological dose to members of the public. We also inventoried all radiological operations that began in 1999. Radionuclide usage inventory forms, with guidance for completing them, were sent to key facilities and to new unmonitored facilities having the potential for radionuclide emissions to the air. The forms were completed by experimenters, and certified by facility managers. Radionuclide usage inventories for all Site 300 explosives experiments and assessments of source terms for known diffuse sources at both sites were also updated.

Dose-assessment modeling runs were conducted for all diffuse sources and for all significant point sources, as noted above. The model used was CAP88-PC (see Section III); we incorporated 1999 on-site meteorological data (wind, precipitation, and temperature) along with the 1999 radionuclide usage inventory or stack effluent monitoring data. Annual dose is reported as whole-body EDE expressed in units of mrem (followed by μSv; 1 mrem = 10 μSv). When reasonable to do so, modeling runs were combined by building, rather than performing a separate model run for each stack or room. This is permitted by the 1995 Memorandum of Understanding between the U.S. EPA and the DOE concerning radionuclide NESHAPs.

A generalized description of each facility and its operations is provided in Attachment 1. 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 in the operation
- Annual radionuclide usage inventory with potential for release (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 for each specific source
- Distance and direction to the maximally exposed individual (MEI) for each specific source
- Calculated EDE to the MEI (source term not adjusted for emission controls)
- Source category

A more complete description of these terms is provided in the introductory material to Attachment 1.

The radionuclides shown in the attachment are those from specific emission points where there was a potential for air emissions. If radionuclides were present, but encapsulated or sealed for the entire year, radionuclides, annual usage inventories, and emissions are not listed.

Actual measurements of radioactivity in air and effluent flow are the basis for reported emissions from continuously monitored sources. LLNL facilities that had continuously monitored discharge points in 1999 are Buildings 175, 177, 251, 292, 331, 332, 490, and 491. Discharge points at Buildings 175, 177, 251, 292, 332, 490, and 491 were monitored for gross alpha and gross beta activity. (During 1999 stack monitoring at some of these locations were removed; see discussion in Section IV, Supplemental Information; in the subpart entitled “Continuous Monitoring”). Building 331 stack discharges were monitored for tritium.

Operations in the Tritium Facility (Building 331) released a total of 280 Ci (1.0×10^{13} Bq) of tritium. Of this, approximately 214 Ci (7.9×10^{12} Bq) were released as tritiated water (HTO). The remaining 24% of the tritium released, 67 Ci (2.5×10^{12} Bq), was elemental tritium gas (HT). The highest single weekly stack emission from the facility was 41 Ci (1.5×10^{12} Bq), of which 15 Ci (5.4×10^{11} Bq) was HTO.

Building 331 tritium emissions, as measured by stack monitoring, while increased compared to 1998, remained considerably lower in 1999 than emissions that occurred during the 1980s. Figure 4 illustrates the combined HTO and HT emissions from the facility since 1981. Increased tritium emissions for 1999 compared to 1998 resulted from a minor equipment failure that occurred in the facility. Small releases from occasional failures of sealing devices are anticipated as part of normal facility operations. The increased 1999 emissions remained below levels that would activate the facility stack exhaust alarms, require notification of facility management, require notification of environmental management, or initiate occurrence reporting. Appropriate, planned responses were taken to repair the equipment and control the environmental consequences. The resulting tritium emissions for 1999 were within

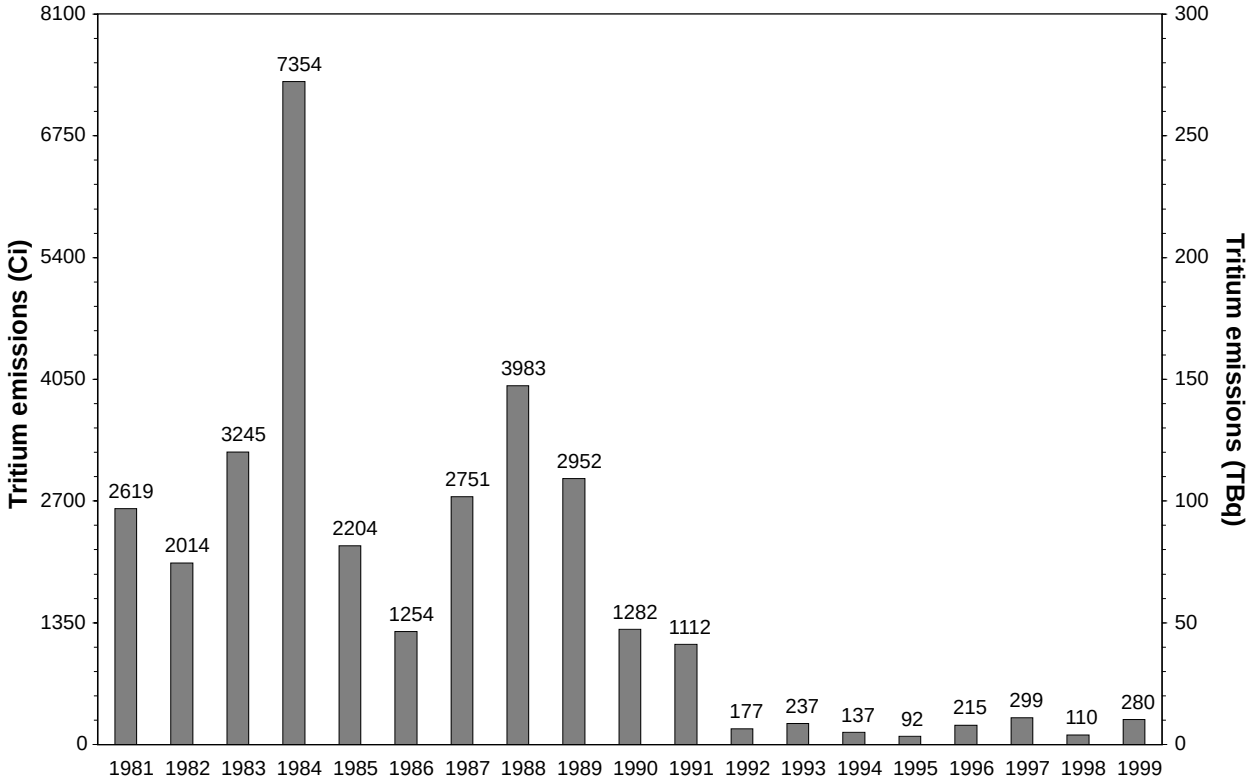

Figure 4. Combined HT and HTO emissions from the Tritium Facility, 1981–1999.

the expected variation in emissions from the facility since 1992, when operations were reduced markedly.

To evaluate the dose from tritium releases, we used the EPA-required CAP88-PC model. The CAP88-PC model ignores the chemical forms of tritiated molecules; all forms are treated as HTO and, therefore, have the same dose consequences. In fact, the doses from exposure to the two major forms of tritiated molecules, HTO and HT, differ greatly. HTO enters the body by ingestion, inhalation, and dermal absorption. Ingested HTO is distributed throughout the entire body and eliminated at the same rate as body water (apart from the small fraction metabolized). Inhaled HTO dissolves in the fluids of the lung and is absorbed. HT enters the body primarily via inhalation, and very little is retained, most being exhaled.

The effective dose equivalent from inhalation of tritium gas is lower by a factor of about 10,000 than that from tritium oxide inhalation, and, when ingestion and dermal absorption are included, HTO is considered to be 25,000 times more toxic (Eckerman et al. 1988). HT requires conversion to HTO (oxidation) to produce a significant dose. This conversion predominately occurs in soil (Brown, Ogram and Spencer, 58 Health Physics, 171–181, 1990) and, to a lesser extent, in vegetation following deposition. HT to HTO conversion is a complicated process to model.

An additional form of tritium for which exposure should be modeled is organically bound tritium (OBT). OBT can be formed by plant or animal metabolism of HTO. The dose rate conversion factor for ingestion of OBT is about 2.3 times larger than that for ingestion of HTO in the free water of plants and animals. However, because the concentration of free water tritium exceeds the concentration of tritium in organic matter for most dietary components in LLNL's ingestion dose assessment, free water tritium makes the dominant contribution to dose, per unit weight consumed. The CAP88-PC model does not address the OBT contribution to dose.

We believe that more work is warranted to develop a more accurate estimate of dose contribution by both HT and OBT. Funding has been provided at LLNL to develop a simple tritium model for incorporation in regulatory compliance codes such as CAP88-PC. The model treats HT releases independently of HTO releases, includes the contribution of organically bound tritium to ingestion dose, and is not overly conservative in predicting doses from HTO.

LLNL discussed the unsuitability of modeling HT as HTO with U.S. EPA Region IX in April 1999. The EPA directed LLNL to evaluate dose from the combined HT and HTO emissions from the Tritium Facility as if they were all HTO. EPA Region IX acknowledged that this dose, based on compliance rules, is a highly conservative overestimate of the actual dose and not indicative of physical reality.

The resulting dose to the SW-MEI from combined emissions of HT and HTO from the Tritium Facility in 1999 is 0.088 mrem (0.88 μSv). Modeling only the HTO emissions from the Tritium Facility results in an estimated dose to the SW-MEI of 0.067 mrem (0.67 μSv).

For most discharge points at the other facilities where continuous stack sampling is performed, the results are below the minimum detectable concentration (MDC) of the analysis; sometimes as few as 1 to 4 samples (out of 25 to 50 per year) have concentrations greater than the MDC. Generally, these few samples having results above the MDC are only marginally above the MDC. Use of zero values for this type of data can be justified based on knowledge of the facility, 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, on the air sampling filters. In addition, because of exhaust configurations at some facilities, the monitoring systems sometimes sample air from the ambient atmosphere along with the HEPA-filtered air from facility operations, giving rise to background atmospheric radioactivity being collected. Because of these considerations, the emissions from such facility operations are reported as zero. Furthermore, even if the MDC values are used in calculations of the emission estimates for these facilities, which would be an extremely conservative approach, the total dose attributable to LLNL activities is not significantly affected.

In 1999, a significant number of samples collected throughout the year from one emission point at Building 251 (the unhardened area) yielded gross alpha results greater than the MDC. We use gross alpha as the primary indicator of potential emissions from Building 251, where operations had involved the use of uranium and transuranic materials (the Building 251 facility is in program standby mode). Gross beta results are used as a further corroboration of those gross alpha results having concentrations above the MDC. The gross alpha monitoring concentrations for Building 251 ranged from -2.1×10^{-15} Ci / m^3 (-7.8×10^{-5} Bq / m^3) to 1.5×10^{-14} Ci / m^3 (5.6×10^{-3} Bq / m^3). Because of the number of samples with values above the MDC, we have taken a

conservative approach and are reporting gross alpha and gross beta measurements as actual emissions. The gross alpha and gross beta emissions for Building 251 were determined to be 3.7×10^{-9} Ci / y (1.4×10^{2} Bq / y) and 6.8×10^{-8} Ci / y (2.5×10^{3} Bq / y). If the results are considered facility emissions, the resulting radiological dose determined with CAP88-PC modeling is 8.8×10^{-7} mrem (8.8×10^{-6} µSv), less than the dose due to many other facility emissions at the Livermore site. Because the dose calculated is estimated from a minimum detectable emission rather than an actual measured emission, it represents an upper bound dose estimate, and is consistent with the dose based on the inventory approach and reported in Attachment 1.

SECTION III. Dose Assessment

Description of Dose Model

Estimates of individual and collective radiological doses to the public from all point sources and many diffuse sources at LLNL were obtained using the EPA-developed computer code CAP88-PC. The four principal pathways—internal exposures from inhalation of air, ingestion of foodstuff and drinking water, 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 μSv). Separate doses for Livermore site and Site 300 point-source emissions (e.g., stack emissions) and diffuse-source emissions are reported.

Three potential doses are emphasized: (1) The dose to the site-wide maximally exposed individual (SW-MEI), which combines the effects of all emission points, for comparison to the 10 mrem/y (100 μSv/y) standard; (2) the maximum dose to any member of the public (assumed to be at the LLNL fence line), in any direction, due to each unabated emission point on the site to determine the need for continuous monitoring; and (3) the collective dose to 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 1999 Livermore-site and Site 300 meteorological data, collected from the meteorological towers for each site. At these towers, wind speed and direction are sampled every few seconds, temperature sampled 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.

Surrogate Radionuclides

CAP88-PC contains a library of 265 radionuclides; however, it does not contain all the radionuclides in use at LLNL. As a consequence, it was necessary in a

few cases to use surrogate radionuclides to estimate EDEs. Attachment 2 shows the surrogate radionuclides used in CAP88-PC. The selection of a suitable surrogate is based upon several criteria, including metabolically similar behavior and similar modes of decay and decay energies of the radiation type of the isotope of interest. Once a surrogate is selected, the equivalent source term is adjusted by the product of the initial inventory of the isotope of interest and the ratio of the effective dose equivalent of the surrogate to that of the isotope of interest. In some cases, experimenters did not have isotopic analyses of mixtures of radionuclides and could only identify their radionuclide usage inventory as "gross alpha," "gross beta," "gross gamma," or "mixed fission products" (MFP). In these cases, ^{239}Pu was used as the surrogate for gross alpha, ^{137}Cs was used as the surrogate for gross gamma, and ^{90}Sr was used as the surrogate for gross beta and mixed fission products to provide conservative dose estimates.

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 1999 modeling effort are described in Section VI under "Collective Effective Dose Equivalent."

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 our investigation in 1995 into the use of the various options, the "user entered" option was again selected for the CAP88-PC modeling effort for 1999. The values entered corresponded to the "local agriculture" option (i.e., everything is home produced), with one exception—all milk consumed was assumed to be imported for individual dose assessment. The assumption that all milk comes from local cows is not supported by the agricultural activities conducted in the area. A detailed discussion of tritium dose calculation by CAP88-PC is presented in the LLNL NESHAPs 1995 Annual report (Gallegos et al., 1996, Lawrence Livermore National Laboratory, UCRL-ID-113867-96).

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 usage inventories, together with time factors and EPA-specified physical state factors, are used to estimate the potential emissions to air from a source. The time factors are used

to adjust for the fact that the radionuclide may not always be in the same facility all year or may be encapsulated or enclosed for a substantial part of the year. The time factors are chosen to allow a reasonable estimate of the amount of radioactive material that may potentially be released into the atmosphere. The EPA-specified factors for potential release to air of materials in different physical states (solid, liquid, powder, or gas) are those stated in 40 CFR Part 61, Appendix D. If the material was an unconfined gas, then the factor 1.0 was used; for liquids and powders, 1.0×10^{-3} was used; and for solids, 1.0×10^{-6} was used. In 1996, U.S. EPA granted approval for LLNL to use alternative emission factors for elemental uranium as follows: an emission factor of 1×10^{-6} can be used for elemental uranium heated at temperatures below 1100°C, an emission factor of 1×10^{-3} can be used for elemental uranium heated at temperatures between 1100°C and 3000°C, and an emission factor of 1 shall be used for temperatures greater than 3000°C. These factors are allowed provided that the uranium is not intentionally dispersed to the environment and that the processes do not alter the chemical form of the uranium. The physical-state-dependent release fraction and the time factor are used to adjust (by multiplication) the total annual usage inventory to yield the potential annual release to air. In addition, emission-control abatement factors (40 CFR 61, Appendix D), when applicable, were applied. Each HEPA filter stage was given a 0.01 abatement factor. (However, abatement factors were not used to evaluate compliance with the 0.1 mrem standard that determines the need for continuous monitoring at a facility.) The use of actual monitoring data is much more direct, and presumably more accurate, than using assumptions based on usage inventory, time factors, release fractions, and emission-control factors.

Site-Wide Maximally Exposed Individual

For LLNL to comply with the NESHAPs regulations, the LLNL site-wide maximally exposed individual cannot receive an EDE greater than 10 mrem/y (100 μSv/y). The site-wide maximally exposed individual (SW-MEI) is 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.

To determine the location of the 1999 SW-MEI, CAP88-PC results from multiple sources were combined. Sources were selected to include those expected to give significant contributions to the EDE. These consisted of Building 331 point and diffuse sources and the Building 612 diffuse source. Because EDE results from CAP88-PC depend on the location of the specified source, direct summing of results from multiple sources can only be accomplished using an interpolation method. To do this, 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 Livermore-site boundary. 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 1999 was located at the UNCLE Credit Union, about 10 m outside the controlled eastern perimeter of the site, as shown in Figure 5. At Site 300, the 1999 SW-MEI was located in an experimental area

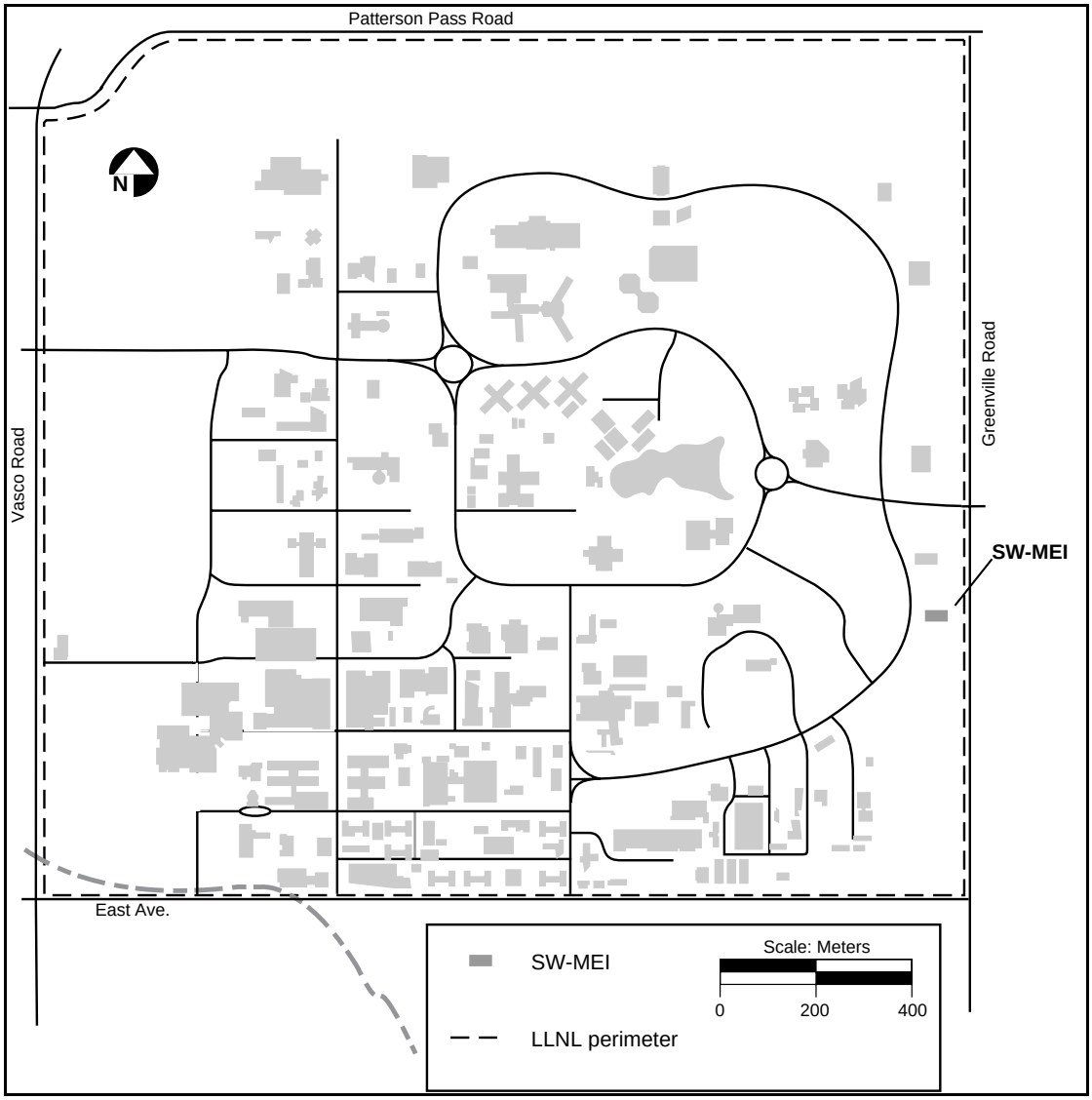

Figure 5. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at the Livermore site, 1999.

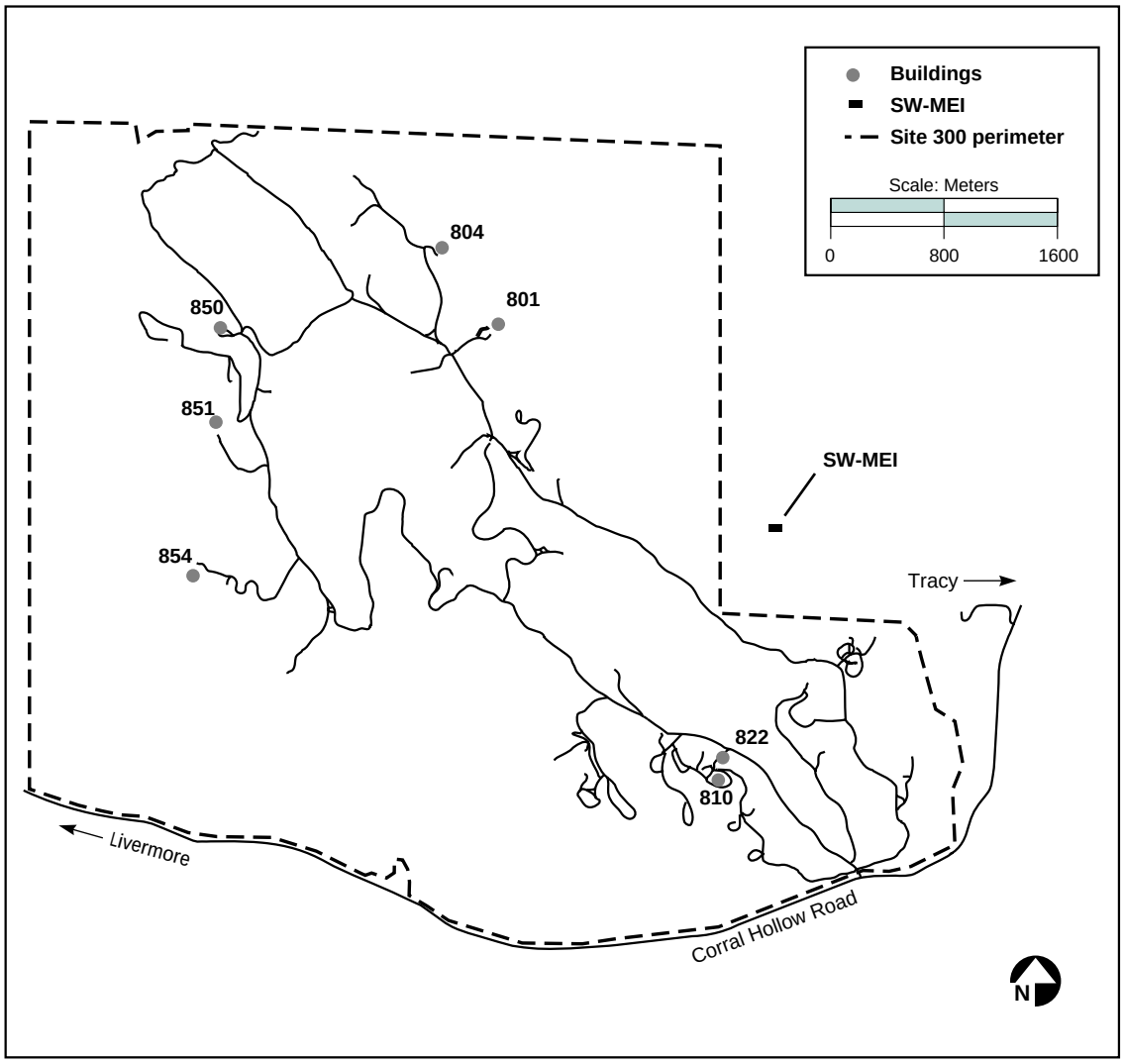

Figure 6. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 1999.

termed "Bunker 2" operated by Primex Physics International. Bunker 2 lies about 300 m outside the east-central boundary of Site 300, as shown in Figure 6. This bunker is approximately 2.4 km east southeast of the firing table at Building 801. (It is unlikely that Bunker 2 will be the SW-MEI for the year 2000 because, as of this writing, operations by Primex Physics International at this site have ended.)

In Attachment 1, the distance and direction to the respective SW-MEI are 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 "Total Dose Estimate" in Section IV).

Maximally Exposed Public Individual

To assess compliance with the requirement for continuous monitoring (potential dose greater than 0.1 mrem/y [1.0 μSv/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 "fence line" 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 in 40 CFR Section 61.93 (b)(4)(ii), modeling for assessment of continuous monitoring requirements assumed unabated emissions (i.e., no credit was taken for emission abatement devices, such as filters). Attachment 1 provides, for each point source, the dose to the MEI and the distance and direction to the LLNL fence line where the MEI is located.

Special Modeling Challenges

Among the sources at LLNL, explosives tests using depleted uranium at Site 300 and diffuse sources at both sites required special attention.

Site 300 Explosives Experiments: Some of the explosives assemblies for Site 300 explosives experiments contain depleted uranium. The explosives assemblies are 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 usage 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}. Their masses are multiplied by their specific activities to determine the total activity for each isotope in the cloud. It is assumed that all 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: Diffuse emissions are generally area sources external to buildings, as discussed in Section IV, below. The dose assessments for diffuse sources can be derived from radionuclide-usage-inventory data, from environmental-surveillance monitoring data, or from samples of contaminated materials.

Modeling Documentation

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

Point Source Summary

The 1999 calculated EDE to the SW-MEI from Livermore-site point sources was 0.094 mrem (0.94 μSv). (The dose from point sources includes HT emissions modeled as HTO as directed by EPA Region IX. EPA Region IX acknowledges that such modeling results in a very conservative overestimation of the dose. This methodology is used for purposes of compliance and, as noted previously, we do not believe it provides a technically accurate dose estimate.) The 1999 dose is higher than the 1998 reported EDE from Livermore-site point sources of 0.031 mrem (0.31μSv). The differences in EDE to the SW-MEI can be attributed to differences in emissions from the Tritium Facility (Building 331) where emissions accounted for 0.088 mrem (0.88 μSv) in 1999, compared to 0.029 mrem (0.29 μSv) in 1998. One reason for the increase in emissions from 1998 to 1999 from the Tritium Facility was, as stated previously, the release due to an anticipated type of equipment failure within the bounds of routine operations.

The calculated EDE to the SW-MEI at Site 300 was calculated to be 0.034 mrem (0.34 μSv) from point-source emissions. Nearly this entire dose resulted from Building 801 and Building 851 firing-table emissions in the course of explosives experiments. The 1999 EDE is an increase from the 0.019 mrem (0.19 μSv) dose modeled for 1998. The increase in dose is primarily the result of an increase in the quantity of depleted uranium used in the experiments.

All 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 μSv/y). Discussion of the contribution to EDE to members of the public from diffuse sources is presented in Section IV.

SECTION IV. Additional Information

Construction and Modifications

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 toxic air contaminants 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.

Three new facilities are currently under construction. All of these facilities were assessed prior to construction for compliance with NESHAPs. Effluent sampling systems are planned for all three. These facilities are the Contained Firing Facility (CFF) at Site 300, and the Decontamination Waste Treatment Facility (DWTF) and the National Ignition Facility (NIF) at the Livermore site.

The CFF project will allow containment of some explosives tests currently conducted outdoors at Site 300's Building 801. The CFF project consists of an enclosed firing chamber, a support facility and a diagnostic equipment facility. The final phase of construction began in April 1999 and is still ongoing. CFF plans include stack monitoring for radioactive particulate emissions.

The DWTF is a waste handling facility that will have improved air emissions controls and will enable the handling of additional waste streams. Phase I construction (site preparation and installation of underground utilities) has been completed. Construction of the solid waste processing building, the storage building, and the office building were completed in 1998. Construction of the building housing the stack, air handling systems and liquid waste processing operations began in December 1999, following the issuance of the RCRA Hazardous Waste Facility permit from the State of California. The DWTF stack will be monitored for tritium and radioactive particulate emissions; some of the stack monitoring equipment has been purchased.

The National Ignition Facility (NIF) will contain the world's largest laser, a research tool allowing scientists to recreate on earth conditions equivalent to the center of the sun. The NIF will focus 192 extremely powerful laser beams onto a BB-sized capsule of deuterium and tritium, forcing the two heavy isotopes of hydrogen to combine through compression and heating, producing ignition and self-sustained fusion burn. The NIF construction project began in 1996 and the conventional construction is scheduled to be completed in 2000. The next phase of construction involves the special equipment inside the buildings, and initial laser operations will commence after the special equipment construction is completed. NIF is being designed, built and operated by a team from Lawrence Livermore, Los Alamos and Sandia National Laboratories and the University of Rochester. Major work has been completed, so that the optics assembly building is already occupied, and the electrical, heating and cooling systems for the buildings are operational.

Unplanned Releases

There were no unplanned atmospheric releases of radionuclides at the Livermore site or Site 300 in 1999.

Diffuse Source Dose Assessments

Diffuse, or non-point, sources 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 are 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 1999 diffuse sources at the Livermore site required three different modeling approaches. Building 331 Yard and Building 612 Yard emissions estimates are based on facility personnel knowledge and environmental-surveillance data to estimate emissions. Building 292 required vegetation monitoring and CAP88-PC modeling techniques. Building 514 required radiological-usage-inventory data and CAP88-PC modeling techniques. Data from radiological measurements were used as the basis for dose estimates for the Southeast Quadrant, the soil staging area, and Building 223 Annex.

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 due to transpiration from vegetation. In 1999, quarterly samples of the pine tree, which had previously been identified as the primary source of transpired tritium, were used to estimate the emission of tritium from this source. The maximum concentration of tritium in the tissue water of the pine tree was 7510 pCi/L (278 Bq/L) in 1999. Assuming the tree has an area of 79 m^2 and a transpiration rate of 190 L/d, the resulting emission rate from this source is 5.2×10^{-4} Ci/y (1.9×10^{7} Bq/y). This estimated emission compares well with previous estimates, which ranged from 4.8×10^{-4} Ci/y (1.8×10^{7} Bq/y) to 1.4×10^{-3} Ci/y (5.1×10^{7} Bq/y) in 1994 through 1998. The current source term produced a calculated 1999 dose to the SW-MEI from the Building 292 area of 7.3×10^{-8} mrem (7.3×10^{-7} µSv).

Building 331 Yard

As the Tritium Facility (Building 331) conducts operations, tritium-contaminated equipment and material slated for disposal is removed from the building, packaged in a waste-accumulation area, and sent to Hazardous Waste Management Division (HWM) facilities. During 1999, outgassing from such waste processing released approximately 7.3 Ci (2.75×10^{11} Bq) of tritium to the atmosphere outside 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 release was modeled in CAP88-PC as a 1 m^2 area source, leading to a calculated 1999 dose to the SW-MEI of 6.1×10^{-3} mrem (6.1×10^{-2} µSv).

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 1999 radionuclide usage inventory was conducted for the facility to determine the diffuse source term (Attachment 1). CAP88-PC modeling gave a 1999 EDE for the Tank Farm to the SW-MEI of 3.2×10^{-3} mrem (3.2×10^{-2} µSv).

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. Several of these containers are not airtight and outgas tritium. A surveillance air monitor has been placed in the Building 612 Yard to provide continuous measurements of tritium in air near this source. The median annual concentration of tritium in air for 1999 in this area was 68 pCi/m^3 (2.5 Bq/m^3). These data were used to calculate the total tritium emissions from the area, using a conservative approach that assumed the source to be 60 m south-southwest of the air sampler. With this assumption, a diffuse source emission of 4.4 Ci/y (1.63×10^{11} Bq/y) was required to produce the concentrations measured at the air sampler. This source term produced a calculated 1999 dose to the SW-MEI from the Building 612 Yard of 1.8×10^{-2} mrem (1.8×10^{-1} μSv).

Waste Accumulation Area Drum Sampling

Waste Accumulations Areas (WAAs) are maintained by the LLNL programs as storage areas for waste prior to the transfer of the waste to Hazardous Waste Management. Before the wastes are transferred, Hazardous Waste Management samples the waste drums. Because this sampling represents a potential for exposure to the atmosphere, estimates of the potential dose from this activity are provided. The waste areas are maintained at various locations around the LLNL Livermore Site, so the potential emissions were modeled from the center of the site. The emissions estimate for this source was not updated for 1999 because it is a minor contributor to dose. The dose for the Waste Accumulation Area Drum Sampling was incorrectly reported in the 1998 report as 5.1×10^{-4} mrem (5.1×10^{-3} μSv). The source produced a calculated 1998 dose to the SW-MEI of 8.9×10^{-9} mrem (8.9×10^{-8} μSv); this dose serves as the dose estimate for 1999 drum sampling activities.

Southeast Quadrant

The Southeast Quadrant of the Livermore site has elevated levels of $^{239+240}Pu$ 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 UNCLE Credit Union (the location of the SW-MEI) to monitor the $^{239+240}Pu$ levels in this area. Monitoring data from this air sampler were used as a direct measurement of potential dose via the air pathway. The median annual concentration of $^{239+240}Pu$ in air of 1.6×10^{-19} μCi/mL (6.0×10^{-15} Bq/mL), the dose-conversion factor of 3.08×10^5 mrem/μCi (8.33×10^{-5} Sv/Bq) from Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency (1988) for ^{239}Pu and

^{240}Pu, and the standard-man breathing rates of 8400 m^3/y were used to calculate the estimated EDE of 4.2×10^{-4} mrem (4.2×10^{-3} μSv) for 1999.

Soil Staging Area

The soil staging area is an area near Building 170 where soil and debris are stored and tritium is remediated by evaporation. The emissions were estimated from the measured concentrations of tritium in the debris. The estimated release is 3.1×10^{-2} Ci (1.1×10^{9} Bq) HTO. The CAP88-PC estimated dose to the SW-MEI is 8.4×10^{-6} mrem (8.4×10^{-5} μSv).

Building 223 Annex Decontamination

Building 223 annex is a location identified for decontamination. The emissions were estimated from samples of building materials. The estimated release is 6.6×10^{-8} Ci (2.4×10^{3} Bq) ^{241}Am; 7.1×10^{-9} Ci (2.6×10^{2} Bq) ^{238}Pu; and 5.4×10^{-7} Ci (2.0×10^{4} Bq) $^{239+240}$Pu. The CAP88-PC estimated dose to the SW-MEI is 1.7×10^{-4} mrem (1.7×10^{-3} μSv).

Site 300 Diffuse Sources

Diffuse sources at Site 300 involve tritium and uranium. During 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 (Final Site Wide Remedial Investigation Report; Webster-Scholten, Ed., 1994, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-108131). Tritium and ^{238}U were identified as contaminants of potential concern.

Tritium Evaporation and Migration at Site 300

Tritium gas and solids containing 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. The tritium contamination at these locations was characterized at Site 300 in 1994. Since that time, natural processes including rainfall and evapotranspiration acted on the locations characterized, but new data have not been collected. Because it is becoming less likely that the 1994 data are representative of current conditions, LLNL personnel installed an air tritium sampler at a location (designated PRIM) that represents the SW-MEI, and doses from diffuse tritium

sources for 1999 are estimated based on the monitoring data for that sampling location. The median annual concentration of tritium in air of 0.11 pCi/m^3 (4.1×10^{-3} Bq/m^3), the dose-conversion factor of 6.4×10^{-8} mrem/pCi (1.73×10^{-11} Sv/Bq) from Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency (1988) for tritium, and the standard-man breathing rates of 8400 m^3/y were used to calculate the estimated EDE of 6.0×10^{-5} mrem (6.0×10^{-4} μSv) for 1999.

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.

For the 1995 NESHAPs annual report, we developed calculations to separate the contribution to measured uranium activities from naturally occurring uranium (NU) (Gallegos et al., 1996, Lawrence Livermore National Laboratory, UCRL-ID-113867-96). We base our dose estimate for resuspended depleted uranium (DU) on the measured environmental surveillance monitoring total concentration in air of uranium-238, subtracting out the part contributed by NU, from the following equation:

$$\mu = \frac{0.00726 - 0.99274\dfrac{M(CU-235)}{M(CU-238)}}{0.00526\dfrac{M(CU-235)}{M(CU-238)} + 0.00526} \quad ,$$

where μ is the fraction (by weight) of uranium contributed by operations, CU is composite uranium (both DU and NU), M(CU-235) the mass of U-235 in the composite (measured) uranium, and M(CU-238) the mass of U-238 in the composite (measured) uranium. (For derivation of the equation see the 1995 NESHAPs annual report, referenced above.) In previous years, this equation was used only for those months in which explosives shots were not conducted. For 1999, we used the median concentration of all months to represent the potential annual exposure from resuspension of DU at Site 300.

Using these calculations to apportion the M(CU) for 1999, we obtain an annual average concentration of DU in air from resuspension of 3.2×10^{-12} g/m^3. Using the fractions 0.998, 0.002, and 0.000005 to represent the amounts of ^{238}U, ^{235}U, and ^{234}U; specific activities of 3.33×10^{-7}, 2.14×10^{-6}, and 6.20×10^{-3} Ci/g for ^{238}U, ^{235}U, and ^{234}U; a yearly inhalation rate of 8400 m^3/y, and dose conversion factors from EPA Regulatory Guide 11 of 1.18×10^{11}, 1.23×10^{11}, and

1.32×10^{11} mrem / Ci; we obtain a total dose for resuspended DU of 1.2×10^{-3} mrem (1.2×10^{-2} μSv).

Errata in 1998 Annual Report

For the Livermore site, the inventory and the dose that was reported for the drum sampling operations at all waste accumulation areas was incorrect. The inventory of all nuclides was reported as zero; the correct inventory values are reported in Attachment 1. The dose at the SW-MEI from these operations should have been reported as 8.9×10^{-9} mrem (8.9×10^{-8} μSv). The dose to the fenceline MEI should have been reported as 3.6×10^{-8} mrem (3.6×10^{-7} μSv). The correction has no effect on the total dose to the SW-MEI. The correct dose estimates are also presented in Attachment 1.

For Site 300, the 1998 report incorrectly stated on page 31 that the population dose for operations conducted in 1997 was 3.6 person-rem (0.0036 person-Sv); the 1998 report should have stated the population dose was 7.2 person-rem (0.0072 person-Sv). The population dose is correctly reported in Attachment 3 of the 1998 report.

Total Dose Estimate and Comparison with Previous Years' Data

For the Livermore site, the dose calculated for the SW-MEI from diffuse emissions in 1999 totaled 0.028 mrem (0.28 μSv). The dose due to point sources was 0.094 mrem (0.94 μSv). When combined, the total annual dose was 0.12 mrem (1.2 μSv). The dose from point sources includes Tritium Facility HT emissions modeled as HTO, as directed by EPA Region IX. EPA Region IX acknowledges that such modeling results in a very conservative overestimation of the dose. A more accurate dose from both point and diffuse source emissions from the Livermore site is 0.10 mrem (0.10 μSv).

The total dose to the Site 300 SW-MEI from operations in 1999 was 0.035 mrem (0.35 μSv). Point-source emissions from firing-table explosives experiments accounted for 0.034 mrem (0.34 μSv), of this total, while 0.0012 mrem (0.012 μSv), or about 3%, was contributed by diffuse sources. Table 4 presents the facilities or sources that account for 90% or more of the doses for the Livermore site or Site 300 SW-MEI.

Table 4. List of facilities or sources whose emissions account for 90% or more of the doses for the Livermore site and Site 300 SW-MEI.

Facility or Source	Dose (mrem)	Percent Contribution to Total Dose

Livermore site		
Building 331 (point source)	0.088 [(a)]	72%
Building 612 Yard (diffuse source)	0.018	15%
Building 331 Area Source (diffuse source)	0.0061	5%
Site 300		
Building 851 Firing Table (point source)	0.021	61%
Building 801 Firing Table (point source)	0.012	36%

[a] The dose includes HT emissions modeled as HTO as directed by EPA Region IX. EPA Region IX acknowledges that such modeling results in a very conservative overestimation of the dose. This methodology is used for purposes of compliance. The dose not having HT emission modeled as HTO is 0.067 mrem.

Comparison of the 1999 total dose estimate with that of previous years can be made by reviewing the information presented in Table 5. No diffuse emissions were reported at Site 300 for years before 1993, so comparison for total dose can only be made with the values for 1993 and later; in addition, diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991.

Table 5. Doses (in mrem) calculated for the Site-Wide Maximally Exposed Individual for the Livermore site and Site 300, 1990 to 1999.

Year	Total Dose	Point Source Dose	Diffuse Source Dose
Livermore site			
1999	0.12 [a]	0.094 [a]	0.028
1998	0.055 [a]	0.031 [a]	0.024
1997	0.097	0.078	0.019
1996	0.093	0.048	0.045
1995	0.041	0.019	0.022
1994	0.065	0.042	0.023
1993	0.066	0.040	0.026
1992	0.079	0.069	0.010
1991	0.234	—b	—b
1990	0.240	—b	—b
Site 300			
1999	0.035	0.034	0.0012
1998	0.024	0.019	0.005
1997	0.020	0.011	0.0088
1996	0.033	0.033	0.00045
1995	0.023	0.020	0.003
1994	0.081	0.049	0.032
1993	0.037	0.011	0.026
1992	0.021	0.021	—c
1991	0.044	0.044	—c
1990	0.057	0.057	—c

[a] The dose includes HT emissions modeled as HTO as directed by EPA Region IX. EPA Region IX acknowledges that such modeling results in a very conservative overestimation of the dose.

This methodology is used for purposes of compliance and we do not believe that it provides a technically valid dose estimate. For 1999, the total dose not having HT emission modeled as HTO is 0.10 mrem; the point source dose is 0.073 mrem.

b Diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991.

c No diffuse emissions were reported at Site 300 for years before 1993.

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: Phillip Hill
Director, Livermore Safety Oversight Division
U.S. Department of Energy
Livermore Site Office
7000 East Avenue, L-293
Livermore, CA 94550

Signature: _____ **Date:** _____
Phillip Hill

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: L. Lynn Cleland
Laboratory Site Manager
Laboratory Site Operations
Lawrence Livermore National Laboratory
7000 East Avenue, L-668
Livermore, CA 94550

Signature: _____ **Date:** _____
L. Lynn Cleland

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.

In 1996, we reconstructed the population distributions centered on the two LLNL sites. These population distributions are based on 1990 census data, as were the previous distributions. However, the 1996 distributions were developed using commercially available, computer-map-based population data and the geographic information system software, ArcView©. The population for each sector segment was determined by selecting census block level data for that segment. In 1997, we further improved the estimates of the 1990 census population distribution by refining the location of the centers of the grids and by using curved arcs rather than straight lines to define the sector segments. 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 improved population data files (distribution of population with distance and direction) are shown in Tables 6 and 7 for the Livermore site and Site 300, respectively.

For the evaluation of the population dose, as distinct from the individual dose, all food (and in particular milk) was assumed to be produced locally. This decision was made because, although there are no commercial dairy animals within the distances used to evaluate individual doses, many dairy animals live within 80 km of the Livermore site and Site 300.

The collective EDE, which is the sum of the individual doses to all 6.3 million people within 80 km of the Livermore site, due to 1999 Livermore-site operations was 2.2 person-rem (0.022 person-Sv). The collective dose includes HT emissions conservatively modeled as HTO as directed by EPA Region IX. This methodology is used for purposes of compliance.

Table 6. Population distribution for LLNL's Livermore site, based on 1990 census information. Values are population in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5°-sector directions.

	Range of distance from site (km)					
Direction	0-16	16-32	32-48	48-64	64-80	**Total**
N	235	12558	25414	6068	1932	**46207**
NNW	2135	1785	121044	1396	166741	**293101**
NW	6975	17085	247376	117130	102863	**491429**
WNW	1774	71710	224893	482899	152988	**934264**
W	49338	78214	312603	410117	568185	**1418457**
WSW	28590	115085	133563	311837	19824	**608899**
SW	304	85476	251417	129576	5113	**471886**
SSW	53	20234	600957	335772	59236	**1016252**
S	89	155	48296	61359	58915	**168814**
SSE	175	209	3	33	2481	**2901**
SE	321	55	50	25	9811	**10262**
ESE	139	166	1918	14064	55714	**72001**
E	77	7961	7103	153249	138118	**306508**
ENE	127	32766	60254	10831	3349	**107327**
NE	75	681	101717	219898	13442	**335813**
NNE	5	7115	1421	5570	18971	**33082**
Total	**90412**	**451255**	**2138029**	**2259824**	**1377683**	**6317203**

Table 7. Population distribution for LLNL's Site 300, based on 1990 census information. Values are population in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5°-sector directions.

	Range of distance from site (km)					
Direction	0-16	16-32	32-48	48-64	64-80	**Total**
N	866	3363	2494	3633	6034	**16390**
NNW	104	4774	72306	4130	33751	**115065**
NW	88	225	25796	267551	107081	**400741**
WNW	152	20378	94428	309007	588389	**1012354**
W	454	72602	168776	285461	492124	**1019417**
WSW	49	43	188555	283552	123768	**595967**
SW	54	72	381738	641040	26040	**1048944**
SSW	4	3	46491	150412	24369	**221279**
S	19	242	3	26045	41175	**67484**
SSE	0	2	2	14	88	**106**
SE	33	15	151	8173	4938	**13310**
ESE	131	1286	13423	50535	32525	**97900**
E	270	2137	129980	133301	10026	**275714**
ENE	1264	21973	30017	22099	2845	**78198**
NE	32442	15122	87148	7502	4079	**146293**
NNE	4411	928	186995	69583	21515	**283432**
Total	**40341**	**143165**	**1428303**	**2262038**	**1518747**	**5392594**

The collective EDE not having HT emission modeled as HTO is 1.7 person-rem (0.017 person-Sv). The collective dose is greater than the 1998 value of 0.84 person-rem (0.0084 person-Sv) because the stack releases from Building 331 (the Tritium Facility) increased in 1999. This collective EDE can also be compared to the collective dose from natural background radioactivity for 6.3 million people of 1.88×10^6 person-rem (1.88×10^4 person-Sv).

The corresponding collective EDE from Site 300 operations in 1999, 11 person-rem (0.11 person-Sv), was due to point-source emissions. The total collective EDE value for Site 300 is the same as the 1998. The similarity of the population dose for the two years is coincidental; the individual dose to the SW-MEI differed by 0.011 mrem (0.11 μSv) for the two years.

The larger collective dose for Site 300 compared to the Livermore site 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.

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 1999 were found to be well below the 10 mrem (100 μSv) 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.

Stack monitoring is based on evaluations of potential emissions without control devices or on EPA concurrence for those facilities for which classification or other issues prevent a usage-inventory-based evaluation. Facilities in the latter category include Building 331, Building 332, and the seismically hardened area of Building 251.

Several other Livermore-site facilities (Buildings 175, 251 unhardened, and 491) also will maintain continuous-monitoring systems; however, calculations using unabated potential emissions resulted in EDEs of less than 0.1 mrem/y

(1 μSv/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. Although many operations were evaluated in 1999, none required new sampling systems.

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

Radon emissions occur naturally by emanation from the earth. Radon-222 emissions that were reported in past NESHAPs annual reports from research experiments at the Livermore site did not occur in 1999.

1999 Air Monitoring

In this section we describe air effluent continuous sampling systems at LLNL facilities, periodic confirmatory measurements made in 1999 of emissions from sources not required to have continuous monitoring, and surveillance monitoring.

Continuous Monitoring

At the beginning of 1999, there were eight buildings (Buildings 175, 177, 251, 292, 331, 332, 490, and 491) at the LLNL site that had radionuclide air effluent monitoring systems. These buildings are listed in Table 8, along with the number of samplers, the types of samplers, and the analytes of interest. Many would operate from emergency power systems if normal power were lost.

Table 8. Air-effluent sampling locations and systems.

Building	Facility	Analytes	Sample type	Number of samplers
175	MARS	Gross α, β on particles	Filter	6
177	Extractor Test	Gross α, β on particles	Filter	1
251	Heavy Elements			
	Unhardened area	Gross α, β on particles	Filters	44[a]
	Hardened area	Gross α, β on particles	Filters	4
	Hardened area	Gross α, β on particles	CAM[b]	4[c]
292	Molten Salt Oxidation	Gross α, β on particles	Filter	1[c]
331	Tritium	Tritium	Ionization Chamber[b]	4
		Gaseous tritium / tritiated water vapor	Molecular sieves	4
332	Plutonium	Gross α, β on particles	CAM[b]	12
		Gross α, β on particles	Filters	16
490	USEC Laser Isotope Separation	Gross α, β on particles	Filters	4[c]
491	USEC Laser Isotope Separation	Gross α, β on particles	Filters	1

Note: "CAM" denotes Eberline continuous air monitors.
[a] Sixteen of these systems were deactivated in 1999.
[b] Alarmed systems.
[c] Sampling at this location was terminated in 1999.

In 1999, sampling at several air effluent locations was terminated. In the past, operations performed in Buildings 175, 177, 490, and 491 have supported research and development for the separation of uranium isotopes under the Advanced Vapor Laser Isotope Separation Program (AVLIS). In 1999, the AVLIS Program was shutdown and samplers on a Building 490 exhaust system were deactivated because the operation of the ventilation system was stopped. Air effluent sampling systems at the Building 175, 177, and 491 continue to operate as part of the maintenance and surveillance shutdown plan for AVLIS facilities. At the Heavy Element Facility, 20 samplers were deactivated. This facility has been in program standby mode for some time and activities involving the use of radiological materials are not expected to resume in the areas previously monitored by the deactivated samplers. Finally, a sampling system located at the Expedited Technology of Molten Salt

Oxidation project in Building 292 was removed because the project was completed. At the end of 1999, LLNL was operating 76 air effluent sampling systems at 6 facilities.

Air samples for particulate emissions are extracted downstream of 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 the end of sample collection 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).

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. Each sieve sampler (not alarmed) is in parallel with an alarmed monitor and consists of two molecular sieves. The first sieve collects tritiated water vapor; the second sieve contains a palladium-coated catalyst that converts molecular tritium to tritiated water, which is then collected. 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.

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

Periodic Confirmatory Sampling

Results of NESHAPs periodic confirmatory sampling serve to confirm two objectives: 1) that operations which are not continuously monitored do not need to be continuously monitored, and 2) that radionuclide-usage-inventory-based estimates of emissions and their corresponding doses are conservative. In 1999, such sampling was performed at Buildings 321 and 251. The sampling results are discussed below. None of the estimated emissions contribute significantly to the dose for the Livermore site SW-MEI. None of the operations require continuous sampling.

Periodic confirmatory sampling was conducted for a 1-month period from Building 321 at an exhaust designated FEV-1000. The HEPA-filtered exhaust ventilates a mechanical shop where uranium parts are machined. Two filter samples for particulate emissions were taken over a 5-week period while machining operations were being performed. The filter samples, Millipore AW-19, 47-mm diameter media, were analyzed for gross alpha and gross beta activity. All measured activity concentrations were less than the minimum detectable concentrations of 1.4×10^{-16} Ci / m^3 (5.2×10^{-6} Bq / m^3) and 3.3×10^{-16} Ci / m^3 (1.2×10^{-5} Bq / m^3) for alpha and beta activity, respectively. Projecting the results to occur for the entire year yields potential emissions of less than 2.3×10^{-8} Ci (8.4×10^{2} Bq) alpha activity and less than 5.6×10^{-8} Ci (2.1×10^{3} Bq) beta activity. CAP88-PC modeling indicates the dose from these emissions to be less than 2.9×10^{-6} mrem (2.9×10^{-5} μSv), or less than 0.003% of the EDE from all Livermore site operations for 1999. Because the dose calculated is estimated from a minimum detectable emission rather than an actual measured emission, it represents an upper bound dose estimate, and is consistent with the dose based on the inventory approach and reported in Attachment 1.

At Building 251, we performed periodic confirmatory measurements on an exhaust designated FHE-16 located in the unhardened portion of the facility. Continuous monitoring of this exhaust was deactivated at the beginning of 1999 because the Building 251 facility is in program standby mode, and operations involving radiological materials in the area exhausted at this location were no longer being performed. The sampling was conducted because some past continuous monitoring results had indicated results greater than minimum detectable concentrations. Two samples were taken, each 1 week in duration. Samples of particulate emissions were collected on Millipore AW-19, 47-mm diameter, filters. Filters were analyzed for gross alpha and gross beta activity. Resulting measured activity concentrations were greater than the minimum detectable concentrations. The average of the

activity concentrations was also compared to the average of activity from low-volume air surveillance samplers during and surrounding the period of sampling. These samplers, located at the FCC and HOSP off-site surveillance locations, are considered to be representative of ambient radioactivity concentrations since the locations are typically not downwind of site operations. (See Larson et al., Environmental Report for 1998, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-98, (October 1999) for a description of the location of these air samplers.) The activity concentrations for the Building 251 measurements were found to differ significantly from those at the FCC location, but not those at the HOSP location. These results, along with the fact that no operations were taking place at the time of sampling, make it likely that the detected concentrations are not indicative of actual emissions. Nevertheless, if projected throughout the entire year, the estimated emissions for gross alpha and gross beta activities are 1.7×10^{-8} Ci (6.1×10^{2} Bq) and 9.4×10^{-8} Ci (3.5×10^{3} Bq), respectively. The EDE estimated for these potential emissions are 2.8×10^{-6} mrem (2.8×10^{-5} μSv) at the SWMEI and 1.6×10^{-5} mrem (1.6×10^{-4} μSv) for the MEI. The EDE at the SWMEI is less that 0.003% of the EDE resulting from all 1999 Livermore site potential emissions.

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, nine in the Livermore Valley, eight at Site 300, one offsite near Site 300, and one in Tracy. LLNL also maintains eleven continuously operating tritiated water vapor samplers on the Livermore site, six samplers in the Livermore Valley and one offsite near Site 300. The samplers are positioned to ensure reasonable probability that any significant airborne concentration of particulate and tritiated water vapor effluents resulting from LLNL operations will be detected. Many of the surveillance air monitors are placed near diffuse emission sources, such as those near Buildings 292, 331, 513, 514, and 612, as well as in and around the Southeast Quadrant of the Livermore site. As such, their results can be used to estimate and/or confirm the emissions from the associated diffuse sources. Also included are air-particulate and tritiated water vapor monitors positioned at the locations of the SW-MEI for the Livermore site and Site 300. Results from the latter samplers provide a source term for large area diffuse sources and also serve to confirm the SW-MEI EDEs as determined from facility emissions using air effluent monitoring results and usage inventories.

The data from the air surveillance 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. Data from the network are presented in the LLNL Environmental Report, which is prepared annually and available to the public. (Larson et al., Environmental Report for 1999, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-99, to be published in October 2000.)

Comparison of 1999 Modeling Results with Surveillance Monitoring Data

A comparison was made between CAP88-PC modeling results and surveillance air monitoring data for the eleven tritiated water vapor monitors on the Livermore site (designated VIS, SALV, POOL, CAFE, MESQ, MET, COW, B331, B514, B624, and B292) and one off-site tritiated water vapor (ZON7). Monitor locations are shown in Figure 7.

Only the three most significant sources of tritium releases to air at the Livermore site were included in the model-data comparison. The largest source is the Tritium Facility (Building 331), where the tritium is emitted from two 30-m-high, continuously monitored stacks; a total of 214 Ci (7.9 TBq) of HTO was

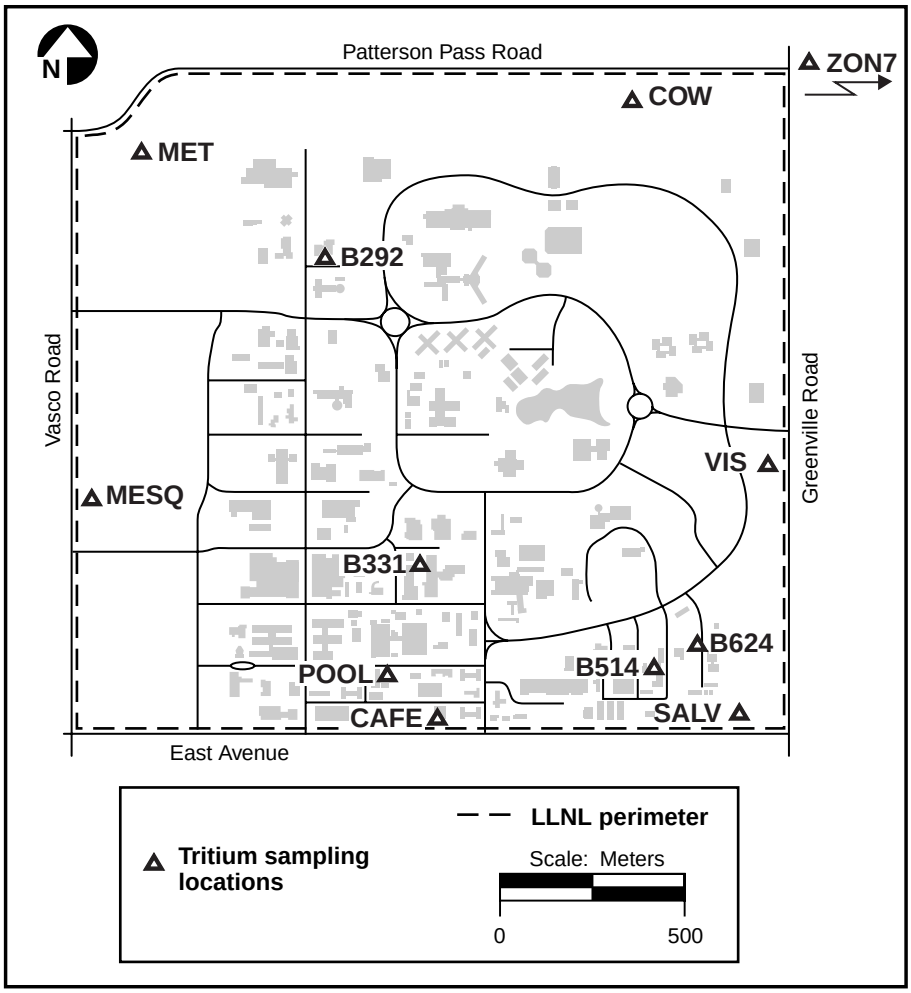

Figure 7. Tritiated water vapor surveillance sampling locations.

emitted from these stacks in 1999. The other two principal sources are diffuse areas associated with the Building 612 yard and Tritium Facility (Building 331) yard. Emissions from these sources were estimated to be 4.4 Ci (0.16 TBq) and 7.3 Ci (0.27 TBq) in 1999. All other potential sources of tritiated water vapor release, such as the hazardous waste management operations in Building 514 and the Building 292 diffuse source were too minor to influence the model-data comparison.

Annual-average concentrations (pCi/m^3 of air) at the locations of the twelve monitors were modeled for the three sources individually and collectively, and compared to the measured annual median concentrations at the twelve monitoring locations. The results are displayed in Figure 8.

The Building 331 stack emissions were used as input to CAP88-PC with the site-specific meteorological data to calculate the annual-average concentrations at

the desired locations. However, both the B331 Yard and the B612 Yard emission rates

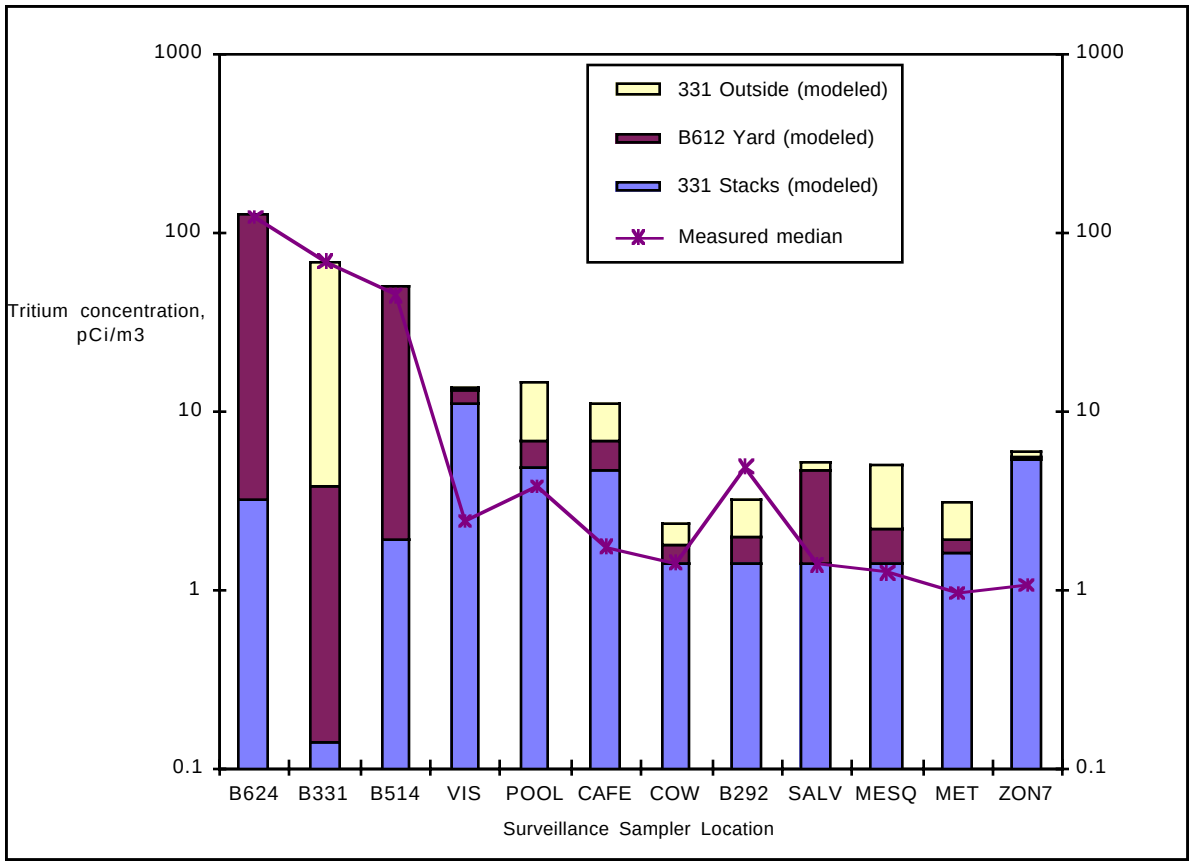

Figure 8. Comparison of measured and modeled tritium concentrations, 1999. Note that the logarithmic scaling used visually distorts the smaller concentration values.

were not independently measured, but rather were determined from the surveillance tritiated water vapor monitor data for the particular monitor in the closest proximity, by requiring that the modeled concentration match the data from that particular monitor. The source term for Building 612 Yard was adjusted to give the observed value at the B624 monitor, and the source term for the B331 Yard was chosen to give agreement with the measured value at all other monitors. Using this approach, the modeling results, by design, agree with the monitoring data at the B624 and B331 locations.

The main conclusion shown in Figure 8 is that by taking into account the three leading sources of tritiated water vapor releases to air—the Building 331 stacks, Building 612 Yard, and the Building 331 Yard—fairly good agreement is obtained with data for all of the monitors. Generally, the modeling results agree with the on-site monitoring data within a factor of 4.0 (at 9 out of twelve

locations). However, in the case of three monitors (CAFE, VIS and ZON7), the difference is nearly a factor of seven, with the model resulting in higher concentration predictions where public exposures could occur. The model result is a factor of 1.6 lower than the measured result at B292, a location well inside the site perimeter and near buildings, where CAP88-PC dispersion modeling is less realistic.

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) and the Analytical Laboratory of the Hazards Control Department (HCD), and the Environmental Protection Department (EPD). NESHAPs Agreement Roles and Responsibilities (NARRs) documents are in place between EPD and the facilities and/or programs and HCD; these NARRs formalize responsibilities and obligations of the organizations regarding many tasks for the air effluent sample network. Tasks that are addressed include air sampler design and installation, procedures and their implementation, sampling, sample analysis and tracking, maintenance and repair of sampling systems, guidance on regulatory requirements, documentation of the sampling network, reporting, and the archival of records.

Facility Safety Procedures (FSPs), Safety Analysis Reports (SARs) and QA Manuals for monitored facilities describe their organizational structures, 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 real-time and passive (i.e., not alarmed) air-monitoring systems, and procedures to be used for measuring flow rates, sampling, and calibration.

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 air sampler 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, CAP88-PC 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 NESHAPs compliance. TAMM members continue to refine mechanisms that ensure they are informed whenever new operations are proposed, significant changes in radionuclide usage 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 has drafted a quality assurance project plan (QAPP) which assembles the quality assurance methods including the above information into one complete document. The document is structured similarly to that specified for a quality assurance program contained in Appendix B, Method 114 of 40 CFR 61. It describes the organization structure and functional responsibilities, objectives of the quality assurance program, administrative controls in place for handling unplanned emissions, sample collection, analysis and tracking procedures, sample collection systems, sample collection and effluent flow rate measurement systems, corrective actions, and reporting. The draft QAPP has been reviewed by EPD and other LLNL organizations and is currently being revised to incorporate comments from personnel in these organizations.

In February through May 1999, the NESHAPs program was the subject of an extensive internal assessment conducted by the LLNL Assurance Review Office (ARO). The assessment addressed the adequacy of effluent monitoring, ambient air sampling, computer modeling, quality assurance, laboratory analytical, data reliability (for calculation of the annual effective dose equivalent), and reporting. The assessment team evaluated data and internal controls through interviews with monitoring and modeling staff; reviews of procedures, standards, and formal communications and reports; and site visits to monitoring equipment, sampling equipment, and analytical laboratories. Although the assessment identified five potential noncompliance conditions or practices, the team concluded that theses conditions or practices did not indicate any immediate or significant impacts on the overall compliance with the requirements of 40 CFR 61 Subpart H or on the reliability of the data used for calculation of the annual effective dose equivalent. The identified items were placed in the LLNL corrective action program, were discussed with EPA (see below), and all five have subsequently been resolved.

Quality Control (QC) for 1999 Radiological Usage Inventory Update and Modeling

Radiological Usage Inventory Update QC

Approximately 15% of the 42 potential sources for which emissions were estimated for 1999 were randomly selected for validation. For this QC check, radiological usage inventories from six potential emission points were selected for validation: two from Site 300 firing tables; one from Building 331; one from Building 514; and one each from diffuse sources at Building 223 and the Southeast Quadrant. An EPD Environmental Analyst contacted the responsible party who signed the NESHAPs usage inventory forms and, when possible, physically visited and inspected the facilities to verify usage inventory data. The responsible party was asked to demonstrate how he/she arrived at the data submitted. Stack parameters also were verified. The QC data were compared to the original data. The accuracy of the usage 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 usage inventories and stack data from the NESHAPs usage inventory forms and pertinent distances from site maps. The QC modeling identified the incomplete distribution of a corrected meteorological file and an inconsistent handling of the weight percentages in depleted uranium. All model runs having these errors were rerun with the corrected input. The data that are presented in the attached spreadsheet are as accurate as possible, demonstrating that quality objectives are being met.

EPA Compliance Evaluation Investigation

There were no compliance evaluations of LLNL facilities in 1999. However, at the EPA's request, a meeting was held on April 6, 1999, to discuss HEPA filter use and maintenance at the Plutonium Facility (Building 332) and other issues of interest to the EPA. The Plutonium Facility Management gave a presentation about HEPA filter use, testing, and planned change out. In response, EPA Region IX staff members stated they had obtained the information that they requested and needed. In addition, LLNL provided information about the minor equipment failure that had occurred in the Tritium Facility. The meeting also included a discussion of findings from the LLNL ARO self-assessment of our NESHAPs program, the modeling of HT

emissions, resulting in the treatment of HT as HTO for the purposes of NESHAPs compliance (see discussion on page 10), and a discussion of time-weighting factors in the estimation of emissions from inventoried sources (see “Emission Source Terms” in Section III). The meeting ended after a presentation on a non-NESHAPs topic, i.e., a summary of the results from the soil sampling effort at Big Trees Park in Livermore (Larson et al., Environmental Report for 1998, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-98, October 1999).

Attachment 1. LLNL NESHAPs 1999 Annual Report Spreadsheet

Guidance for Interpreting 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 in the operation
- Annual radionuclide usage inventory with potential for release (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 usage inventories, and emissions are not listed.

Radionuclide Usage Inventories with Potential for Release

The annual radionuclide usage 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 usage inventories make use of the usage inventory/modeling approach impractical. However, all such affected emission points in these buildings are continuously

monitored, and emissions are therefore directly determined. LLNL conducted a complete radionuclide-usage inventory update in 1997.

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 usage 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. In 1996, U.S. EPA granted approved alternative emissions factors for elemental uranium as follows: an emission factor of 1×10^{-6} can be used for elemental uranium heated at temperatures below 1100°C, an emission factor of 1×10^{-3} can be used for elemental uranium heated at temperatures between 1100°C and 3000°C, and an emission factor of 1 shall be used for temperatures greater than 3000°C. These factors are allowed provided that the uranium is not intentionally dispersed to the environment and that the processes do not alter the chemical form of the uranium.

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 and 1995. Stack physical parameters for sources evaluated in 1999 were updated, as necessary, by experimenters and managers for those facilities.

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).

Estimated Annual Emissions

For unmonitored and non-continuously monitored sources, estimated annual emissions for each radionuclide are based on the product of (1) usage inventory data, (2) time factors (discussed in "Emission Source Terms" of in Section III, (3) EPA potential-release fractions (physical-state factors), and (4) applicable emission-control-device abatement factors.

Actual emission measurements are the basis for reported emissions from continuously monitored facilities. LLNL facilities that had continuous monitoring systems at the beginning of 1999 were Buildings 175, 177, 251, 292, 331, 332, 490, and 491; as noted earlier, systems at Buildings 292 and 490 were removed before the end of the year. See the subsection titled “1999 Usage inventory Update and Effective Dose Equivalent (EDE) Calculations” for a discussion of the use of emissions measurements for monitored sources.

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) cannot receive an EDE greater than 10 mrem/y (100 μSv/y).

In Attachment 1, the distance and direction to the respective SW-MEI are 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 “Total Dose Estimate” in Section IV).

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 μSv/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 “fence line” 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 and time factors were applied. The unabated EDE cannot be calculated for monitored facilities. Because the monitoring equipment is placed after HEPA filtration, there is no way to obtain an estimate for what the emissions might have been had there been no filtration. It is not reasonable to apply factors for the effects of the HEPA filters on the emission rate because most of what is measured on the HEPA filters is the result of the radioactive decay of radon, which is capable of penetrating the filter. Attachment 1 gives, for each inventoried point source, the dose to the MEI and the distance and direction to the LLNL fence line where the MEI is located. However, for monitored sources, no value is shown.

Source Categories

LLNL radionuclide air-emission sources have been classified into seven source categories, indicated by the number in the next to last column of the spreadsheet: (1) Unmonitored or non-continuously monitored Livermore-site facilities that have had a radionuclide-usage-inventory update for 1999; (2) Unmonitored or non-continuously monitored Livermore site facilities with a previous radionuclide-usage-inventory update (this category is not used in years with complete usage inventory updates, like 1997); (3) Continuously monitored Livermore-site facilities; (4) Site 300 explosives experiments; (5) Diffuse sources where emissions and subsequent doses were estimated using inventory processes; (6) Diffuse sources where emission and dose estimates were supported by environmental-surveillance measurements; and (7) Sources whose emissions estimates and subsequent doses were estimated based on periodic confirmatory air sampling rather than continuous sampling.

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Attachment 1 - 1999 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
NOTE: CAP88-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 millirem to sieverts use 1 Sv=1.0E+05 mrem.																			
LIVERMORE SITE POINT SOURCES																			
Building 131 complex is a large office/laboratory facility housing both Mechanical and Electrical Engineering Divisions.																			
131	1248	Room Air	Display of parts	U-238	5.6E-04	1.0E-06	NA	NA	NA	None	1	5.6E-10	1326	E	3.6E-08	524	W	4.1E-07	2
				U-235	7.2E-06	1.0E-06						7.2E-12							
				U-234	5.2E-05	1.0E-06						5.2E-11							
131	1248A	Room Air	Display of parts	U-238	1.7E-03	1.0E-06	NA	NA	NA	None	1	1.7E-09	1326	E	1.1E-07	524	W	1.2E-06	2
				U-235	2.2E-05	1.0E-06						2.2E-11							
				U-234	1.6E-04	1.0E-06						1.6E-10							
131	1258	Room Air	Display of parts	U-238	1.0E-02	1.0E-06	NA	NA	NA	None	1	1.0E-08	1326	E	6.5E-07	524	W	7.5E-06	2
				U-235	1.3E-04	1.0E-06						1.3E-10							
				U-234	9.4E-04	1.0E-06						9.4E-10							
Building 132N provides office and laboratory space for a range of activities, including the Directorate Offices for Chemistry and Materials Sciences;																			
laboratories in the Analytical & Nuclear Chemistry Division and Chemistry and Chemical Engineering Division; and NAI Directorate Forensic Sciences Center offices and laboratories.																			
132N	2675	FHE-6000/7000	Preparation of aqueous	U-238	2.2E-13	1.0E-03	38.1	2.13	8.6	None	1	2.2E-16	1504	E	1.0E-14	1891	NE	1.2E-14	2
			solutions for analysis	U-235	1.0E-14	1.0E-03						1.0E-17							
				U-234	2.3E-13	1.0E-03						2.3E-16							
		FHE-6000/7000	Analysis of aqueous solutions	U-238	2.2E-15	1.0E-03	38.1	2.13	8.6	HEPA	0.01	2.2E-20	1504	E	1.0E-18	1891	NE	1.2E-16	2
				U-235	1.0E-16	1.0E-03						1.0E-21							
				U-234	2.3E-15	1.0E-03						2.3E-20							
132N	2671	FHE-6000/7000	Mass spectrometry analysis	U-238	4.8E-09	1.0E-06	38.1	2.13	11.2	None	1	4.8E-15	1504	E	2.2E-13	1891	NE	3.1E-13	1
				U-235	1.3E-09	1.0E-06						1.3E-15							
				U-234	4.5E-09	1.0E-06						4.5E-15							
				U-238	4.8E-18	1.0E-03						4.8E-21							
				U-235	1.3E-18	1.0E-03						1.3E-21							
				U-234	4.5E-18	1.0E-03						4.5E-21							
132N	2679	FHE-6000/7000	Preparation of aqueous	H-3	1.0E-10	1.0E-03	38.1	2.13	8.6	None	1	1.0E-13	1504	E	8.3E-13	1891	NE	9.7E-13	2
			solutions for analysis	U-238	3.4E-11	1.0E-03						3.4E-14							
				U-235	4.4E-12	1.0E-03						4.4E-15							
				U-234	3.2E-12	1.0E-03						3.2E-15							
				Th-232	9.6E-15	1.0E-03						9.6E-18							
132N	2679	FHE-6000/7000	Analysis of aqueous solutions	H-3	2.0E-12	1.0E+00	38.1	2.13	8.6	HEPA	0.01	2.0E-12	1504	E	1.4E-15	1891	NE	1.7E-13	2
				U-238	1.6E-18	1.0E+00						1.6E-20							
				U-235	2.1E-20	1.0E+00						2.1E-22							
				U-234	1.5E-19	1.0E+00						1.5E-21							
				Th-232	1.9E-17	1.0E+00						1.9E-19							
132N	2680	FHE-6000/7000	Preparation of aqueous	U-238	9.5E-12	1.0E-03	38.1	2.13	8.6	None	1	9.5E-15	1504	E	4.6E-13	1891	NE	5.4E-13	2
			solutions for analysis	U-235	4.4E-13	1.0E-03						4.4E-16							
				U-234	1.0E-11	1.0E-03						1.0E-14							
132N	2685	FHE-6000/7000	Preparation of waste	Gross alpha	1.9E-12	1.0E-03	38.1	2.13	8.6	None	1	1.9E-15	1504	E	1.2E-13	1891	NE	1.4E-13	2
			samples for analysis	Gross beta	1.9E-12	1.0E-03						1.9E-15							
				Gross gamma	1.9E-12	1.0E-03						1.9E-15							
		FHE-6000/7000	Analysis of waste samples	Gross alpha	4.5E-17	1.0E+00	38.1	2.13	8.6	None	1	4.5E-17	1504	E	3.0E-15	1891	NE	3.5E-15	2
				Gross beta	4.5E-17	1.0E+00						4.5E-17							
				Gross gamma	4.5E-17	1.0E+00						4.5E-17							
132N	2699	FHE-6000/7000	Ion chromatography analysis	H-3	2.8E-13	1.0E-03	38.1	2.13	8.6	None	1	2.8E-16	1504	E	6.1E-15	1891	NE	7.1E-15	2
				U-238	2.5E-13	1.0E-03						2.5E-16							
				U-235	3.3E-15	1.0E-03						3.3E-18							
				U-234	2.4E-14	1.0E-03						2.4E-17							
132N	2879	FHE-6000/7000	Preparation of samples	Pu-239	2.0E-09	1.0E-03	38.1	2.13	8.6	None	1	2.0E-12	1504	E	3.3E-10	1891	NE	3.9E-10	2
			for radiochemical analysis	Am-241	2.0E-09	1.0E-03						2.0E-12							
				U-238	2.0E-11	1.0E-03						2.0E-14							
				U-235	9.3E-13	1.0E-03						9.3E-16							
				U-234	2.1E-11	1.0E-03						2.1E-14							
132S	2788	FHE-6000/7000	Transfer of uranium	U-238	5.7E-10	1.0E-03	4.6	1.22	8.9	None	1	5.7E-13	1504	E	2.5E-11	453	SW	6.2E-11	1
				U-235	7.3E-12	1.0E-03						7.3E-15							
				U-234	5.3E-11	1.0E-03						5.3E-14							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 151 houses the Isotope Sciences Division which applies nuclear and isotope sciences to a wide range of problems, including stockpile stewardship, nonproliferation, safeguard technologies, forensic science, and waste characterization and analysis.																			
Building 151 also contains the Chemistry and Materials Sciences Environmental Services laboratory where samples of waste streams and environmental media (air, water, soil etc.) are analyzed for their radionuclide content.																			
151	1033	FHE-2	Drying of core drilling samples from NTS	Pu-239	4.3E-06	1.0E-03	7.6	0.61	3.1	None	1	4.3E-09	1308	E	1.0E-06	584	WNW	5.5E-06	2
				Cs-137	2.1E-06	1.0E-03						2.1E-09							
				Sr-90	9.0E-07	1.0E-03						9.0E-10							
				Am-241	1.5E-06	1.0E-03						1.5E-09							
				H-3	1.2E-04	1.0E+00						1.2E-04							
151	1034B	Room Air	Decontamination operations	Gross alpha	2.0E-08	1.0E-06	NA	NA	NA	None	1	2.0E-14	1308	E	3.0E-12	584	WNW	2.6E-11	2
				Gross beta	2.0E-08	1.0E-06						2.0E-14							
151	1043	FHE-5	Drying of core samples	Sr-90	1.7E-06	1.0E-03	7.6	0.46	2.9	None	1	1.7E-09	1308	E	2.0E-06	584	WNW	1.2E-05	2
				Cs-137	4.2E-06	1.0E-03						4.2E-09							
				Pu-239	8.5E-06	1.0E-03						8.5E-09							
				Am-241	2.9E-06	1.0E-03						2.9E-09							
				H-3	2.3E-04	1.0E+00						2.3E-04							
151	1143	FHE-64	Sample preparation	Pu-239	2.3E-08	1.0E-03	19.2	0.61	2.8	None	1	2.3E-11	1308	E	1.5E-05	584	WNW	5.3E-05	2
				U-234	1.2E-06	1.0E-03						1.2E-09							
				U-235	3.8E-08	1.0E-03						3.8E-11							
				U-238	6.0E-10	1.0E-03						6.0E-13							
				U-234	3.4E-07	1.0E-06						3.4E-13							
				U-235	1.1E-08	1.0E-06						1.1E-14							
				U-238	1.7E-10	1.0E-06						1.7E-16							
				Cm-244	2.0E-06	1.0E-03						2.0E-09							
				Cm-244	1.3E-10	1.0E+00						1.3E-10							
151	1241	FHE-68	Sample preparation	U-234	1.6E-10	1.0E-03	11.9	0.61	1.4	None	1	1.6E-13	1308	E	1.5E-09	584	WNW	6.5E-09	2
				U-235	2.2E-11	1.0E-03						2.2E-14							
				U-238	1.7E-09	1.0E-03						1.7E-12							
				U-234	1.1E-05	1.0E-06						1.1E-11							
				U-235	5.1E-07	1.0E-06						5.1E-13							
				U-238	1.7E-05	1.0E-06						1.7E-11							
151	1318	FHE-26	Sample preparation	Pu-239	1.0E-09	1.0E-03	11.9	0.46	2.9	None	1	1.0E-12	1308	E	2.0E-10	584	WNW	7.7E-10	2
				Am-241	2.0E-10	1.0E-03						2.0E-13							
				Cm-244	1.0E-10	1.0E-03						1.0E-13							
151	1322	FHE-35	Sample preparation	MFP	2.1E-09	1.0E-03	11.9	0.61	3.5	None	1	2.1E-12	1308	E	2.8E-12	584	WNW	9.4E-12	2
151	1326	FHE-43	Sample preparation	MFP	3.0E-06	1.0E-03	11.9	0.61	3.3	None	1	3.0E-09	1308	E	4.0E-09	584	WNW	1.4E-08	2
				U-233	2.0E-11	1.0E-03						2.0E-14							
				U-233	2.0E-11	1.0E-06						2.0E-17							
				Am-241	2.0E-11	1.0E-03						2.0E-14							
				Am-241	2.0E-11	1.0E-06						2.0E-17							
151	1330	FHE-54	Sample screening/disposal	Gross alpha	2.5E-05	1.0E-03	11.9	0.61	1.9	None	1	2.5E-08	1308	E	3.6E-06	584	WNW	1.4E-05	2
				Gross beta	2.5E-05	1.0E-03						2.5E-08							
151	2107	FHE-63	Transfer of waste samples for analysis	H-3	1.4E-12	1.0E-03	12.5	0.41	7.7	None	1	1.4E-15	1308	E	4.0E-19	584	WNW	8.5E-19	2
151	2117	FHE-23	Preparation of waste samples for analysis	Gross alpha	2.0E-09	1.0E+00	11.9	0.61	2.5	None	1	2.0E-09	1308	E	2.8E-07	584	WNW	1.1E-06	2
				Gross beta	2.0E-09	1.0E+00						2.0E-09							
151	2121	FHE-36	Sample preparation	Gross alpha	2.0E-09	1.0E+00	11.9	0.61	2.8	None	1	2.0E-09	1308	E	2.8E-07	584	WNW	1.0E-06	2
				Gross beta	2.0E-09	1.0E+00						2.0E-09							
151	2125	FHE-37	Chemical analysis	Gross alpha	2.5E-09	1.0E-03	11.9	0.61	2.8	None	1	2.5E-12	1308	E	3.5E-10	584	WNW	1.3E-09	2
				Gross beta	2.5E-09	1.0E-03						2.5E-12							
151	2131	FHE-56	Chemical analysis	Gross alpha	2.5E-09	1.0E-03	11.9	0.61	2.8	None	1	2.5E-12	1308	E	3.5E-10	584	WNW	1.3E-09	2
				Gross beta	2.5E-09	1.0E-03						2.5E-12							
151	2133	FHE-57	Analysis of standards for waste samples; analysis of waste samples; analysis of yield tracers in waste samples	H-3	8.4E-11	1.0E-03	12.5	0.41	7.7	None	1	8.4E-14	1308	E	5.7E-12	584	WNW	1.2E-11	2
				Th-229	8.2E-13	1.0E-03						8.2E-16							
				U-232	8.2E-13	1.0E-03						8.2E-16							
				Pu-242	8.2E-13	1.0E-03						8.2E-16							
				Cm-244	8.2E-13	1.0E-03						8.2E-16							
				Gross alpha	3.2E-11	1.0E-03						3.2E-14							
				Gross beta	3.2E-11	1.0E-03						3.2E-14							
				Gross gamma	3.2E-11	1.0E-03						3.2E-14							

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source Category
													Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	
151	2135	FHE-62	Standards preparation	Pu-239	1.0E-08	1.0E-03	11.9	0.61	3.5	None	1	1.0E-11	1308	E	3.3E-09	584	WNW	1.1E-08	2
				H-3	1.0E-05	1.0E-03						1.0E-08							
				Cs-137	1.0E-08	1.0E-03						1.0E-11							
				Sr-90	1.0E-08	1.0E-03						1.0E-11							
				Eu-152	1.0E-08	1.0E-03						1.0E-11							
				Eu-154	1.0E-08	1.0E-03						1.0E-11							
				Co-60	1.0E-08	1.0E-03						1.0E-11							
				Th-232	1.0E-08	1.0E-03						1.0E-11							
				Ba-133	1.0E-08	1.0E-03						1.0E-11							
				U-238	4.7E-09	1.0E-03						4.7E-12							
				U-235	2.2E-10	1.0E-03						2.2E-13							
				U-234	5.1E-09	1.0E-03						5.1E-12							
151	2143	FHE-63	Transfer of standards for	H-3	7.0E-12	1.0E-03	12.5	0.41	7.7	None	1	7.0E-15	1308	E	2.0E-18	584	WNW	4.3E-18	2
			the analysis of environmental																
			samples; analysis of standards																
			for environmental samples																
151	2147	FHE-67	Transfer of yield tracers for	Pu-239	7.1E-13	1.0E-03	12.5	0.41	7.7	None	1	7.1E-16	1308	E	1.2E-12	584	WNW	2.6E-12	2
			the analysis of environmental	Pu-242	2.1E-12	1.0E-03						2.1E-15							
			samples; analysis of standards	Am-241	2.5E-13	1.0E-03						2.5E-16							
			sample blanks with yield tracers	Am-243	2.9E-12	1.0E-03						2.9E-15							
				Cm-244	8.2E-14	1.0E-03						8.2E-17							
151	2149	FHE-78	Tracers added to environmental	Pu-238	2.0E-14	1.0E-03	11.9	0.61	3.3	None	1	2.0E-17	1308	E	3.1E-13	584	WNW	1.7E-12	2
			samples as yield tracers	Pu-239	4.0E-14	1.0E-03						4.0E-17							
			during analysis	Pu-240	4.0E-14	1.0E-03						4.0E-17							
				Pu-242	3.0E-12	1.0E-03						3.0E-15							
				U-232	1.0E-12	1.0E-03						1.0E-15							
				U-233	9.0E-13	1.0E-03						9.0E-16							
				U-238	4.0E-15	1.0E-03						4.0E-18							
151	2308	FHE-16	Actinide research	Th-232	3.0E-10	1.0E-03	11.9	0.61	2.9	Double HEPA	0.0001	3.0E-17	1308	E	1.4E-09	584	WNW	5.2E-05	2
				Pu-239	1.0E-04	1.0E-03						1.0E-11							
				Pu-242	5.0E-07	1.0E-03						5.0E-14							
151	2312	FHE-21	Actinide research	Pu-242	2.0E-07	1.0E-03	11.9	0.61	2.8	Double HEPA	0.0001	2.0E-14	1308	E	2.8E-09	584	WNW	1.0E-04	2
				U-233	1.6E-08	1.0E-03						1.6E-15							
				Np-237	1.4E-04	1.0E-03						1.4E-11							
151	2318	FHE-30	Sample preparation	Pu-242	6.0E-07	1.0E-03	11.9	0.61	2.8	Double HEPA	0.0001	6.0E-14	1308	E	8.0E-12	584	WNW	2.9E-07	2
151	2322	FHE-31	Chemical leaching experimentation	Gross alpha	1.2E-06	1.0E-03	11.9	0.61	3.4	None	1	1.2E-09	1308	E	1.7E-07	584	WNW	5.8E-07	2
				Gross beta	1.2E-06	1.0E-03						1.2E-09							
151	2326	FHE-39	Chemical analysis of waste	Gross alpha	2.5E-06	1.0E-03	11.9	0.61	2.8	None	1	2.5E-09	1308	E	3.5E-07	584	WNW	1.3E-06	2
				Gross beta	2.5E-06	1.0E-03						2.5E-09							
151	2326A	FHE-40	Preparation of environmental	Gross alpha	1.0E-12	1.0E-03	12.8	0.31	7.0	None	1	1.0E-15	1308	E	1.6E-13	584	WNW	5.8E-13	1
			and waste samples	Gross beta	1.0E-12	1.0E-03						1.0E-15							
				Gross gamma	1.0E-12	1.0E-03						1.0E-15							
151	2330	FHE-55	Analysis of standards for	H-3	2.5E-10	1.0E-03	12.5	0.41	7.7	None	1	2.5E-13	1308	E	7.3E-17	584	WNW	1.5E-16	2
			waste samples; analysis																
			of waste samples																
151	2330	FHE-50	Analysis of yield tracers in	Th-232	2.8E-13	1.0E-03	12.5	0.41	7.7	None	1	2.8E-16	1308	E	1.9E-12	584	WNW	4.6E-12	2
			waste samples; analysis	U-232	2.8E-13	1.0E-03						2.8E-16							
			of waste samples	Pu-242	2.8E-13	1.0E-03						2.8E-16							
				Cm-244	2.8E-13	1.0E-03						2.8E-16							
				Gross alpha	1.1E-11	1.0E-03						1.1E-14							
				Gross beta	1.1E-11	1.0E-03						1.1E-14							
				Gross gamma	1.1E-11	1.0E-03						1.1E-14							
151	2344	FHE-65	Chemical analysis of waste	Gross alpha	2.0E-06	1.0E-03	11.9	0.61	2.8	None	1	2.0E-09	1308	E	2.8E-07	584	WNW	1.0E-06	2
				Gross beta	2.0E-06	1.0E-03						2.0E-09							
151	2348	FHE-75	Freeze trapping/analysis of tritium	H-3	1.5E-13	1	12.8	0.41	8.7	None	1	1.5E-13	1308	E	4.3E-17	584	WNW	1.1E-16	1

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
151	2350	FHE-76	Transfer of tracer solutions	Pu-242	1.2E-12	1.0E-03	12.8	0.41	8.5	None	1	1.2E-15	1308	E	5.4E-12	584	WNW	1.4E-11	1
				Am-243	5.7E-13	1.0E-03						5.7E-16							
				U-233	8.2E-11	1.0E-03						8.2E-14							
				U-232	3.3E-13	1.0E-03						3.3E-16							
				Cs-134	2.4E-12	1.0E-03						2.4E-15							
				Th-229	4.3E-14	1.0E-03						4.3E-17							
				Pu-239	4.2E-14	1.0E-03						4.2E-17							
				Tc-99	5.2E-11	1.0E-03						5.2E-14							
				Po-209	7.3E-13	1.0E-03						7.3E-16							
				Th-230	1.5E-14	1.0E-03						1.5E-17							
				Cs-137	1.3E-13	1.0E-03						1.3E-16							
				Sr-90	4.5E-13	1.0E-03						4.5E-16							
				Am-241	8.6E-14	1.0E-03						8.6E-17							
				U-234	4.2E-13	1.0E-03						4.2E-16							
				U-235	1.8E-14	1.0E-03						1.8E-17							
				U-238	3.9E-13	1.0E-03						3.9E-16							
Building 174 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																			
174	Annex-1401	Room air	Pulse laser experimentation	U-238	9.0E-08	1.0E-06	NA	NA	NA	None	1	9.0E-14	1446	ESE	1.5E-12	480	W	5.4E-11	2
				U-235	1.2E-09	1.0E-06						1.2E-15							
				U-234	8.4E-09	1.0E-06						8.4E-15							
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).																			
*Gross alpha and Gross beta emissions are continuously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions.																			
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 47.)																			
175	103	FFE-02	Cleaning and refurbishment	Gross alpha	*	NA	9.4	0.61	4.5	HEPA	1.0E-02	0.0E+00	**	**	0.0E+00	**	**	**	3
	103	FFE-01	of parts	Gross beta	*	NA	9.4	0.61	4.6			0.0E+00							
	112	FHE-02					6.8	0.36	6.4										
	112	FHE-01					6.7	0.33	6.4										
	128	FHE-2000					8.9	0.59	4.6										
	128	FHE-1000					8.9	0.59	5.2										
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).																			
*Gross alpha and Gross beta emissions are continuously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions.																			
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 47.)																			
177	1000	Room Air	Corrosion studies of liquid	U-238	1.7E-03	1.0E-03	N/A	N/A	N/A	None	1	1.7E-06	1350	ESE	2.1E-04	565	W	5.0E-03	2
			uranium; melting uranium in	U-235	2.7E-05	1.0E-03						2.7E-08							
			crucibles in a vacuum	U-234	6.1E-03	1.0E-03						6.1E-06							
177	1008	Room Air	Corrosion studies of liquid	U-238	1.0E-02	1.0E-03	N/A	N/A	N/A	None	1	1.0E-05	1350	ESE	1.2E-03	565	W	2.9E-02	2
			uranium; preparation of	U-235	1.6E-04	1.0E-03						1.6E-07							
			custom-blended uranium alloys	U-234	3.6E-02	1.0E-03						3.6E-05							
177	1010	FHE-18	Corrosion studies of liquid	U-238	8.3E-04	1.0E-03	9.1	0.36	1.6	HEPA	0.01	8.3E-09	1350	ESE	1.1E-06	565	W	1.7E-03	2
			uranium; preparation of	U-235	1.4E-05	1.0E-03						1.4E-10							
			custom-blended uranium alloys	U-234	3.2E-03	1.0E-03						3.2E-08							
177	1014	FHE-10	Examination/cleaning of apparatus	U-238	3.3E-05	1.0E-03	5.8	0.41	2.4	HEPA	0.01	3.3E-10	1350	ESE	1.8E-08	565	W	3.5E-05	2
			contaminated by uranium; ceramic	U-235	1.5E-06	1.0E-03						1.5E-11							
			processing of uranium oxide powder	U-234	3.5E-05	1.0E-03						3.5E-10							
177	1015	FHE-27	Preparation and examination of	U-238	1.3E-04	1.0E-06	7.9	0.56	12.9	HEPA	0.01	1.3E-12	1350	ESE	5.4E-09	764	NNE	4.1E-06	2
			metallographic samples	U-235	1.2E-05	1.0E-06						1.2E-13							
				U-234	2.4E-02	1.0E-06						2.4E-10							
177	1020	FHE-22	Uranium vaporized under vacuum	Gross alpha	*	NA	6.4	0.30	8.9	HEPA	0.01	0.0E+00	**	**	0.0E+00	**	**	**	3
			in Extractor Test Facility	Gross beta	*	NA						0.0E+00							
177	1021	FHE-24, 25	Sample preparation	U-238	6.6E-04	1.0E-03	11.0	0.41	7.8	HEPA	0.01	6.6E-09	1350	ESE	4.4E-05	611	WNW	2.7E-02	2
				U-235	8.4E-05	1.0E-03						8.4E-10							
				U-234	1.8E-01	1.0E-03						1.8E-06							
177	1024	Room Air	Vaporization of uranium;	U-238	1.7E-07	1.0E+00	N/A	N/A	N/A	None	1	1.7E-07	1350	ESE	2.1E-05	565	W	5.0E-04	2
			investigation of isotope	U-235	2.7E-09	1.0E+00						2.7E-09							
			separation processes	U-234	6.1E-07	1.0E+00						6.1E-07							

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 194 is operated by N-Division for the Physics and Space Technology Directorate. The facility houses a high-energy linear accelerator (LINAC) and research laboratories.																			
The accelerator beam can produce small quantities of short-lived air activation products.																			
194	B122	TE-FE4	Linac accelerator vault	O-15	6.0E-02	1.0E+00	30.5	1.37	4.5	None	1	6.0E-02	1525	SSE	9.4E-06	538	NE	5.3E-04	2
		(Target Exhaust)		N-13	1.1E-01	1.0E+00						1.1E-01							
194	B124	TE-FE4	Storage	Na-22	5.0E-05	1.0E-03						5.0E-08							
				U-233	1.2E-05	1.0E-06						1.2E-11							
				U-234	6.0E-09	1.0E-06						6.0E-15							
				U-235	3.9E-06	1.0E-06						3.9E-12							
				U-236	3.5E-08	1.0E-06						3.5E-14							
				U-238	1.0E-04	1.0E-06						1.0E-10							
	B130	TE-FE4	Positron beam generation	O-15	5.5E-01	1.0E+00				None	1	5.5E-01							
				N-13	1.1E+00	1.0E+00						1.1E+00							
194	1131	Room Air	Positron materials science experiments	Na-22	3.6E-06	1.0E-03	NA	NA	NA	None	1	3.6E-09	1525	ESE	1.3E-09	412	NNE	4.0E-08	2
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	1.7E-02	1.0E-06	4.3	0.5	0.5	None	1	1.7E-08	1278	ENE	6.8E-12	38	SW	2.4E-10	2
212	184	Room Air	Contamination	H-3	1.0E-03	1.0E-06	NA	NA	NA	None	1	1.0E-09	1278	ENE	4.0E-13	38	SW	1.4E-11	2
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 source of radionuclides in Building 222 is from analysis of hazardous-waste samples.																			
222	1106	Room Air	Analysis of waste samples	Gross alpha	3.0E-14	1.0E-03	NA	NA	NA	None	1	3.0E-17	1239	ENE	7.3E-15	191	SSW	1.0E-13	2
				Gross beta	3.0E-13	1.0E-03						3.0E-16							
				Gross gamma	3.0E-13	1.0E-03						3.0E-16							
				H-3	7.5E-13	1.0E-03						7.5E-16							
222	1405	Room Air	Chemical analysis	U-238	4.9E-13	1.0E-03	NA	NA	NA	None	1	4.9E-16	1239	ENE	3.9E-14	191	SSW	5.5E-13	2
				U-235	6.3E-15	1.0E-03						6.3E-18							
				U-234	4.6E-14	1.0E-03						4.6E-17							
				H-3	1.1E-12	1.0E-03						1.1E-15							
222	1427	FHE-2000	Analysis of C-14 labeled materials	C-14	2.8E-13	1.0E+00	10.7	0.84	13.7	None	1	2.8E-13	1239	ENE	5.1E-15	178	S	1.3E-14	2
222	1511B	FHE-113	Chemical analysis	U-234	1.0E-16	1.0E+00	5.5	0.15	5.8	HEPA	0.01	1.0E-18	1239	ENE	1.5E-16	191	SSW	1.2E-13	2
				U-235	4.4E-18	1.0E+00						4.4E-20				253	SW		
				U-238	9.5E-17	1.0E+00						9.5E-19							
222	1511B	Room Air	Preparation of aqueous solutions for analysis	U-238	1.0E-13	1.0E-03	NA	NA	NA	None	1	1.0E-16	1239	ENE	1.6E-14	253	SW	3.5E-13	2
				U-235	4.9E-15	1.0E-03						4.9E-18							
				U-234	1.1E-13	1.0E-03						1.1E-16							
222	1511B		Analysis of aqueous solutions	U-238	1.0E-15	1.0E-03	5.5	0.15	5.7	HEPA	0.01	1.0E-20	1239	ENE	1.6E-18	253	SW	1.7E-15	2
				U-235	4.9E-17	1.0E-03						4.9E-22							
				U-234	1.1E-15	1.0E-03						1.1E-20							
222	1514	Room Air	X-ray fluorescence analysis	U-238	9.9E-11	1.0E-06	NA	NA	NA	None	1	9.9E-17	1239	ENE	8.0E-15	191	SSW	1.1E-13	2
				U-235	1.3E-12	1.0E-06						1.3E-18							
				U-234	9.3E-12	1.0E-06						9.3E-18							
222	1524C	FHE-87	Sample digestion	Gross alpha	2.4E-09	1.0E+00	6.1	0.26	6.7	None	1	2.4E-09	1239	ENE	5.0E-07	191	SSW	3.2E-06	2
				Gross beta	2.4E-09	1.0E+00						2.4E-09				253	SW		
The 231 complex houses research and development activities conducted by the Chemistry and Materials Science Directorate, Engineering, Weapons Engineering, and Safeguards and Security Materials Management Division.																			
Management oversight for Building 231 is provided by the Engineering Directorate through the Engineering Sciences Division.																			
231	1000	FFE-5	Quench furnace operations	U-238	6.3E-06	1	8.2	0.32	7.7	HEPA	0.01	6.3E-08	1167	E	4.8E-06	725	WNW	2.0E-03	1
				U-235	8.2E-08	1						8.2E-10							
				U-234	5.9E-07	1						5.9E-09							
231	1200	Room Air		U-238	7.2E-06	1.0E-06	NA	NA	NA	None	1	7.2E-12	1167	E	5.8E-10	725	WNW	4.4E-09	1
				U-235	9.3E-08	1.0E-06						9.3E-14							
				U-234	6.8E-07	1.0E-06						6.8E-13							
231	1427	Room Air		U-238	4.1E-03	1.0E-06	NA	NA	NA	None	1	4.1E-09	1167	E	2.8E-07	439	SSW	1.4E-06	2
				U-235	5.2E-05	1.0E-06						5.2E-11							
				U-234	3.8E-04	1.0E-06						3.8E-10							

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
231	1600	Room Air		U-238	9.0E-07	1.0E-06	NA	NA	NA	None	1	9.0E-13	1167	E	7.2E-11	725	WNW	5.5E-10	1
				U-235	1.2E-08	1.0E-06						1.2E-14							
				U-234	8.4E-08	1.0E-06						8.4E-14							
231	1737	FGBE-5	Storage area	U-238	1.9E-07	1.0E-06	10.1	0.46	1.5	HEPA	0.01	1.9E-15	1167	E	1.2E-13	725	WNW	4.4E-11	2
				U-235	2.5E-09	1.0E-06						2.5E-17							
				U-234	1.8E-08	1.0E-06						1.8E-16							
231	1737A	FHE-54	Electron beam welding	U-238	3.6E-05	1.0E-06	10.1	0.46	1.5	HEPA	0.01	3.6E-13	1167	E	2.3E-11	725	WNW	8.1E-09	2
				U-235	4.5E-07	1.0E-06						4.5E-15							
				U-234	3.3E-06	1.0E-06						3.3E-14							
				U-238	9.4E-11	1.0E-03						9.4E-16							
				U-235	1.2E-12	1.0E-03						1.2E-17							
				U-234	8.8E-12	1.0E-03						8.8E-17							
231	1739	FGBE-5		U-238	1.6E-01	1.0E-06	10.1	0.46	11.5	HEPA	0.01	1.6E-09	1167	E	1.1E-09	725	WNW	1.9E-07	1
				U-235	2.0E-03	1.0E-06						2.0E-11							
				U-234	1.5E-02	1.0E-06						1.5E-10							
231	1841	Room Air	Measurements on solid uranium	U-234	2.6E-04	1.0E-06	NA	NA	NA	None	1	2.6E-10	1167	E	2.1E-08	568	W	1.2E-07	2
				U-235	3.3E-06	1.0E-06						3.3E-12				439	SSW		
				U-238	2.4E-07	1.0E-06						2.4E-13				404	S		
231	1900HB	FGBE-7/8	Storage	U-234	4.9E-06	1.0E-06	2.4	0.20	14.4	None	1	4.9E-12	1167	E	3.3E-10	725	WNW	1.4E-09	2
				U-235	6.3E-08	1.0E-06						6.3E-14				671	W		
				U-238	3.0E-07	1.0E-06						3.0E-13				439	SSW		
231	1944	FHE-42	Metal processing	U-234	1.9E-10	1.0E-06	2.4	0.36	40.4	HEPA	0.01	1.9E-18	1167	E	1.2E-15	439	SSW	2.4E-13	2
				U-235	2.6E-11	1.0E-06						2.6E-19							
				U-238	2.0E-09	1.0E-06						2.0E-17							
231	1945	FHE-40	Metal characterization	U-234	1.9E-10	1.0E-06	10.7	0.36	3.8	None	1	1.9E-16	1167	E	1.3E-13	725	WNW	4.1E-13	2
				U-235	2.6E-11	1.0E-06						2.6E-17							
				U-238	2.0E-09	1.0E-06						2.0E-15							
231	1945A	Room Air	Metal characterization	U-234	1.9E-13	1.0E-06	NA	NA	NA	None	1	1.9E-19	1167	E	1.4E-16	439	SSW	6.6E-16	2
				U-235	2.6E-14	1.0E-06						2.6E-20							
				U-238	2.0E-12	1.0E-06						2.0E-18							
231	1945B	FHE-40	Metal characterization	U-234	1.3E-10	1.0E-03	10.0	0.41	4.6	None	1	1.3E-13	1167	E	9.0E-11	725	WNW	2.8E-10	2
				U-235	1.7E-11	1.0E-03						1.7E-14							
				U-238	1.4E-09	1.0E-03						1.4E-12							
				U-234	3.7E-09	1.0E-06						3.7E-15							
				U-235	5.1E-10	1.0E-06						5.1E-16							
				U-238	4.0E-08	1.0E-06						4.0E-14							
231	1945C	Room Air	Metal characterization	U-234	1.9E-13	1.0E-06	NA	NA	NA	None	1	1.9E-19	1167	E	1.4E-16	439	SSW	6.6E-16	2
				U-235	2.6E-14	1.0E-06						2.6E-20							
				U-238	2.0E-12	1.0E-06						2.0E-18							
231	1945D	Room Air	Metal polishing	U-234	1.9E-10	1.0E-06	NA	NA	NA	None	1	1.9E-16	1167	E	1.4E-13	439	SSW	6.6E-13	2
				U-235	2.6E-11	1.0E-06						2.6E-17							
				U-238	2.0E-09	1.0E-06						2.0E-15							
231	1945E	Room Air	Wet grinding/polishing	U-234	1.9E-07	1.0E-03	NA	NA	NA	None	1	1.9E-10	1167	E	1.4E-07	439	SSW	6.6E-07	2
				U-235	2.6E-08	1.0E-03						2.6E-11							
				U-238	2.0E-06	1.0E-03						2.0E-09							
231	1950	FHE-43	Metal casting	U-234	9.3E-06	1.0E-06	9.5	0.40	12.6	HEPA	0.01	9.3E-14	1167	E	6.2E-11	725	WNW	1.3E-08	2
				U-235	1.3E-06	1.0E-06						1.3E-14							
				U-238	1.0E-04	1.0E-06						1.0E-12							
231	2730	Room Air	Measurements on solid uranium	U-234	8.4E-07	1.0E-06	NA	NA	NA	None	1	8.4E-13	1167	E	7.2E-10	725	WNW	5.5E-09	1
				U-235	1.2E-07	1.0E-06						1.2E-13							
				U-238	9.0E-06	1.0E-06						9.0E-12							
Building 235 is part of the Chemistry and Materials Sciences Directorate. Operations in the facility include examination of material structure, surface, and subsurface; precision cutting, ion implanting, and metallurgical studies.																			
Most of the depleted uranium in this building is there for characterization studies; some is used for ion beam implantation experiments.																			
235	1131	FHE-1A,1B (HDCH-6,7)	Metallographic sample preparation	U-234	1.0E-08	1.0E-06	10.7	2.75	14.3	HEPA	0.01	1.0E-16	1065	ENE	6.7E-14	1541	NE	5.9E-12	2
				U-235	1.5E-09	1.0E-06						1.5E-17				1184	ENE		
				U-238	1.2E-07	1.0E-06						1.2E-15							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
235	1133	Room Air	Microstructure examination	U-234	2.8E-09	1.0E-06	NA	NA	NA	None	1	2.8E-15	1065	ENE	3.1E-12	473	SSW	9.0E-12	2
				U-235	3.8E-10	1.0E-06						3.8E-16							
				U-238	3.0E-08	1.0E-06						3.0E-14							
235	1138	FHE-2A,2B/HD-13	Sample preparation	U-234	6.8E-09	1.0E-06	10.7	2.75	14.3	HEPA	0.01	6.8E-17	1065	ENE	4.2E-14	1541	NE	3.7E-12	2
				U-235	9.4E-10	1.0E-06						9.4E-18							
				U-238	7.3E-08	1.0E-06						7.3E-16							
Building 241 is administered by the Chemistry and Material Sciences Directorate for material properties research and testing.																			
241	1616	Room Air	Size analysis of powders	U-234	7.6E-11	1.0E-03	NA	NA	NA	None	1	7.6E-14	1140	ENE	1.2E-11	754	WNW	8.1E-11	1
				U-235	3.3E-12	1.0E-03						3.3E-15							
				U-238	7.1E-11	1.0E-03						7.1E-14							
241	1678	FHE-55	Research and development	U-234	6.4E-05	1.0E-03	7.6	0.31	9.2	HEPA	0.01	6.4E-10	1140	E	9.7E-08	754	WNW	3.6E-05	1
			of methods for plutonium	U-235	2.8E-06	1.0E-03						2.8E-11							
			immobilization	U-238	6.0E-05	1.0E-03						6.0E-10							
				U-234	4.0E-10	1.0E-06						4.0E-18							
				U-235	1.8E-11	1.0E-06						1.8E-19							
				U-238	3.8E-10	1.0E-06						3.8E-18							
241	1678	FHE-32	Sintering of uranium oxide disks	U-234	1.9E-11	1	6.4	0.23	8.1	None	1	1.9E-11	1140	E	2.9E-09	754	WNW	1.5E-08	1
				U-235	8.4E-13	1						8.4E-13							
				U-238	1.8E-11	1						1.8E-11							
241	1686	FHE-9	Synthesis of organometallic	U-234	1.1E-12	1	6.1	0.43	4.8	None	1	1.1E-12	1140	E	1.7E-10	754	WNW	9.3E-10	1
			complexes of uranium	U-235	1.5E-14	1						1.5E-14							
				U-238	1.1E-12	1						1.1E-12							
				U-234	5.3E-12	1.0E-03						5.3E-15							
				U-235	7.3E-14	1.0E-03						7.3E-17							
				U-238	5.7E-12	1.0E-03						5.7E-15							
241	1826	Room Air	X-ray analysis	U-234	9.0E-10	1.0E-06	NA	NA	NA	None	1	9.0E-16	1140	E	1.2E-13	697	W	5.3E-13	2
				U-235	4.0E-11	1.0E-06						4.0E-17							
				U-238	8.5E-10	1.0E-06						8.5E-16							
241	1838	FGBE-9 &10	Ceramic waste form	U-234	7.1E-09	1	12.2	0.46	1.6	HEPA	0.01	7.1E-11	1140	E	8.9E-09	754	WNW	2.7E-06	2
			research	U-235	3.1E-10	1						3.1E-12							
				U-238	6.6E-09	1						6.6E-11							
241	1838	FHE-6	Ceramic waste form	U-234	1.4E-06	1.0E-03	6.4	0.54	5.8	None	1	1.4E-09	1140	E	1.8E-07	754	WNW	5.7E-07	2
			research	U-235	6.2E-08	1.0E-03						6.2E-11							
				U-238	1.3E-06	1.0E-03						1.3E-09							
241	1886	Room Air	Hybridization studies with nucleic	P-32	6.3E-08	1.0E-03	NA	NA	NA	None	1	6.3E-11	1140	E	1.6E-12	754	WNW	1.1E-11	1
			with nucleic acids from soil bacteria																
Building 251, the Heavy Element Facility, is managed by the Physics and Space Technology Directorate for the Institutions as a standby, non-operational facility in which transuranic isotopes are stored until they can be disposed.																			
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 unhardened area, also HEPA filtered, are continuously sampled by simple filter systems.																			
*Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding; measured emissions, rather than the inventory approach, are used to determine annual emissions.																			
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 47.)																			
	Unhardened Area*																		
251	1234	CD-01	Out of service	Gross alpha	*	NA	6.8	0.35	5.8	HEPA	0.01	3.7E-09	1185	E	8.8E-07	**	**	**	3
				Gross beta								6.8E-08							
251		FHE-16	Out of service	Gross alpha	*	NA	6.4	0.31	5.4	HEPA	0.01	1.7E-08	1185	E	2.8E-06	713	WNW	1.6E-05	7
				Gross beta								9.4E-08							
	Unhardened Area*																		
251	1003	FHE-5	General chemistry	Gross alpha	*	NA	4.3	0.26	8.6	HEPA	0.01	0.0E+00	1188	E	0.0E+00	**	**	**	3
	1003	FHE-4		Gross beta			4.3	0.27	4.2			0.0E+00							
	1117	FGBE-21,22					5.5	0.11	7.6										
	1117	FGBE-25,26					8.5	0.10	12.8										
	1117	FGBE-23,24																	
	1142	FHE-8					4.3	0.32	4.1										
	1142	FHE-9					4.3	0.26	5.1										
	1142	FHE-10					4.3	0.28	13.7										
	1150	FGBE-33,34					8.0	0.15	12.8										
	1150	FFE-15					4.3	0.31	7.6										
	1165	FGBE-31,32					5.5	0.87	0.1										
	1211	FHE-6					6.4	0.25	8.0										
	1211	FHE-7					6.4	0.25	4.3										

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source Category
													Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	
251	1212	FGBE-15,16					5.5	0.10	8.0										
(cont'd)	1219	FGBE-27,28					10.5	0.15	3.3										
	1232	FGBE-38,39					7.2	0.15	5.1										
	1234	FFE-9					4.3	0.19	14.7										
	1235	FFE-12					4.3	0.25	7.6										
	1235	FGBE-29,30					5.5	0.13	7.1										
	1363	FGBE-35,36					4.3	0.13	11.2										
	1363	FHE-12					4.3	0.32	9.1										
	1363	FHE-13					6.4	0.28	6.8										
	1364	FFE-23					4.3	0.34	9.1										
	1314, 1354	FGBE-44,45					10.2	0.15	10.2										
	Hot cells	FGBE-40,41					5.5	0.23	5.6										
	Hot cells	FGBE-42,43					5.5	0.36	12.7										
		FFE-13					5.5	0.28	4.1										
	Hardened Area																		
251	Glove Boxes*	FGBE-1000	Previous transuranic research	Gross alpha	*	NA	7.8	0.30	4.8	Triple HEPA	0.000001	0.0E+00	1188	E	0.0E+00	**	**	**	3
		FGBE-2000		Gross beta			7.8	0.30	4.8			0.0E+00							
	Room Exhaust*	FFE-1000		Gross alpha	*	NA	7.8	0.50	11.7	Double HEPA	0.0001	0.0E+00	1188	E	0.0E+00	**	**	**	3
		FFE-2000		Gross beta			7.8	0.50	11.7			0.0E+00							
Building 253 houses the Hazards Control Department, and the facility includes laboratories for the chemical analysis and counting of radioactive samples.																			
253	1734	Room Air	Distillation of environmental	H-3	9.9E-10	1.0E+00	NA	NA	NA	None	1	9.9E-10	1122	ESE	2.0E-10	736	W	2.1E-09	2
			samples	Pu-239	2.8E-12	1.0E+00						2.8E-12				798	WNW		
				Sr-90	1.2E-11	1.0E+00						1.2E-11							
253	1734	FGBE-1,2	Sieve soil samples	Pu-239	2.7E-10	1.0E-06	6.1	0.10	23.6	HEPA	0.01	2.7E-18	1122	ESE	1.8E-16	736	W	1.6E-13	2
				Sr-90	4.6E-10	1.0E-06						4.6E-18				798	WNW		
253	1734	FHE-2	Samples and standards plating	Cs-137	1.7E-11	1.0E+00	6.4	0.30	8.7	None	1	1.7E-11	1122	ESE	9.3E-10	798	WNW	8.2E-09	2
				Th-230	2.2E-12	1.0E+00						2.2E-12							
				Pu-239	1.2E-11	1.0E+00						1.2E-11							
				Sr-90	1.7E-12	1.0E+00						1.7E-12							
				Y-90	7.8E-13	1.0E+00						7.8E-13							
				Np-237	6.4E-13	1.0E+00						6.4E-13							
				H-3	4.3E-12	1.0E+00						4.3E-12							
253	1734	FHE-4	Quality control sample	H-3	2.2E-14	1.0E+00	6.4	0.30	9.4	None	1	2.2E-14	1122	ESE	7.9E-10	798	WNW	6.8E-09	2
				Cs-137	3.8E-12	1.0E+00						3.8E-12							
				Th-230	6.3E-13	1.0E+00						6.3E-13							
				Pu-239	7.5E-12	1.0E+00						7.5E-12							
				Gross alpha	1.4E-13	1.0E+00						1.4E-13							
				Gross beta	2.1E-13	1.0E+00						2.1E-13							
253	1734	FHE-11	Acid digestion for	H-3	6.8E-09	1.0E+00	10.4	0.30	12.3	None	1	6.8E-09	1122	ESE	3.3E-09	798	WNW	2.2E-08	2
			sample analysis	Pu-239	5.3E-11	1.0E+00						5.3E-11							
				Sr-90	2.6E-10	1.0E+00						2.6E-10							
				Y-90	2.6E-12	1.0E+00						2.6E-12							
				Np-237	3.1E-12	1.0E+00						3.1E-12							
253	1910	FHE-22	Preparations of calibration	H-3	3.0E-11	1.0E-03	7.0	0.20	5.2	None	1	3.0E-14	1122	ESE	1.3E-15	736	W	1.2E-14	2
			standards	C-14	1.5E-11	1.0E-03						1.5E-14				798	WNW		
				P-32	1.5E-10	1.0E-03						1.5E-13							
Building 254 is run by Hazards Control for the purpose of conducting bioassays and providing analytical services.																			
254	106	Room Air	Analysis of urine for	U-238	2.5E-16	1.0E-03	NA	NA	NA	None	1	2.5E-19	1032	E	2.2E-17	817	W	7.5E-17	2
			radionuclides	U-235	1.8E-18	1.0E-03						1.8E-21							
				U-234	1.3E-20	1.0E-03						1.3E-23							
254	108	FHE-1000	Analysis of urine for	Am-243	1.3E-17	1.0E-03	8.2	1.07	5.3	None	1	1.3E-20	1032	E	1.1E-16	817	W	1.6E-16	2
			radionuclides	Pu-242	1.6E-16	1.0E-03						1.6E-19							
				Pu-239	2.6E-17	1.0E-03						2.6E-20							
				H-3	1.4E-14	1.0E-03						1.4E-17							
				Sr-90	3.1E-14	1.0E-03						3.1E-17							
				Y-90	3.1E-14	1.0E-03						3.1E-17							
254	110	FHE-1000	Analysis of urine for	Am-241	8.2E-19	1.0E-03	8.2	1.07	5.3	None	1	8.2E-22	1032	E	1.9E-13	817	W	6.4E-13	2
			radionuclides	Am-243	2.3E-17	1.0E-03						2.3E-20				849	WNW		
				Cm-244	8.7E-16	1.0E-03						8.7E-19							
				Np-237	1.1E-15	1.0E-03						1.1E-18							
				Th-230	8.9E-17	1.0E-03						8.9E-20							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 254 (continued)				Cf-252	8.0E-17	1.0E-03						8.0E-20							
				U-233	2.7E-19	1.0E-03						2.7E-22							
				U-234	1.1E-17	1.0E-03						1.1E-20							
				U-235	2.7E-19	1.0E-03						2.7E-22							
				U-236	8.4E-17	1.0E-03						8.4E-20							
				U-238	6.3E-21	1.0E-03						6.3E-24							
				Mixed gamma	1.4E-11	1.0E-03						1.4E-14							
				Cf-249	6.7E-13	1.0E-03						6.7E-16							
				U-232	6.4E-13	1.0E-03						6.4E-16							
				Po-209	7.3E-14	1.0E-03						7.3E-17							
Building 255 is operated by Hazards Control and houses a radiation calibration and standards laboratory. Many operations involve the use of sealed sources.																			
255	165	FHE-4	Analysis of urine for radionuclides	Am-241	3.8E-15	1.0E-03	6.9	0.30	5.1	None	1	3.8E-18	1056	E	7.4E-12	790	W	1.3E-11	2
				Am-243	1.9E-14	1.0E-03						1.9E-17							
				Cm-244	3.8E-14	1.0E-03						3.8E-17							
				I-125	2.3E-09	1.0E-03						2.3E-12							
				I-131	7.2E-09	1.0E-03						7.2E-12							
				Np-237	5.7E-14	1.0E-03						5.7E-17							
				Pu-239	1.9E-14	1.0E-03						1.9E-17							
				Pu-242	1.9E-15	1.0E-03						1.9E-18							
				Th-230	5.7E-14	1.0E-03						5.7E-17							
				Th-232	1.0E-16	1.0E-03						1.0E-19							
				U-233	1.0E-11	1.0E-03						1.0E-14							
				U-238	1.3E-16	1.0E-03						1.3E-19							
255	180	FHE-2	Tritium gas monitor calibrations	H-3	2.5E-02	1.0E+00	8.1	0.31	5.2	None	1	2.5E-02	1056	E	9.8E-06	855	WNW	2.5E-05	2
Building 281 is part of the Chemistry and Materials Sciences Directorate. In rooms 1311 and 1319, there are a number of sources, both as solids and in solution, which are kept and used in glove boxes. 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 tritiated water.																			
281	1174	FHE-13	Tracer work	C-14	3.0E-06	1.0E-03	6.7	0.30	6.1	None	1	3.0E-09	1332	ESE	1.8E-11	579	NNE	2.9E-10	2
281	1307	FHE-6	Tracer work	Ni-63	1.0E-06	1.0E-03	6.4	0.61	2.7	None	1	1.0E-09	1332	ESE	1.7E-12	579	NNE	2.8E-11	2
				Ni-59	3.5E-10	1.0E-03						3.5E-13							
281	1311	FHE-12	Sample preparation	U-233	4.5E-11	1.0E-03	6.1	0.41	4.0	None	1	4.5E-14	1332	ESE	8.6E-13	579	NNE	1.5E-11	2
281	1311A	FHE-3	Sample preparation	Th-232	2.5E-10	1.0E-03	4.9	0.25	10.3	None	1	2.5E-13	1332	ESE	4.9E-10	579	NNE	8.5E-09	2
				Pu-242	1.0E-08	1.0E-03						1.0E-11							
281	1311B	FHE-3	Sample preparation	Pu-242	4.0E-08	1.0E-03	4.9	0.25	10.3	Double HEPA	0.0001	4.0E-15	1332	ESE	1.9E-13	579	NNE	3.3E-08	2
281	1319	FHE-1	Sample preparation	Th-232	3.0E-10	1.0E-03	5.2	0.28	9.2	Double HEPA	0.0001	3.0E-17	1332	ESE	4.9E-10	579	NNE	8.5E-05	2
				Np-237	7.0E-05	1.0E-03						7.0E-12							
				Pu-242	5.0E-07	1.0E-03						5.0E-14							
281	1322	FHE-1	Radioactivity migration studies	U-233	2.7E-09	1.0E-03	6.7	0.30	6.1	None	1	2.7E-12	1332	ESE	1.6E-09	579	NNE	2.6E-08	2
				Np-237	2.2E-08	1.0E-03						2.2E-11							
Building 282 is administered by the Physics and Space Directorate. Residual contamination exists in the facility from past operations.																			
282	1000	Room Air	Contamination	H-3	4.0E-06	1.0E-03	NA	NA	NA	None	1	4.0E-09	1332	ESE	6.2E-13	579	NNE	8.5E-12	2
Building 292 is administered by the Environmental Programs Directorate. Residual contamination exists throughout the facility from the past operation of a rotating target neutron source, that is no longer in operation. Also, neutrino mass experiments have not been conducted since 1993.																			
292	1200,1202	Room Air	Contamination	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	ESE	1.8E-07	456	N	4.6E-06	2
292	1204	Room Air	Contamination	H-3	2.3E+01	1.0E-03	NA	NA	NA	None	1	2.3E-02	1380	ESE	2.3E-06	456	N	5.9E-05	2
292	1402, 1402A	Room Air	Contamination	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	ESE	1.8E-07	456	N	4.6E-06	2
	1404, 1406																		
	1407																		
Building 298 is part of the Laser Fusion Program. Small amounts of tritium are used in this facility in conjunction with fusion target research and development.																			
298	185	FEV-1	Laser cutting	U-238	9.0E-05	1.0E-06	6.5	0.63	15.0	HEPA	0.01	9.0E-13	1398	SE	1.1E-11	344	NE	5.8E-08	2
				U-235	1.2E-06	1.0E-06						1.2E-14							
				U-234	8.4E-06	1.0E-06						8.4E-14							
298	189	FHE-14	Laser fusion target coating	U-238	4.5E-04	1.0E-06	6.4	0.63	15.1	HEPA	0.01	4.5E-12	1398	SE	5.3E-11	344	NE	2.9E-07	2
				U-235	6.0E-06	1.0E-06						6.0E-14							
				U-234	4.2E-05	1.0E-06						4.2E-13							

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
298	Various	Room Air	Laser fusion target research and development	H-3	4.0E-02	1.0E+00	NA	NA	NA	None	1	4.0E-02	1398	SE	3.5E-06	264	NNE	2.7E-04	2
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 and machining of depleted uranium.																			
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 amount of depleted uranium that is handled depends on programmatic demands and varies from month to month. NOTE: Machining only occurs in 321C.																			
**Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.																			
321A	1001A	FHE-24	Machining and manufacturing	U-234	7.5E-04	1.0E-06	3.7	0.46	2.9	HEPA	0.01	7.5E-12	1032	ENE	8.90E-09	252	SSW	5.2E-06	2
				U-235	1.0E-04	1.0E-06						1.0E-12							
				U-238	8.1E-03	1.0E-06						8.1E-11							
321C	234B	FHE-13	Lapping of DU metal	U-238	1.6E-04	1.0E-06	10.7	0.49	2.5	None	1	1.6E-10	1032	ENE	1.50E-08	326	SW	3.8E-08	2
				U-235	2.0E-06	1.0E-06						2.0E-12							
				U-234	9.4E-06	1.0E-06						9.4E-12							
321C	Various**	FHE-9	Machining and manufacturing	U-234	3.2E+00	1.0E-06	8.5	0.31	16.1	HEPA	0.01	3.2E-08	1032	ENE	3.1E-08	252	SSW	6.4E-06	2
		FHE-11		U-235	4.0E-02	1.0E-06	12.5	0.60	6.0	HEPA	0.01	4.0E-10							
		FHE-15		U-238	3.0E-01	1.0E-06	11.2	0.23	13.4	HEPA	0.01	3.0E-09							
		FEV-1000					11.3	0.83	6.5	HEPA	0.01								
Building 322 is operated by the Mechanical Engineering Department.																			
322	109	FHE-1	Cleaning and plating of depleted uranium	U-234	3.1E-07	1.0E-06	7.9	0.35	1.0	None	1	3.1E-13	930	ENE	4.3E-10	316	SSW	1.1E-09	2
				U-235	4.3E-08	1.0E-06						4.3E-14							
				U-238	3.3E-06	1.0E-06						3.3E-12							
Building 327 is operated by the Mechanical Engineering Department.																			
327	1275	Room Air	Non-destructive ultrasonic material evaluation	U-234	1.3E-05	1.0E-06	NA	NA	NA	None	1	1.3E-11	1018	ENE	1.6E-08	321	SSW	7.5E-08	2
				U-235	1.9E-06	1.0E-06						1.9E-12							
				U-238	1.4E-04	1.0E-06						1.4E-10							
Building 331 is operated by the Defense and Nuclear Technologies Directorate. The building houses the tritium research facility and associated laboratories.																			
*Tritium HT and HTO emissions from the two 30-m stacks are continuously monitored in compliance with NESHAPs regulations. Monitoring data, rather than the inventory approach, are used to determine emissions.																			
**Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.																			
***Calculated dose of 8.8E-02 mrem includes modeling the HT emissions as HTO, as directed by U.S. EPA, Region IX. This dose is unduly conservative. The dose from HTO emissions alone is 6.7E-02 mrem. See discussion on page 11.																			
331	All**	Stack 1	Tritium research and development	H-3	*	1.0E+00	30.0	1.22	7.6	None	1	5.7E+00	957	ENE	8.8E-02	957	ENE	8.8E-02	3
		Stack 2	Decontamination of parts	H-3	*	1.0E+00	30.0	1.22	10.5	None	1	2.7E+02			6.7E-02 ***			6.7E-02 ***	
Building 332 is operated by the Defense Sciences Program for plutonium research. Exhausts from glove box operations and the workplace are triply filtered by high efficiency particulate air (HEPA) filters. Exhausts are monitored with both continuous filter sampling (PAMs) and plutonium-specific, continuous real-time monitors (CAMs).																			
*Because building plutonium inventory and the plutonium associated with specific tasks is classified, the standard NESHAPs approach, based on inventory, cannot be utilized without classifying this report. The air monitoring data for all emission points show no detectable released plutonium activity, i.e. at or below the limit of sensitivity of the analytical analysis.																			
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 47.)																			
332	Increment 1 Rooms	FHE-1000/2000	Plutonium research	Transuranics	*	NA	8.8	0.8x1.1	17.3	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	**	**	**	3
332	Increment 1 Glove boxes	FGBE-1000/2000	Plutonium research	Transuranics	*	NA	11	0.3	6.9	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	**	**	**	3
332	Downdraft	FHE-4/5	Plutonium research	Transuranics	*	NA	11	0.2	14.2	Double HEPA	0.0001	0.0E+00	912	ENE	0.0E+00	**	**	**	3
332	Loft	FE-4	Plutonium research	Transuranics	*	NA	11	0.6x0.9	4.6	HEPA	0.01	0.0E+00	912	ENE	0.0E+00	**	**	**	3
		FE-5	Plutonium research	Transuranics	*	NA	11	0.6x0.9	4.6	HEPA	0.01	0.0E+00	912	ENE	0.0E+00	**	**	**	3
332	Increment 1 Glove boxes	FGBE-3000/4000	Plutonium research	Transuranics	*	NA	11	0.3	2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	**	**	**	3
332	Increment 3 Room and Glove boxes	FFE-1000/2000 FGBE-7000/8000	Plutonium research	Transuranics	*	NA	10.1	0.9	12.2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	**	**	**	3
The research complex for the Biology and Biotechnology Research Directorate includes Buildings 361, 362, 363, 364, 365, 366 and 377. Building 365 contains small amounts of tritium, carbon-14 and sulfur-35 used in animal research, and incorporated in animal carcasses stored frozen pending disposal. The building air is filtered through 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, phosphorous-32, phosphorous-33, and sulfur-35, mostly incorporated as constituent atoms (tracers) in organic compounds.																			
361	1020	FHE-5	DNA hybridization	P-32	2.0E-03	1.0E-03	1.7	0.41	0.5	None	1	2.0E-06	919	ESE	2.2E-08	976	W	9.6E-08	2
361	1137	FHE-26	Drying gels from DNA labeling	P-32	1.0E-09	1.0E-03	6.2	0.42	2.5	None	1	1.0E-12	919	ESE	1.1E-14	1047	WNW	4.9E-14	2

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Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source Category
													Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	
361	1238	Room Air	P-32 Labeling	P-32	8.0E-05	1.0E-03	NA	NA	NA	None	1	8.0E-08	919	ESE	1.2E-09	1047	WNW	7.4E-09	1
361	1242	FHE-24	P-32 Labeling	P-32	2.5E-06	1.0E-03	1.7	0.41	0.5	None	1	2.5E-09	919	ESE	2.8E-11	976	W	1.2E-10	2
361	1245	FHE-20,21	Human Genome	P-32	4.0E-02	1.0E-03	1.7	0.41	0.5	None	1	4.0E-05	919	ESE	4.5E-07	976	W	1.9E-06	2
361	1345	Room Air	Radiolabeling and hybridization	P-32	1.0E-02	1.0E-03	NA	NA	NA	None	1	1.0E-05	919	ESE	1.1E-07	976	W	5.0E-07	2
361	1446	FHE-15	Radiolabeling of DNA substrates	P-32	2.0E-03	1.0E-03	6.2	0.42	1.7	None	1	2.0E-06	919	ESE	2.7E-08	976	W	1.2E-07	2
				S-35	1.0E-03	1.0E-03						1.0E-06				1047	WNW		
361	1542	FHE-12	Hybridization and enzyme assay	P-32	2.5E-06	1.0E-03	7.0	0.41	4.4	None	1	2.5E-09	919	ESE	2.6E-11	1047	WNW	1.2E-10	2
361	1546	FHE-10	DNA protein interaction studies	P-32	4.0E-03	1.0E-03	1.7	0.41	0.5	None	1	4.0E-06	919	ESE	4.5E-08	1047	WNW	1.9E-07	2
361	1642	FHE-11	DNA labeling	P-32	2.5E-06	1.0E-03	7.0	0.41	4.4	None	1	2.5E-09	919	ESE	2.6E-11	1047	WNW	1.2E-10	2
361	1649	FHE-4	DNA hybridization	P-33	5.0E-04	1.0E-03	7.0	0.41	4.4	None	1	5.0E-07	919	ESE	2.2E-07	1047	WNW	9.4E-07	2
				P-32	2.0E-02	1.0E-03						2.0E-05							
361	1650	Room Air	Gel electrophoresis	P-32	1.0E-03	1.0E-03	NA	NA	NA	None	1	1.0E-06	919	ESE	1.1E-08	976	W	5.0E-08	2
361	1742	FHE-8	DNA hybridization	P-32	2.0E-02	1.0E-03	7.0	0.41	4.4	None	1	2.0E-05	919	ESE	2.1E-07	1047	WNW	9.2E-07	2
361	1846	Room Air	Human genome research	P-32	4.0E-02	1.0E-03	NA	NA	NA	None	1	4.0E-05	919	ESE	4.6E-07	1047	WNW	2.0E-06	2
Building 362																			
362	105	FHE-1000	Compound purification by HPLC	H-3	1.0E-03	1.0E-03	6.8	0.65	2.7	None	1	1.0E-06	996	ESE	9.5E-09	954	WNW	5.7E-08	2
				C-14	1.0E-03	1.0E-03						1.0E-06							
362	106	FHE-1000	Characterization of	C-14	1.0E-07	1.0E-03	6.8	0.65	2.7	None	1	1.0E-10	996	ESE	7.6E-10	954	WNW	4.5E-09	2
			metabolic pathways	H-3	5.0E-03	1.0E-03						5.0E-06				882	W		
Building 363																			
363	1005	FHE-1	Labeling of biological materials	P-32	7.7E-05	1.0E-03	6.5	0.25	18.6	HEPA	0.01	7.7E-10	918	ESE	9.6E-12	1047	WNW	4.2E-09	1
363	1008	FHE-3000	Rotary evaporation	C-14	1.0E-09	1.0E-03	7.6	0.41	6.5	HEPA	0.01	1.0E-14	996	ESE	8.8E-17	954	WNW	5.0E-14	2
363	1009	FHE-2000	Human urine sample project	H-3	1.0E-09	1.0E-03	1.7	0.41	0.4	HEPA	0.01	1.0E-14	996	ESE	1.0E-16	882	W	7.3E-14	2
				C-14	1.0E-09	1.0E-03						1.0E-14							
363	1010	Room Air	HPLC analysis	H-3	1.0E-09	1.0E-03	NA	NA	NA	None	1	1.0E-12	996	ESE	1.1E-14	882	W	6.9E-14	2
				C-14	1.0E-09	1.0E-03						1.0E-12							
363	1001	FHE-1	Isotopic labeling	P-32	7.7E-05	1.0E-03	6.5	0.25	18.5	HEPA	0.01	7.7E-10	919	ESE	6.4E-10	1047	WNW	2.7E-09	1
Building 364																			
364	1507	Room Air	DNA labeling	P-32	5.0E-03	1.0E-03	NA	NA	NA	None	1	5.0E-06	919	ESE	4.9E-08	893	W	2.9E-07	2
364	1509	FHE-02P	AMS sample preparation	H-3	5.5E-14	1.0E+00	5.5	0.52	2.9	None	1	5.5E-14	919	ESE	9.8E-09	976	W	4.8E-08	2
				C-14	5.5E-07	1.0E+00													
364	1509A	Room Air	AMS sample preparation	H-3	5.5E-14	1.0E+00	NA	NA	NA	None	1	5.5E-14	919	ESE	9.2E-09	976	W	4.2E-08	2
				C-14	5.5E-07	1.0E+00													
364	1519	Room Air	DNA and protein extraction	C-14	5.0E-04	1.0E-03	NA	NA	NA	None	1	5.0E-07	919	ESE	5.3E-09	893	W	3.4E-08	2
				H-3	5.0E-04	1.0E-03						5.0E-07							
Building 365																			
365	104	FHE-1000	Equipment decontamination	C-14	1.0E-07	1.0E-03	6.1	0.58	7.2	HEPA	0.01	1.0E-12	996	ESE	8.7E-15	894	NNE	4.7E-12	2
				H-3	1.0E-07	1.0E-03						1.0E-12							
365	107	Room Air	Animal research	C-14	1.3E-04	1.0E-03	NA	NA	NA	None	1	1.3E-07	996	ESE	1.4E-09	902	W	8.5E-09	2
				H-3	5.0E-07	1.0E-03						5.0E-10							
365	109	FHE-5	Animal housing	C-14	1.3E-04	1.0E-03	1.7	0.41	0.6	Double HEPA	0.0001	1.3E-11	996	ESE	1.4E-13	902	W	8.9E-09	2
				H-3	5.0E-07	1.0E-03						5.0E-14							
Building 366																			
366	110	Room Air	DNA labeling	P-32	5.0E-04	1.0E-03	NA	NA	NA	None	1	5.0E-07	902	ESE	5.9E-09	901	NNE	2.6E-08	2

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Building 381 is part of the Laser Fusion Program. Small quantities of tritium are handled in support of laser target research and development.																			
381	B150,B154,B156	381-B156-FHE-1	Tritium handling for laser target R&D	H-3	8.0E+00	1.0E-06	11.3	0.36	20.6	None	1	8.0E-06	1092	ESE	7.0E-10	731	NE	7.8E-09	2
Building 391 is part of the Laser Fusion Program. The high energy laser is located in this facility. Small amounts of tritium are handled in support of laser target research and development.																			
391	Target Chamber	391-FHE-1	Fusion Target Irradiation Area	H-3	7.0E-02	1.0E+00	6.1	0.30	9.9	None	1	7.0E-02	1149	SE	7.4E-06	403	NNE	1.7E-04	2
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 Separator Demonstration Facility (SDF), 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 (HEPA) filter banks to control emissions. *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 NESHAPs 40 CFR 61 regulations. **Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 47.)																			
490	1061	FFE-1,2,3,4	Isotope separation	Gross alpha	*	NA	9.1	0.90	5.7	Double HEPA	0.0001	0.0E+00	900	SE	0.0E+00	**	**	**	3
				Gross beta	*							0.0E+00							
Building 491																			
491	All	FFE-1	Isotope separation	Gross alpha	*	NA	9.1	0.9	12.1	Double HEPA	0.0001	0.0E+00	1000	SSE	0.0E+00	**	**	**	3
				Gross beta	*							0.0E+00							
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. Solidification agents are added during mixing to transfer sludges to 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 from waste storage because the wastes are fully contained.																			
513	Stabilization	Room Air	Treatment of hazardous, mixed or radioactive waste	H-3	1.5E-02	1	NA	NA	NA	None	1	1.5E-02	588	NE	3.7E-08	128	SW	1.2E-07	1
513	1000	FHE-4	Process optimization and treatibility studies	H-3	5.5E-01	1.0E-03	10.5	0.30	5.5	HEPA	1	5.5E-04	588	NE	1.0E-06	389	ENE	1.4E-06	1
				U-238	1.4E-10	1.0E-03					0.01	1.4E-15							
				K-40	1.7E-08	1.0E-03					0.01	1.7E-13							
Building 514 is operated by the Hazardous Waste Management Division.																			
514	108	Room Air	Vacuum filtration of treated waste water	Am-241	3.5E-04	1.00E-03	NA	NA	NA	None	1	3.5E-07	528	NE	1.3E-03	218	SW	3.2E-03	1
				Am-243	7.0E-07	1.00E-03						7.0E-10							
				Ba-133	2.5E-09	1.00E-03						2.5E-12							
				Bi-207	5.9E-08	1.00E-03						5.9E-11							
				C-14	1.2E-04	1.00E-03						1.2E-07							
				Ce-141	5.5E-10	1.00E-03						5.5E-13							
				Ce-144	6.4E-06	1.00E-03						6.4E-09							
				Co-57	5.0E-07	1.00E-03						5.0E-10							
				Co-60	1.0E-07	1.00E-03						1.0E-10							
				Cs-134	2.6E-09	1.00E-03						2.6E-12							
				Cs-137	5.3E-06	1.00E-03						5.3E-09							
				Eu-152	1.5E-06	1.00E-03						1.5E-09							
				Eu-154	1.3E-06	1.00E-03						1.3E-09							
				Eu-155	4.0E-07	1.00E-03						4.0E-10							
				H-3	1.1E-02	1.00E-03						1.1E-05							
				I-125	2.2E-05	1.00E-03						2.2E-08							
				K-40	9.5E-06	1.00E-03						9.5E-09							
				Mn-54	7.3E-08	1.00E-03						7.3E-11							
				Na-22	3.7E-06	1.00E-03						3.7E-09							
				Nb-95	4.1E-07	1.00E-03						4.1E-10							
				Ni-63	2.2E-08	1.00E-03						2.2E-11							
				Np-239	1.2E-07	1.00E-03						1.2E-10							
				P-32	2.1E-03	1.00E-03						2.1E-06							
				Pm-147	3.3E-10	1.00E-03						3.3E-13							
				Pu-236	1.1E-08	1.00E-03						1.1E-11							
				Pu-238	3.3E-05	1.00E-03						3.3E-08							
				Pu-239	3.1E-05	1.00E-03						3.1E-08							
				Pu-240	7.7E-05	1.00E-03						7.7E-08							
				Pu-241	3.9E-06	1.00E-03						3.9E-09							
				Pu-242	5.9E-06	1.00E-03						5.9E-09							
				Ra-226	5.0E-08	1.00E-03						5.0E-11							
				Ru-103	6.6E-10	1.00E-03						6.6E-13							
				Ru-106	1.3E-09	1.00E-03						1.3E-12							
				Sb-125	2.5E-07	1.00E-03						2.5E-10							
				Sm-151	3.3E-11	1.00E-03						3.3E-14							
				Sr-90	3.3E-07	1.00E-03						3.3E-10							
				Tc-99	1.1E-08	1.00E-03						1.1E-11							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 514 (continued)				Th-228	9.7E-07	1.00E-03						9.7E-10							
				Th-230	1.3E-08	1.00E-03						1.3E-11							
				Th-232	1.8E-07	1.00E-03						1.8E-10							
				U-232	1.1E-07	1.00E-03						1.1E-10							
				U-233	2.2E-07	1.00E-03						2.2E-10							
				U-234	8.2E-05	1.00E-03						8.2E-08							
				U-235	7.0E-06	1.00E-03						7.0E-09							
				U-237	5.5E-10	1.00E-03						5.5E-13							
				U-238	3.2E-04	1.00E-03						3.2E-07							
				Y-88	2.2E-09	1.00E-03						2.2E-12							
				Zr-95	7.4E-09	1.00E-03						7.4E-12							
				MFP	1.1E-06	1.00E-03						1.1E-09							
514	Evaporator	Room Air	Waste consolidation	Am-241	5.93E-06	1.0E-03	NA	NA	NA	None	1	5.9E-09	528	NE	5.9E-05	217	SW	1.4E-04	1
				Cs-134	1.95E-07	1.0E-03						2.0E-10							
				Cs-137	2.34E-07	1.0E-03						2.3E-10							
				Eu-155	9.36E-09	1.0E+00						9.4E-09							
				H-3	2.07E-03	1.0E-03						2.1E-06							
				P-32	5.03E-03	1.0E-03						5.0E-06							
				Pm-147	7.02E-08	1.0E-03						7.0E-11							
				Pu-238	9.75E-09	1.0E-03						9.8E-12							
				Pu-239	1.17E-10	1.0E-03						1.2E-13							
				Pu-240	1.17E-09	1.0E-03						1.2E-12							
				Pu-241	2.73E-07	1.0E-03						2.7E-10							
				Pu-242	2.15E-07	1.0E-03						2.1E-10							
				Sm-151	7.02E-09	1.0E-03						7.0E-12							
				Sr-90	1.87E-07	1.0E-03						1.9E-10							
				Th-228	1.28E-08	1.0E-03						1.3E-11							
				U-234	6.77E-06	1.0E-03						6.8E-09							
				U-235	2.54E-06	1.0E-03						2.5E-09							
				U-238	7.07E-05	1.0E-03						7.1E-08							
Building 612 is operated by the Hazardous Waste Management Division. It is a facility in which waste is repackaged for shipment off site.																			
612	100	Room Air	Waste sampling	Am-241	6.29E-08	1.0E-03	NA	NA	NA	None	1	6.3E-11	444	NE	1.2E-03	295	ENE	1.9E-03	1
				Am-243	5.30E-13	1.0E-03						5.3E-16							
				Au-195	3.10E-12	1.0E-03						3.1E-15							
				Ba-133	1.28E-10	1.0E-03						1.3E-13							
				Ba-140	4.20E-09	1.0E-03						4.2E-12							
				Be-7	1.83E-09	1.0E-03						1.8E-12							
				C-14	9.98E-05	1.0E-03						1.0E-07							
				Cd-109	2.47E-12	1.0E-03						2.5E-15							
				Ce-141	1.59E-08	1.0E-03						1.6E-11							
				Ce-144	1.43E-08	1.0E-03						1.4E-11							
				Cf-250	9.13E-13	1.0E-03						9.1E-16							
				Cl-36	2.10E-11	1.0E-03						2.1E-14							
				Co-60	2.12E-08	1.0E-03						2.1E-11							
				Cr-51	9.13E-10	1.0E-03						9.1E-13							
				Cs-134	2.02E-09	1.0E-03						2.0E-12							
				Cs-137	4.48E-08	1.0E-03						4.5E-11							
				Eu-152	9.13E-10	1.0E-03						9.1E-13							
				Eu-154	9.13E-10	1.0E-03						9.1E-13							
				Eu-155	9.22E-10	1.0E-03						9.2E-13							
				Fe-55	5.48E-09	1.0E-03						5.5E-12							
				H-3	2.28E-03	1.0E-03						2.3E-06							
				I-125	5.20E-08	1.0E-03						5.2E-11							
				I-131	1.83E-09	1.0E-03						1.8E-12							
				K-40	7.72E-10	1.0E-03						7.7E-13							
				Mn-54	1.16E-10	1.0E-03						1.2E-13							
				Mo-99	8.86E-10	1.0E-03						8.9E-13							
				Nb-94	1.26E-04	1.0E-03						1.3E-07							
				Nd-147	9.13E-10	1.0E-03						9.1E-13							
				Np-237	3.97E-15	1.0E-03						4.0E-18							
				Np-239	7.30E-10	1.0E-03						7.3E-13							
				P-32	1.65E-05	1.0E-03						1.7E-08							
				Pm-147	8.22E-11	1.0E-03						8.2E-14							
				Pm-151	2.74E-10	1.0E-03						2.7E-13							
				Pt-195m	5.48E-10	1.0E-03						5.5E-13							
				Pu-238	4.16E-09	1.0E-03						4.2E-12							
				Pu-239	2.53E-08	1.0E-03						2.5E-11							
				Pu-240	1.40E-09	1.0E-03						1.4E-12							
				Pu-241	3.34E-08	1.0E-03						3.3E-11							
				Pu-242	2.76E-08	1.0E-03						2.8E-11							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 612 (continued)				Ra-223	2.74E-12	1.0E-03						2.7E-15							
				Ra-226	1.26E-12	1.0E-03						1.3E-15							
				Ru-103	9.13E-09	1.0E-03						9.1E-12							
				Ru-106	1.37E-08	1.0E-03						1.4E-11							
				S-35	3.93E-06	1.0E-03						3.9E-09							
				Sb-125	4.40E-12	1.0E-03						4.4E-15							
				Sm-151	8.22E-12	1.0E-03						8.2E-15							
				Sr-90	7.14E-09	1.0E-03						7.1E-12							
				Th-228	7.84E-10	1.0E-03						7.8E-13							
				Th-230	6.77E-10	1.0E-03						6.8E-13							
				Th-232	1.20E-09	1.0E-03						1.2E-12							
				U-233	1.84E-09	1.0E-03						1.8E-12							
				U-234	1.93E-04	1.0E-03						1.9E-07							
				U-235	2.07E-05	1.0E-03						2.1E-08							
				U-237	1.92E-08	1.0E-03						1.9E-11							
				U-238	1.45E-03	1.0E-03						1.5E-06							
				Zr-95	3.38E-08	1.0E-03						3.4E-11							
				MFP	2.14E-08	1.0E-03						2.1E-11							
612	101	FHE-4	Laboratory analysis	Am-241	4.48E-04	1.0E-03	NA	NA	NA	None	1	4.5E-07	444	NE	2.7E-04	295	ENE	3.4E-04	1
			of waste treatment	Am-243	8.88E-07	1.0E-03						8.9E-10							
			and treatability samples	Ba-133	3.15E-09	1.0E-03						3.2E-12							
				Bi-207	7.55E-08	1.0E-03						7.5E-11							
				C-14	1.54E-04	1.0E-03						1.5E-07							
				Ce-141	7.00E-10	1.0E-03						7.0E-13							
				Ce-144	8.18E-06	1.0E-03						8.2E-09							
				Co-57	6.37E-07	1.0E-03						6.4E-10							
				Co-60	1.33E-07	1.0E-03						1.3E-10							
				Cs-134	3.29E-09	1.0E-03						3.3E-12							
				Cs-137	6.72E-06	1.0E-03						6.7E-09							
				Eu-152	1.95E-06	1.0E-03						1.9E-09							
				Eu-154	1.60E-06	1.0E-03						1.6E-09							
				Eu-155	5.14E-07	1.0E-03						5.1E-10							
				H-3	1.35E-02	1.0E-03						1.3E-05							
				I-125	2.80E-05	1.0E-03						2.8E-08							
				K-40	1.21E-05	1.0E-03						1.2E-08							
				Mn-54	9.24E-08	1.0E-03						9.2E-11							
				Na-22	4.75E-06	1.0E-03						4.7E-09							
				Nb-95	5.19E-07	1.0E-03						5.2E-10							
				Ni-63	2.80E-08	1.0E-03						2.8E-11							
				Np-239	1.54E-07	1.0E-03						1.5E-10							
				P-32	2.70E-03	1.0E-03						2.7E-06							
				Pm-147	4.20E-10	1.0E-03						4.2E-13							
				Pu-236	1.40E-08	1.0E-03						1.4E-11							
				Pu-238	4.20E-05	1.0E-03						4.2E-08							
				Pu-239	3.92E-05	1.0E-03						3.9E-08							
				Pu-240	9.80E-05	1.0E-03						9.8E-08							
				Pu-241	4.93E-06	1.0E-03						4.9E-09							
				Pu-242	7.56E-06	1.0E-03						7.6E-09							
				Ra-226	6.41E-08	1.0E-03						6.4E-11							
				Ru-103	8.40E-10	1.0E-03						8.4E-13							
				Ru-106	1.68E-09	1.0E-03						1.7E-12							
				Sb-125	3.23E-07	1.0E-03						3.2E-10							
				Sm-151	4.20E-11	1.0E-03						4.2E-14							
				Sr-90	4.24E-07	1.0E-03						4.2E-10							
				Tc-99	1.40E-08	1.0E-03						1.4E-11							
				Th-228	1.24E-06	1.0E-03						1.2E-09							
				Th-230	1.69E-08	1.0E-03						1.7E-11							
				Th-232	2.28E-07	1.0E-03						2.3E-10							
				U-232	1.40E-07	1.0E-03						1.4E-10							
				U-233	2.83E-07	1.0E-03						2.8E-10							
				U-234	1.04E-04	1.0E-03						1.0E-07							
				U-235	8.89E-06	1.0E-03						8.9E-09							
				U-237	7.00E-10	1.0E-03						7.0E-13							
				U-238	4.09E-04	1.0E-03						4.1E-07							
				Y-88	2.80E-09	1.0E-03						2.8E-12							
				Zr-95	9.38E-09	1.0E-03						9.4E-12							
				MFP	1.40E-06	1.0E-03						1.4E-09							
612	102	Room Air	Laboratory analysis	Am-241	4.48E-04	1.0E-03	NA	NA	NA	None	1	4.5E-07	444	NE	2.0E-03	295	ENE	3.0E-03	1
			of waste treatment	Am-243	8.88E-07	1.0E-03						8.9E-10							
			and treatability samples	Ba-133	3.15E-09	1.0E-03						3.2E-12							
				Bi-207	7.55E-08	1.0E-03						7.5E-11							
				C-14	1.54E-04	1.0E-03						1.5E-07							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 612 (continued)				Ce-141	7.00E-10	1.0E-03						7.0E-13							
				Ce-144	8.18E-06	1.0E-03						8.2E-09							
				Co-57	6.37E-07	1.0E-03						6.4E-10							
				Co-60	1.33E-07	1.0E-03						1.3E-10							
				Cs-134	3.29E-09	1.0E-03						3.3E-12							
				Cs-137	6.72E-06	1.0E-03						6.7E-09							
				Eu-152	1.95E-06	1.0E-03						1.9E-09							
				Eu-154	1.60E-06	1.0E-03						1.6E-09							
				Eu-155	5.14E-07	1.0E-03						5.1E-10							
				H-3	1.35E-02	1.0E-03						1.3E-05							
				I-125	2.80E-05	1.0E-03						2.8E-08							
				K-40	1.21E-05	1.0E-03						1.2E-08							
				Mn-54	9.24E-08	1.0E-03						9.2E-11							
				Na-22	4.75E-06	1.0E-03						4.7E-09							
				Nb-95	5.19E-07	1.0E-03						5.2E-10							
				Ni-63	2.80E-08	1.0E-03						2.8E-11							
				Np-239	1.54E-07	1.0E-03						1.5E-10							
				P-32	2.70E-03	1.0E-03						2.7E-06							
				Pm-147	4.20E-10	1.0E-03						4.2E-13							
				Pu-236	1.40E-08	1.0E-03						1.4E-11							
				Pu-242	2.05E-10	1.0E-03						2.1E-13							
				Pu-238	4.20E-05	1.0E-03						4.2E-08							
				Pu-239	3.92E-05	1.0E-03						3.9E-08							
				Pu-240	9.80E-05	1.0E-03						9.8E-08							
				Pu-241	4.93E-06	1.0E-03						4.9E-09							
				Pu-242	7.56E-06	1.0E-03						7.6E-09							
				Ra-226	6.41E-08	1.0E-03						6.4E-11							
				Ru-103	8.40E-10	1.0E-03						8.4E-13							
				Ru-106	1.68E-09	1.0E-03						1.7E-12							
				Sb-125	3.23E-07	1.0E-03						3.2E-10							
				Sm-151	4.20E-11	1.0E-03						4.2E-14							
				Sr-90	4.24E-07	1.0E-03						4.2E-10							
				Tc-99	1.40E-08	1.0E-03						1.4E-11							
				Th-228	1.24E-06	1.0E-03						1.2E-09							
				Th-230	1.69E-08	1.0E-03						1.7E-11							
				Th-232	2.28E-07	1.0E-03						2.3E-10							
				U-232	1.40E-07	1.0E-03						1.4E-10							
				U-233	2.83E-07	1.0E-03						2.8E-10							
				U-234	1.04E-04	1.0E-03						1.0E-07							
				U-235	8.89E-06	1.0E-03						8.9E-09							
				U-237	7.00E-10	1.0E-03						7.0E-13							
				U-238	4.09E-04	1.0E-03						4.1E-07							
				Y-88	2.80E-09	1.0E-03						2.8E-12							
				Zr-95	9.38E-09	1.0E-03						9.4E-12							
				MFP	1.10E-06	1.0E-03						1.1E-09							
612	110	Room Air	Decontamination of compactor baler	Am-241	5.60E-14	1.0E-03	NA	NA	NA	None	1	5.6E-17	444	NE	4.2E-12	295	ENE	6.4E-12	1
				Am-243	2.32E-15	1.0E-03						2.3E-18							
				Pu-238	7.04E-14	1.0E-03						7.0E-17							
				Pu-239	4.01E-14	1.0E-03						4.0E-17							
				U-233	2.41E-12	1.0E-03						2.4E-15							
				U-234	9.63E-13	1.0E-03						9.6E-16							
				U-235	4.12E-14	1.0E-03						4.1E-17							
				U-238	1.36E-12	1.0E-03						1.4E-15							
SITE 300 POINT SOURCES																			
Site 300 - Explosives tests in which radionuclides may be present are conducted on open-air firing tables located at Bunkers 801 and 851. These tests have depleted uranium material as part of the material inventory. There are multiple tests per year.																			
Air activation products are created at the flash x-ray and LINAC. The radionuclides in Buildings 804, 810A, 810B, 822B, and 854F are encapsulated or sealed and are not used.																			
810A	133	Room Air	Assembly of explosives	U-238	9.0E-04	1.0E-06	NA	NA	NA	None	1	9.0E-10	2208	NNE	1.2E-08	944	SSE	7.3E-08	2
				U-235	1.2E-05	1.0E-06						1.2E-11							
				U-234	8.4E-05	1.0E-06						8.4E-11							
801	Firing Table	None	Explosive tests	U-238	4.8E-02	1.0E+00	NA	NA	NA	None	1	4.8E-02	2380	ESE	1.2E-02	3423	WSW	2.1E-02	4
				U-235	6.1E-04	1.0E+00						6.1E-04							
				U-234	4.4E-03	1.0E+00						4.4E-03							
801	125	FE-4	Flash X-ray (FXR)	N-13	3.4E-03	1.0E+00	NA	NA	NA	None	1	3.4E-03	2380	ESE	5.2E-08	1809	ENE	3.7E-07	2
				Ar-41	2.0E-07	1.0E+00						2.0E-07							

Attachment 1 - 1999 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
851	Firing Table	None	Explosive tests	U-238	2.4E-02	1.0E+00	NA	NA	NA	None	1	2.4E-02	3870	E	2.1E-02	3836	ENE	3.1E-02	4
				U-235	3.1E-04	1.0E+00						3.1E-04							
				U-234	2.3E-03	1.0E+00						2.3E-03							
				H-3	1.9E+01	1.0E+00						1.9E+01							
851	111	None	Linear accelerator	N-13	8.2E-02	1.0E+00	NA	NA	NA	None	1	8.2E-02	3870	E	9.6E-07	1386	WNW	2.9E-06	2
				O-15	7.6E-02	1.0E+00						7.6E-02							
				Ar-41	1.5E-04	1.0E+00						1.5E-04							
LIVERMORE SITE DIFFUSE SOURCES																			
Building 170 - Diffuse emissions resulted from the remediation activities at a soil staging area.																			
170	Outside	None	Soil contamination	H-3	3.1E-02	1	NA	NA	NA	None	1	3.1E-02	1538	E	8.4E-06	324	WNW	5.6E-04	1
Building 223 - This facility underwent radiological decontamination and decomissioning activities.																			
223	Outside	None	Decontamination and decomissioning	Am-241	1.3E-03	1.0E-03	NA	NA	NA	Other	0.05	6.6E-08	1239	ENE	1.7E-04	191	SSW	7.7E-02	5
				Pu-238	1.4E-04	1.0E-03						7.1E-09							
				Pu-293	1.1E-02	1.0E-03						5.4E-07							
Building 292 - Diffuse emissions result from tritium-contaminated water which leaked from an underground storage tank. Vegetation in the area transpires water with elevated tritium concentrations.																			
292	Spill Area	None	Evaporation and transpiration	H-3	NA	1	NA	NA	NA	None	1	5.2E-04	1380	ESE	7.3E-08	456	N	1.5E-06	6
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	NA	NA	NA	None	1	7.3E+00	957	ENE	6.1E-03	441	SSW	2.2E-02	6
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. The treatment process may involve batch chemical treatment consisting of neutralization, flocculation, oxidation, reduction, precipitation, separation, and filtration.																			
514	Tank Farm	Area Source	Processes liquid hazardous mixed and radioactive wastes in open topped tanks.	Am-241	1.0E-03	1.0E-03	NA	NA	NA	None	1	1.0E-06	528	NE	3.2E-03	217	SW	1.0E-02	5
				Am-243	2.0E-06	1.0E-03						2.0E-09							
				Ba-133	7.2E-09	1.0E-03						7.2E-12							
				Bi-207	1.7E-07	1.0E-03						1.7E-10							
				C-14	3.5E-04	1.0E-03						3.5E-07							
				Ce-141	1.6E-09	1.0E-03						1.6E-12							
				Ce-144	1.9E-05	1.0E-03						1.9E-08							
				Co-57	1.5E-06	1.0E-03						1.5E-09							
				Co-60	3.0E-07	1.0E-03						3.0E-10							
				Cs-134	7.5E-09	1.0E-03						7.5E-12							
				Cs-137	1.9E-05	1.0E-03						1.9E-08							
				Eu-152	4.4E-06	1.0E-03						4.4E-09							
				Eu-154	3.6E-06	1.0E-03						3.6E-09							
				Eu-155	1.2E-06	1.0E-03						1.2E-09							
				H-3	3.1E-02	1.0E-03						3.1E-05							
				I-125	6.4E-05	1.0E-03						6.4E-08							
				K-40	2.8E-05	1.0E-03						2.8E-08							
				Mn-54	2.1E-07	1.0E-03						2.1E-10							
				Na-22	1.1E-05	1.0E-03						1.1E-08							
				Nb-95	1.2E-06	1.0E-03						1.2E-09							
				Ni-63	6.4E-08	1.0E-03						6.4E-11							
				Np-239	3.5E-07	1.0E-03						3.5E-10							
				P-32	6.2E-03	1.0E-03						6.2E-06							
				Pm-147	9.6E-10	1.0E-03						9.6E-13							
				Pu-236	3.2E-08	1.0E-03						3.2E-11							
				Pu-238	9.6E-05	1.0E-03						9.6E-08							
				Pu-239	9.0E-04	1.0E-03						9.0E-07							
				Pu-240	2.2E-04	1.0E-03						2.2E-07							
				Pu-241	1.1E-05	1.0E-03						1.1E-08							
				Pu-242	1.7E-05	1.0E-03						1.7E-08							
				Ra-226	1.5E-07	1.0E-03						1.5E-10							
				Ru-103	1.9E-09	1.0E-03						1.9E-12							
				Ru-106	3.8E-09	1.0E-03						3.8E-12							
				Sb-125	7.4E-07	1.0E-03						7.4E-10							
				Sm-151	9.6E-11	1.0E-03						9.6E-14							
				Sr-90	4.2E-06	1.0E-03						4.2E-09							
				Tc-99	3.2E-08	1.0E-03						3.2E-11							
				Th-228	2.8E-06	1.0E-03						2.8E-09							
				Th-230	3.9E-08	1.0E-03						3.9E-11							
				Th-232	5.2E-07	1.0E-03						5.2E-10							
				U-232	3.2E-07	1.0E-03						3.2E-10							
				U-233	6.5E-07	1.0E-03						6.5E-10							
				U-234	2.4E-04	1.0E-03						2.4E-07							

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category
Building 514 (continued)				U-235	2.0E-05	1.0E-03						2.0E-08							
				U-237	1.6E-09	1.0E-03						1.6E-12							
				U-238	9.4E-04	1.0E-03						9.4E-07							
				Y-88	6.4E-09	1.0E-03						6.4E-12							
				Zr-95	2.1E-08	1.0E-03						2.1E-11							
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 outdoors. The containers, which are not air tight, can outgas tritium.																			
*The drum sampling operation takes place at all site Waste Accumulation Areas. Inventories were combined and modeled as if the operation occurred at the center of the site.																			
612	Yard	Area Source	Storage of low level waste	H-3	4.4E+00	1	NA	NA	NA	None	1	4.4E+00	420	NNE	1.8E-02	216	SSW	4.8E-02	6
612	All WAAs*	Area source	Drum sampling in	Am-241	4.1E-10	1.0E-03	NA	NA	NA	None	1	4.1E-13	923	ESE	8.9E-09	969	W	3.6E-08	5
			612 yard and all LLNL Waste	Am-243	1.5E-11	1.0E-03						1.5E-14							
			Accumulation Areas (WAAs)	Bi-207	8.5E-13	1.0E-03						8.5E-16							
				C-14	1.2E-09	1.0E-03						1.2E-12							
				Ce-144	1.2E-10	1.0E-03						1.2E-13							
				Co-57	2.4E-12	1.0E-03						2.4E-15							
				Co-60	6.8E-12	1.0E-03						6.8E-15							
				Cs-134	4.8E-11	1.0E-03						4.8E-14							
				Cs-137	3.0E-10	1.0E-03						3.0E-13							
				Eu-152	4.9E-11	1.0E-03						4.9E-14							
				Eu-154	4.9E-11	1.0E-03						4.9E-14							
				Eu-155	3.6E-12	1.0E-03						3.6E-15							
				H-3	1.0E-05	1.0E-03						1.0E-08							
				K-40	3.3E-11	1.0E-03						3.3E-14							
				Mn-54	2.3E-12	1.0E-03						2.3E-15							
				Nb-95	1.2E-12	1.0E-03						1.2E-15							
				Ni-63	9.5E-11	1.0E-03						9.5E-14							
				Np-239	2.5E-12	1.0E-03						2.5E-15							
				P-32	7.6E-07	1.0E-03						7.6E-10							
				Pu-238	1.1E-12	1.0E-03						1.1E-15							
				Pu-239	1.4E-10	1.0E-03						1.4E-13							
				Pu-240	9.5E-12	1.0E-03						9.5E-15							
				Pu-241	3.1E-10	1.0E-03						3.1E-13							
				Pu-242	4.8E-11	1.0E-03						4.8E-14							
				Ra-226	1.1E-12	1.0E-03						1.1E-15							
				Sb-125	3.6E-12	1.0E-03						3.6E-15							
				Sr-90	1.4E-13	1.0E-03						1.4E-16							
				Tc-99	1.1E-11	1.0E-03						1.1E-14							
				Th-228	6.5E-12	1.0E-03						6.5E-15							
				Th-230	5.5E-14	1.0E-03						5.5E-17							
				Th-232	1.0E-12	1.0E-03						1.0E-15							
				U-234	1.7E-08	1.0E-03						1.7E-11							
				U-235	2.3E-09	1.0E-03						2.3E-12							
				U-238	1.7E-07	1.0E-03						1.7E-10							
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 past waste management operations.																			
Southeast Quadrant		Area Source	Resuspension	Pu-239	NA	NA	NA	NA	NA	None	1	NA	0	NA	4.2E-04	NA	NA	NA	6
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.																			
Site 300	All	Area Source	Tritium evaporation	H-3	NA	NA	NA	NA	NA	None	1	NA	0	NA	6.0E-05	NA	NA	NA	6
Site 300	All	Area Source	Soil resuspension	U-238	NA	NA	NA	NA	NA	None	1	NA	0	NA	1.2E-03	NA	NA	NA	6
				U-235	NA	NA						NA							
				U-234	NA	NA						NA							
804	Open Area	Area Source	Low-level waste staging area	H-3	NA	NA	NA	NA	NA	None	1	3.9E-04	3108	SE	6.0E-07	828	N	4.5E-06	6
				U-238	NA	NA						5.1E-08							
				U-235	NA	NA						6.5E-10							
				U-234	NA	NA						3.1E-09							

Attachment 1 - 1999 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source Category
													Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	
EMISSIONS WHICH CONTRIBUTE 10% OR MORE TO THE POTENTIAL EFFECTIVE DOSE EQUIVALENT AT EACH SITE.																			
LIVERMORE SITE SOURCES																			
331	All**	Stack 1	Tritium research and development	H-3	*	1	30	1.22	7.6	None	1	5.7E+00	957	ENE	8.80E-02	957	ENE	8.80E-02	3
		Stack 2	Decontamination of parts	H-3	*	1	30	1.22	10.5	None	1	2.7E+02			6.7E-02 ***			6.7E-02 ***	
331	Outside	None	Storage of contaminated parts	H-3	NA	1	NA	NA	NA	None	1	7.3E+00	957	ENE	6.10E-03	441	SSW	2.20E-02	6
612	Yard	Area Source	Storage of low level waste	H-3	4.4E+00	1	NA	NA	NA	None	1	4.4E+00	420	NNE	1.80E-02	216	SSW	4.80E-02	6
SITE 300 SOURCES																			
851	Firing Table	None	Explosive tests	U-238	2.4E-02	1.0E+00	NA	NA	NA	None	1	2.4E-02	3870	E	2.1E-02	3836	ENE	3.1E-02	4
				U-235	3.1E-04	1.0E+00						3.1E-04							
				U-234	2.3E-03	1.0E+00						2.3E-03							
				H-3	1.9E+01	1.0E+00						1.9E+01							
801	Firing Table	None	Explosive tests	U-238	4.8E-02	1.0E+00	NA	NA	NA	None	1	4.8E-02	2380	ESE	1.2E-02	3423	WSW	2.1E-02	4
				U-235	6.1E-04	1.0E+00						6.1E-04							
				U-234	4.4E-03	1.0E+00						4.4E-03							

Attachment 2. Surrogate Radionuclides List

The need for selection of a surrogate isotope occurs when an isotope used in operations (isotope of interest) is not contained in the limited nuclide library in the NESHAPs dose compliance model CAP88-PC. The selection of a suitable surrogate is based upon several criteria. If possible, a surrogate isotope is chosen from the CAP88-PC radionuclide library that has a metabolically similar behavior to the isotope of interest. Following an acute inhalation exposure, the metabolically similar surrogate would concentrate in specific organs and tissues as the isotope of interest. In most cases the surrogate selected possesses similar modes of decay and decay energies of the radiation type of the isotope of interest. Thus, the surrogate models the behavior of the isotope with similar relative biological effect due to deposition energy.

According to present knowledge, the daughter nuclides produced following physical decay are assumed to remain organ site specific and follow the translocation pathway of the parent. Therefore, when a surrogate of similar metabolic behavior is not available or has a greatly dissimilar half-life, the surrogate chosen is a daughter nuclide of the isotope of interest that will remain organ site specific and follow the translocation pathway of the parent.

Once a surrogate has been selected, the equivalent source term is adjusted by the product of the initial inventory of the isotope of interest and the ratio of the effective dose equivalent of the surrogate to that of the isotope of interest. For determining the dose ratio, the primary exposure pathway is assumed to be that of inhalation and inhalation dose conversion factors (International Commission on Radiological Protection Publication No. 71, “Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients,” Elsevier Science Ltd., 1996) are used for determination of the effective dose equivalents.

In addition, isotopic analysis of mixtures of radionuclides are not always available, and radionuclide usage inventories are stated as “gross alpha,” “gross beta,” “gross gamma,” or “mixed fission products” (MFP). In these cases, ^{239}Pu is used as the surrogate for gross alpha, ^{137}Cs is used as the surrogate for gross gamma, and ^{90}Sr is used as the surrogate for gross beta and mixed fission products to provide conservative dose estimates.

Table 2-1 provides a list a radionuclides not in the CAP88-PC library and their respective surrogates.

Table 2-1. List of surrogate radionuclides.

Isotope	Half-Life	Lung Class[a]	ALI (inh) µCi	DAC (inh) µCi/m^3	Surrogate	Half-Life	Lung Class[a]	A LI (inh) µCi	DAC (inh) µCi/m^3
Ca-108m	127 y	Y	2.0×10^{1}	1.0×10^{-8}	**Co-60**	5.271 y	Y	3.0×10^{1}	1.0×10^{-8}
Bi-207	38 d	W	4.0×10^{2}	1.0×10^{-7}	**Bi-214**	19.9 min	W	9.0×10^{2}	4.0×10^{-7}
Ca-45	163 d	W	8.0×10^{2}	4.0×10^{-7}	**Sr-90**	29.12 y	D	2.0×10^{1}	8.0×10^{-9}
Cd-109	464 d	Y	1.0×10^{2}	5.0×10^{-8}	**Co-60**	5.271 y	Y	3.0×10^{1}	1.0×10^{-8}
Cf-249	350.6 y	Y	1.0×10^{-2}	4.0×10^{-12}	**Cm-245**	8500 y	W	6.0×10^{-3}	3.0×10^{-12}
Cf-250	13.1 y	W	9.0×10^{-3}	4.0×10^{-12}	**Am-241**	432.2 y	W	6.0×10^{-3}	3.0×10^{-12}
Cl-36	3.01×10^{5} y	W	2.0×10^{2}	1.0×10^{-7}	**Cs-137**	30 y	D	2.0×10^{2}	6.0×10^{-8}
Es-254	275.7 d	W	7.0×10^{-2}	3.0×10^{-11}	**Pu-239**	24065 y	Y	2.0×10^{-2}	7.0×10^{-12}
Eu-149	93.1 d	W	3.0×10^{3}	1.0×10^{-6}	**Pm-151**	28.4 hr	Y	3.0×10^{3}	1.0×10^{-6}
Gd-148	93 y	D	8.0×10^{-3}	3.0×10^{-12}	**La-140**	40.272 h	W	1.0×10^{3}	5.0×10^{-7}
Os-185	94 d	D	5.0×10^{2}	2.0×10^{-7}	**Mo-99**	66 h	Y	1.0×10^{3}	6.0×10^{-7}
P-33	25.4 d	W	3.0×10^{3}	1.0×10^{-6}	**P-32**	14.29 d	D	9.0×10^{2}	4.0×10^{-7}
Re-184	38 d	W	1.0×10^{3}	6.0×10^{-7}	**Mo-99**	66 h	Y	1.0×10^{3}	6.0×10^{-7}
Se-75	119.8 d	W	6.0×10^{2}	3.0×10^{-7}	**As-76**	26.32 h	W	1.0×10^{3}	6.0×10^{-7}
Sr-85	64.8 d	D	3.0×10^{3}	1.0×10^{-6}	**Sr-90**	29.12 y	D	2.0×10^{1}	8.0×10^{-9}
Ta-182	115 d	Y	1.0×10^{2}	6.0×10^{-8}	**Hf-181**	42.4 d	W	4.0×10^{2}	2.0×10^{-7}
Tb-157	110 y	W	3.0×10^{2}	1.0×10^{-7}	**La-140**	40.272 h	W	1.0×10^{3}	5.0×10^{-7}
Tb-158	180 y	W	2.0×10^{1}	8.0×10^{-9}	**La-140**	40.272 h	W	1.0×10^{3}	5.0×10^{-7}
Tl-204	3.78 y	D	2.0×10^{3}	9.0×10^{-7}	**Pb-214**	26.8 min	D	8.0×10^{2}	3.0×10^{-7}
Tm-168	93.1 d	W	2.0×10^{3}	8.0×10^{-7}	**La-140**	40.272 h	W	1.0×10^{3}	5.0×10^{-7}
Tm-171	1.92 y	Y	3.0×10^{2}	1.0×10^{-7}	**La-140**	40.272 h	W	1.0×10^{3}	5.0×10^{-7}
Y-88	106.64 d	Y	2.0×10^{2}	1.0×10^{-7}	**Y-90**	64 h	Y	6.0×10^{2}	3.0×10^{-7}
Am-244	10.1 h	W	2.0×10^{2}	8.0×10^{-8}	**Cm-244**	18.11 y	W	1.0×10^{-2}	5.0×10^{-12}
Au-195	183 d	Y	4.0×10^{2}	2.0×10^{-7}	**Ba-133**	10.74 y	D	7.0×10^{2}	3.0×10^{-7}
Co-56	78.76 d	Y	2.0×10^{2}	8.0×10^{-8}	**Co-60**	5.271 y	Y	3.0×10^{1}	1.0×10^{-8}
Gd-146	48.3 d	W	3.0×10^{2}	1.0×10^{-7}	**Sm-147**	1.06×10^{11} y	W	4.0×10^{-2}	2.0×10^{-11}
Kr-85	10.72 y	Gas	See Note	1.0×10^{-4}					
Rh-102	2.9 y	Y	6.0×10^{1}	2.0×10^{-8}	**Rh-106m**	29.9 s	Y	4.0×10^{4}	1.0×10^{-5}
U-239	23.54 min	Y	2.0×10^{5}	6.0×10^{-5}	**U-240**	14.1 h	Y	2.0×10^{3}	1.0×10^{-6}
Zr-90	809 ms	W	N/A	N/A	**Y-90**	64 h	Y	6.0×10^{2}	3.0×10^{-7}
Po-209[b]	102 y	N/A	N/A	N/A	**Pu-239**	24065 y	Y	2.0×10^{-2}	7.0×10^{-12}

Note: The DAC for Kr-85 also has been relaxed considerably since its beta emission only irradiates the skin. The DAC is based on limitation of non-stochastic effects in the skin; the MPC was derived assuming that the beta particles of energy greater than 0.1 MeV contributed to the whole body dose.

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

[b] No ALI or DAC information available. Pu-239 used to provide a conservative alpha-emitter dose.

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.