This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

LLNL NESHAPs 2005 Annual Report

Jennifer M. Larson
Sylvie-Ring Peterson
Kent R. Wilson

Contributors:

Brent M. Bowen
Donald H. MacQueen
Anthony M. Wegrecki

U.S. Department of Energy
Radionuclide Air Emission Annual Report
(under Subpart H of 40 CFR Part 61)
Calendar Year 2005

Site Name: Lawrence Livermore National Laboratory

Operations Office Information

Office: U.S. Department of Energy
Livermore Site Office

Address: 7000 East Avenue, L-293
Livermore, CA 94550

Contact: Vijay Mishra Phone: 925-423-8163

Site Information

Operator: University of California

Address: 7000 East Avenue
Livermore, CA 94551

Contact: C. Susi Jackson Phone: 925-423-6577

June 2006

SECTION IV. Results of 2005 Radiological Dose Assessment 17

Total Dose to Site-Wide Maximally Exposed Individuals 17

Table 8. Ranked list of facilities or sources whose emissions collectively accounted for nearly 100% of the SW-MEI doses for the Livermore site and Site 300 in 2005. 18

Table 9. Doses (in mrem) calculated for the Site-Wide Maximally Exposed Individual (SW-MEI) for the Livermore site and Site 300, 1990 to 2005. 18

Doses from Unplanned Releases 19

Population Doses 19

Table 10. Disaggregations of collective dose for the Livermore site, 2005. 20

Table 11. Disaggregations of collective dose for Site 300, 2005. 20

Compliance with 40 CFR 61 Subpart H (61.93) 21

SECTION V. Certification 22

SECTION VI. Supplemental Information on NESHAPs Compliance and QA/QC Activities 23

Periodic Confirmatory Measurements 23

NESHAPs Quality Assurance (QA) Program 23

Evaluation of New Radiological Projects 24

Quality Control (QC) for 2005 Air Dispersion and Dose Assessment Model Runs 24

SECTION VII. Supplementary Information on Radiological Dose Assessment for 2005 ... 25

Livermore Site Principal Diffuse Sources 25

Building 331 Outside Yard 25

Building 612 Yard 25

DWTF Transportainer Storage 26

Southeast Quadrant 26

Site 300 Principal Diffuse Sources 26

Tritium Evaporation and Migration at Site 300 26

Resuspension of Depleted Uranium in Soil at Site 300 27

Radioactive and Hazardous Waste Management Operations and Facilities 27

Modeling Dose from Tritium 28

Comparison of 2005 Modeling Results with Tritium Surveillance Air Monitoring Data 29

Figure 5. Radiological air monitoring at the Livermore site showing locations for air surveillance monitoring of tritiated water vapor (triangles) and radioactive particles (circles) and stack air effluent monitoring (indicated by building number and icon). 30

Table 12. Comparison of measured and modeled annual mean concentrations of tritiated water vapor (HTO) in air at selected Livermore site locations, 2005 32

SECTION VIII. Supplemental Information on Other Compliance 33

Status of Compliance with Other Regulations 33

Status of compliance with 40 CFR 61 Subpart Q – National Emission Standards for Radon Emissions from Department of Energy Facilities 33

Status of compliance with 40 CFR 61 Subpart T – National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings 33

ATTACHMENT 1. LLNL NESHAPs 2005 Annual Report Guidance and Spreadsheet....34

Guidance for Interpreting the Data Spreadsheet....34
Radionuclides....34
Radionuclide Usage Inventories....34
Physical State Factors....34
Stack Parameters....35
Emission Control Devices....35
Control Device Abatement Factors....35
Estimated Annual Emissions....35
10 mrem/y Site-Wide Dose Requirement....35
0.1 mrem/y Monitoring Requirement....36
Source Categories....36
2005 LLNL NESHAPs Annual Report Spreadsheet....37

ATTACHMENT 2. ERRATA for the NESHAPs 2004 Annual Report....39

Lawrence Livermore National Laboratory NESHAPs 2005 Annual Report

This annual report is prepared pursuant to the National Emission Standards for Hazardous Air Pollutants (NESHAPs; Title 40 Code of Federal Regulations [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 operations in 2005 are summarized here.

- Livermore site: 0.0065 mrem (0.065 μSv) (41% from point source emissions, 59% from diffuse source emissions). The point source emissions include gaseous tritium modeled as tritiated water vapor as directed by EPA Region IX; the resulting dose is used for compliance purposes.

- Site 300: 0.018 mrem (0.18 μSv) (48% from point source emissions, 52% from diffuse source emissions).

The EDEs were calculated using the EPA-approved CAP88-PC air dispersion/dose-assessment model, except for doses for two diffuse sources that were estimated using measured radionuclide concentrations and dose coefficients. Specific inputs to CAP88-PC for the modeled sources included site-specific meteorological data and source emissions data, the latter variously based on continuous stack effluent monitoring data, stack flow or other release-rate information, ambient air monitoring data, and facility knowledge.

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. In round numbers, 7 million people live within 80 km of the Livermore site; about 80,000 of them live in the City of Livermore.

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

The climate of the Livermore Valley is characterized by mild, rainy winters and warm, dry summers. The mean daily maximum, minimum, and average temperatures for the Livermore site in 2005 were 22.0°C, 8.0°C, and 15.0°C, respectively, typical for the site. Temperatures typically range from –5°C during some pre-dawn hours in the winter, to 40°C on a few summer afternoons. The 2005 annual wind data for the Livermore site are displayed as a wind rose in **Figure 2**. In the wind rose, the length of each spoke is proportional to the frequency at which the wind blows from the indicated direction; different line widths of each spoke represent wind speed classes. These data show that 49% of the time the winds blew from the south-southwest through west directions. However, during the winter, the wind often blew from the northeast. The average wind speed in 2005 at the Livermore site was 2.3 m/s (5.2 mph). Most precipitation occurs as rain between October and April with very little rainfall during the summer months. In 2005, the Livermore site received 45.5 cm of precipitation.

Site 300

Site 300, LLNL's Experimental Test Facility, 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. SRI International operates a testing site located approximately 1 km south of Site 300. Property immediately to the east of Site 300 is owned by Fireworks America which uses it for packaging and storing fireworks displays. The Carnegie State Vehicular Recreation Area is located south of the western portion of Site 300, and wind-turbine generators line the hills to the northwest. The remainder of the surrounding area is in agricultural use, primarily grazing land for cattle and sheep. The nearest residential area is the city of Tracy (population of over 80,000), located 10 km to the northeast. About 6.2 million people live within 80 km of Site 300. Ninety-five percent live more than 32 km from Site 300 in such distant metropolitan areas as Oakland, San Jose, and Stockton.

The topography of Site 300 is much more irregular than that of the Livermore site; it consists of a series of steep hills and ridges, which are oriented along a generally northwest/southeast trend, separated by intervening ravines. The elevation ranges from approximately 540 m in the northwestern portion of the site to 150 m at the southeast corner. The climate at Site 300 is similar to that of the Livermore site, with mild winters and dry summers. The complex topography of the site significantly influences local wind and temperature patterns. The stronger

SECTION II. Air Emission Sources and Data

Sources

Approximately eighty different radioisotopes were available for use at LLNL in 2005 for research purposes, including biomedical tracers, tritium, mixed fission products, transuranic isotopes, and others—see **Table 1**. Radioisotope handling procedures and work enclosures are determined for each project or activity, depending on the isotopes, the quantities being used, and the types of operations being performed. Work enclosures include gloveboxes, exhaust hoods, and laboratory bench tops. Exhaust paths to the atmosphere include High Efficiency Particulate Air (HEPA) filtered ventilation systems, roof vents and stacks lacking abatement devices, direct open-air dispersal of depleted uranium during explosives testing at Site 300, and releases to ambient air from a variety of diffuse area sources.

Table 1. Radionuclides at LLNL during 2005.

Hydrogen-3	Iron-55	Silver-110m	Bismuth-207	Uranium-233	Americium-242m
Nitrogen-13	Cobalt-57	Iodine-125	Polonium-208	Uranium-234	Plutonium-242
Carbon-14	Nickel-59	Iodine-131	Polonium-209	Uranium-235	Americium-243
Oxygen-15	Cobalt-60	Barium-133	Polonium-210	Neptunium-236	Curium-243
Sodium-22	Nickel-63	Cesium-134	Lead-210	Plutonium-236	Curium-244
Phosphorus-32	Zinc-65	Cesium-137	Radium-226	Uranium-236	Plutonium-244
Phosphorus-33	Selenium-75	Cerium-144	Actinium-227	Neptunium-237	Californium-249
Sulfur-35	Krypton-85	Promethium-147	Radium-228	Uranium-237	Californium-250
Chlorine-36	Strontium-85	Europium-152	Thorium-228	Plutonium-238	Californium-252
Potassium-40	Yttrium-88	Europium-154	Thorium-229	Uranium-238	
Calcium-41	Strontium-89	Europium-155	Thorium-230	Plutonium-239	
Argon-41	Strontium-90	Rhenium-187	Protactinium-231	Plutonium-240	
Chromium-51	Technetium-99	Mercury-203	Thorium-232	Americium-241	
Manganese-54	Cadmium-109	Thallium-204	Uranium-232	Plutonium-241	

Sources of radioactive material emissions to air at LLNL are divided into two categories for purposes of evaluating NESHAPs compliance: point sources and diffuse area sources. The former includes stacks, roof vents, and explosive experiments conducted on Site 300's firing tables; the latter are for the most part dedicated waste accumulation areas and other areas of known contamination, generally external to buildings.

Air Monitoring in 2005

Continuous stack-effluent sampling systems at selected LLNL facilities and ambient air monitors in place at numerous locations on and off LLNL sites are described in this section.

Continuous Stack Air Effluent Monitoring

Actual measurements of radioactivity in air and effluent flow are the basis for reported emissions from continuously monitored sources. In 2005, there were seven buildings (Buildings 235, 251, 331, 332, 491, and 695/696; the last two share a common stack) at the Livermore site and one building (the Contained Firing Facility, Building 801A) at Site 300 that had radionuclide air

effluent monitoring systems. These buildings are listed in **Table 2**, along with the number of samplers, the types of samplers, and the analytes of interest.

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 gross beta activity on a weekly or bi-weekly frequency depending on the facility. In most cases, passive filter 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 an unplanned 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. The Radiological Measurements Laboratory (RML) in LLNL's Hazards Control Department (HCD) performs the analyses.

Each stack of the Tritium Facility (Building 331) is monitored for tritium release by both an alarmed continuous monitoring system and by molecular sieve continuous samplers. The alarmed monitors provide real time tritium concentration release levels (HT, HTO, or other gaseous forms). The sieve samplers discriminate between tritiated water (HTO) vapor and molecular tritium (HT); they 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 put 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.

In addition to particulate monitoring for gross alpha and gross beta, the Decontamination and Waste Treatment Facility (DWTF) stack effluent has continuous monitoring for tritium with the use of a glycol bubbler. The bubbler uses a two-stage glycol impinging process. Stack air to be sampled enters the instrument and flows through two impingers in series capturing the HTO present. Next, the sampled air is directed through a palladium catalyst where oxidation of any HT in the sample takes place, converting HT to HTO. Then the HTO is collected in two more bottle impingers in series. The impingers are analyzed by the RML using liquid scintillation analysis. This type of sampling quantifies the amount of tritium for both species HT and HTO.

Environmental Protection Department (EPD) environmental analysts review data from air particulate sampling filters, molecular sieves, and the glycol bubbler.

Table 2. Air effluent sampling systems and locations.

Building	Facility	Analytes	Sample type	Number of samplers
235	Chemistry and Materials Science	Gross α, β on particles	Filter	1
251	Heavy Elements			
	Unhardened[a] area	Gross α, β on particles	Filters	24
	Hardened[a] area	Gross α, β on particles	Filters	4
		Gross α, β on particles	CAM[b]	2
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	15
491	Isotope Separation[c]	Gross α, β on particles	Filter	1
695/696	Decontamination and Waste Treatment Facility	Gross α, β on particles	Filter	1
		Gaseous tritium/tritiated water vapor	Glycol Bubbler	1
695 Yard	TRU Mover[d]	Gross α, β on particles	Filter	1
801A	Contained Firing Facility	Gross α, β on particles	Filter	1

Note: "CAM" denotes Eberline continuous air monitors.
[a] Hardening refers to seismic reinforcement.
[b] Alarmed systems.
[c] Isotope separation operations were discontinued; area now used for storage of contaminated parts.
[d] In January 2006, with the completion of TRU Mover activities, air effluent sampling was discontinued.

Results of Stack Monitoring for Tritium

Operations in the Tritium Facility (Building 331) in 2005 released a total of 32 Ci (1.2 TBq) of tritium. Of this, approximately 30 Ci (1.1 TBq) were released as HTO. The remaining tritium released, 2.0 Ci (7.4×10^{-2} TBq), was tritiated hydrogen gas (HT). The highest single weekly stack emission from the facility was 4.9 Ci (0.18 TBq), of which greater than 99% was HTO.

This 2005 level of tritium emissions continues to be low in comparison to those typically seen in the 1980's and 1990's, indicative of a reduced level of operations in the Tritium Facility. **Table 3** displays the combined HTO and HT emissions from the Tritium Facility since 1981.

Continuously monitored tritium releases from the stack of DWTF began in February of 2005. A total of 2.3 Ci (8.5×10^{-2} TBq) of measured tritium was released with 2.2 Ci (8.1×10^{-2} TBq) as HTO and 0.088 Ci (3.3×10^{-3} TBq) as HT. Since monitoring did not begin at the first of the year, an estimate emission of 0.47 Ci (1.7×10^{-2} TBq), was calculated by taking an average of measured emissions and applying it to the time period when monitoring was not in place. The

emissions for Building 801A were 4.2×10^{-7} Ci/y (1.6×10^{4} Bq/y) and 1.6×10^{-6} Ci/y (5.9×10^{4} Bq/y). Because more than ten percent of the weekly samples had values above the MDC, we have taken a conservative approach and are reporting gross alpha and gross beta measurements as actual emissions.

The resulting radiological dose to the maximally exposed individual (MEI) member of the public determined with CAP88-PC modeling was 1.1×10^{-5} mrem/y (1.1×10^{-6} μSv/y); doses are discussed in Sections III and IV and in Attachment 1.

Among the facilities monitored for particulate gross alpha and gross beta in 2005, only Building 801A (Site 300) showed emissions.

Air Surveillance Monitoring for Radioactive Particles and Gases

Surveillance air monitoring for tritium and radioactive particles has been in place since the early 1970s. LLNL currently maintains seven continuously operating, high volume, air particulate samplers on the Livermore site, nine in the Livermore Valley, eight at Site 300, and one in Tracy. LLNL also maintains eleven continuously operating tritiated water vapor samplers on the Livermore site, six in the Livermore Valley and one at Site 300. The samplers are positioned to provide reasonable probability that any significant airborne concentration of particulate or tritiated water vapor effluents resulting from LLNL operations will be detected. Several surveillance air monitors are placed near diffuse emission sources, such as those near Building 331 and in the Building 612 Yard, as well as in and around the Southeast Quadrant of the Livermore site. Their results can be used to estimate and/or confirm emissions from associated diffuse sources. Both an air particulate monitor and an ambient air tritium sampler are positioned at the location of the hypothetical maximally exposed member of the public (defined in Section III) for the Livermore site. Data from air surveillance monitors provide a valuable test of predictions based on air dispersion modeling and can help characterize unplanned releases of radioactive material.

Summary data are provided in **Table 4** and in Section VII, "Comparison of 2005 Modeling Results with Tritium Surveillance Air Monitoring Data." Detailed data from the surveillance air-monitoring network are presented annually in the LLNL Site Annual Environmental Report (SAER), which is available to the public in hardcopy form, on CD, and on the Internet at the address http://www.llnl.gov/saer.

Compliance Demonstration for Minor Radiological Sources

With the Environmental Protection Agency's (EPA) Region IX approval, LLNL demonstrates compliance for minor emissions sources (which are primarily non-monitored stack sources) through the use of existing ambient air monitoring data. The method entails comparing measured ambient air concentrations at the location of the site-wide maximally exposed individual (SW-MEI), defined in Section III, to concentration limits set by the U.S. EPA in its Table 2 of Appendix E to 40 CFR 61. The radionuclides for which the comparison is made are tritium and plutonium-239+240 for the Livermore SW-MEI and uranium-238 for the Site 300 SW-MEI. At the Livermore site, all 2005 monitoring results from the Discovery Center (VIS) and the UNCLE Credit Union (CRED) sampling locations (shown in **Figure 5** in Section VII) that are greater than zero are averaged to represent the SW-MEI for the purposes of this minor

surrogate for gross alpha, ^{137}Cs for gross gamma, and ^{90}Sr for gross beta and mixed fission products to provide conservative dose estimates. For a list of surrogate radionuclides, see Table 2-1 in the 2003 NESHAPs annual report (Harrach et al. *LLNL NESHAPs 2003 Annual Report*, UCRL-ID-11367-04, June 2004).

Population Inputs

The population distributions centered on the two LLNL sites are based on the LandScan Global Population 2001 Database (Dobson, J. E., E. A. Bright, P. R. Coleman, R.C. Durfee, B. A. Worley, LandScan: A Global Population Database for Estimating Populations at Risk, *Photogrammetric Engineering & Remote Sensing* Vol. 66, No. 7, July 2000, pp. 849-857; see also the Website http://www.ornl.gov/sci/landscan). The population distributions were developed using the geographic information system software, ArcView©, to construct five equidistant radial sectors in each of the 16 wind directions required by CAP88-PC. The population for each sector segment was determined by running code developed in the LandScan project and distributed with the LandScan Database. Key population centers affected by LLNL emissions are the 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 DOE, there are 7.1 million residents included for the Livermore site collective dose determination, and 6.2 million for Site 300.

Land Use and Agricultural Inputs

For agricultural parameters in CAP88-PC, LLNL used mean values for California based on data from the California Department of Food and Agriculture (CDFA 2002; California Department of Food and Agriculture Resource Directory 2002; http://www.cdfa.ca.gov/card/pdfs/cdfa_rd02.pdf). The mean values are shown in **Table 6**.

Table 6. CAP88PC's agricultural parameter values representing LLNL.

Parameter	Value
Beef cattle density (# cows/km^2)	1.9
Milk cattle density (# cows/km^2)	4.0
Land fraction cultivated for vegetable crops	0.046

For individual dose from ingestion, it was assumed that 25% of the vegetables and meat are home-grown, while the remaining 75% of vegetables and meat and 100% of the milk is imported (i.e., free from LLNL-generated radioactivity). For collective dose, the urban default choice in CAP88-PC was used (in which 7.6% of vegetables, 0% of milk, and 0.8% of meat are home-grown, with the balances obtained from the assessment area exposed to the released radioactivity).

Emission Source Terms

The source term for each emission source in the calculations was determined by one of three methods. For continuously monitored sources, the sampling data (curies released per unit time) for each radionuclide were used directly. For sources qualifying as "minor sources," ambient air

At the Livermore site, the SW-MEI for 2005 was found, as usual, to be located at the UNCLE Credit Union, about 10 m outside the controlled eastern fence line of the site, but about 10 m within the perimeter of the site property, as shown in **Figure 3**. At Site 300, the 2005 SW-MEI was located, as in the past several years, at the boundary with the Carnegie State Vehicle Recreation Area, managed by the California Department of Parks and Recreation, approximately 3.2 km south-southeast of the firing table at Building 851, as shown in **Figure 4**.

Doses to the SW-MEIs were evaluated for each source and then totaled for site-specific evaluations against the 10 mrem/y (100 μSv) dose standard (see "Total Dose to Site-Wide Maximally Exposed Individuals" in Section IV).

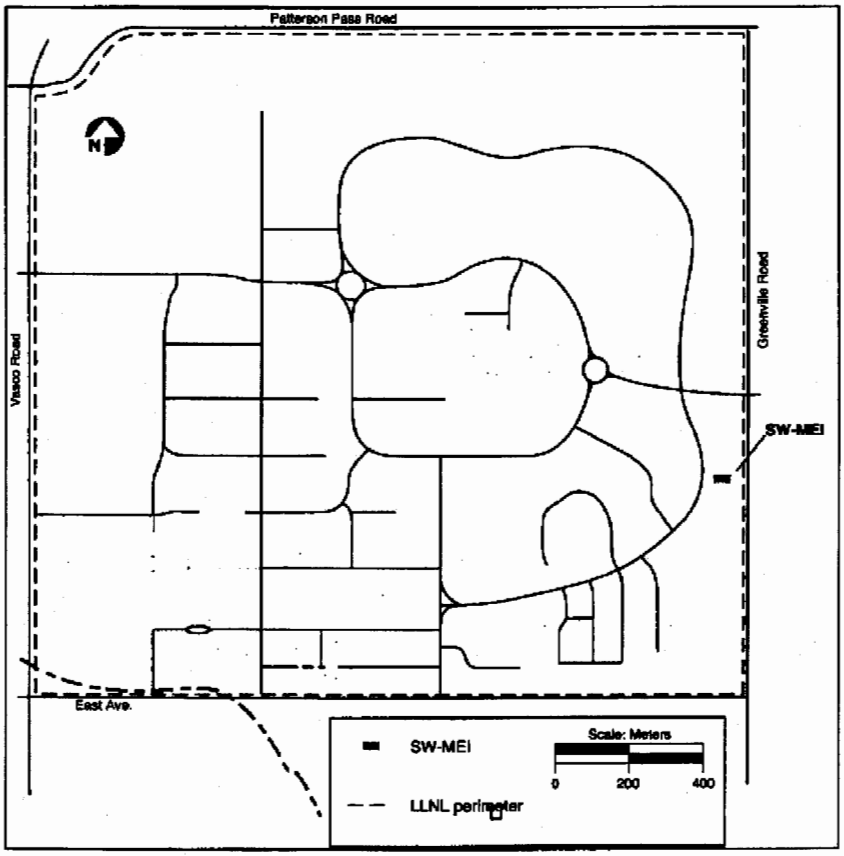

Figure 3. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at the Livermore site, 2005.

Maximally Exposed Public Individual

To assess compliance with the EPA requirement for continuous monitoring of a release point (potential dose greater than 0.1 mrem/y [1.0 μSv/y]), emissions must be individually evaluated from each point source to determine the dose to the maximally exposed individual (MEI) member of the public. The location of the MEI is generally different for each emission point, and must occur at a location of unrestricted public access. Typically, this location is a point on

the site perimeter, prompting the MEI dose to be referred to as the maximum "fence line" dose. However the off-site maximum dose can occur some distance beyond the perimeter, e.g., when a facility stack is close to the perimeter. Modeling calculations show that ground level concentrations of radionuclides can be expected to reach maximum values beyond the LLNL boundaries for releases from the DWTF stack on the Livermore site and dispersals from open-air explosives experiments conducted at Site 300. As stipulated by the regulations in 40 CFR Section 61.93 (b)(4)(ii), modeling for evaluation of the need for continuous monitoring must assume unabated emissions (i.e., no credit can be taken for emission abatement devices, such as filters). Model run documentation typically includes evaluation of the dose to the MEI, specification of emission abatement factors (in place but not credited for the required monitoring evaluation), and the distance and direction to the LLNL fence line point where (or beyond which) the MEI is located; see Attachment 1.

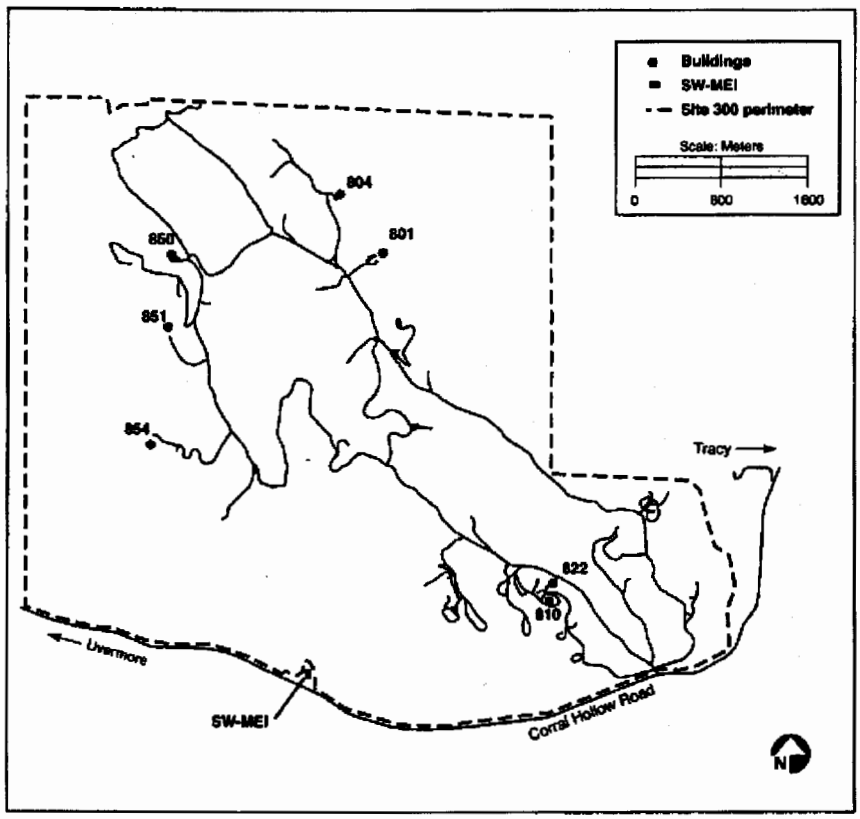

Figure 4. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 2005.

SECTION IV. Results of 2005 Radiological Dose Assessment

This section summarizes the doses to the most exposed public individuals from LLNL operations in 2005, shows the comparison to previous years, presents the potential doses to the populations residing within 80 km of either the Livermore site or Site 300, and summarizes LLNL's compliance with 40 CFR 61, Subpart H (61.93).

Total Dose to Site-Wide Maximally Exposed Individuals

The total dose to the Livermore site SW-MEI from operations in 2005 was 0.0065 mrem (0.065 μSv). Of this, 0.0027 mrem (0.027 μSv), or 41%, was contributed by point sources, while diffuse emissions accounted for 0.0038 mrem (0.038 μSv), or 59%, of the total. The point source dose includes Tritium Facility HT emissions modeled as HTO, as directed by EPA Region IX. (See "Modeling Dose from Tritium" in Section VII for changes [decreases] in the dose from tritium when this assumption is not used.)

This SW-MEI dose is the lowest reported for the Livermore site since 1990, when NESHAPs reporting commenced. There were no significant changes in LLNL operations or changes to modeling assumptions in 2005, and so this dose is comparable to the value reported for 2004. The most significant factors leading to this and the 2004 low dose were the relatively low level of operations and emissions from the Tritium Facility (**Table 3**) and a readjustment of the food intake assumptions (see "Land Use and Agricultural Inputs" in Section III, *LLNL NESHAPs 2004 Annual Report*, Harrach et al., UCRL-ID-113867-05, June 2005). The reorganization of operations of the Radioactive and Hazardous Waste Management Division (see "Changes in Operations and Facilities" in Section VI) was also a contributing factor, although a far less significant one.

The total dose to the Site 300 SW-MEI from operations in 2005 was 0.018 mrem (0.18 μSv). Point source emissions from firing table explosives experiments accounted for about 48% of this total, while 52% was contributed by diffuse sources. The total dose to the Site 300 SW-MEI was comparable to historical values, although the percent contributions from point and diffuse sources did not reflect the typical values reported over the last decade. The reason for the change is the coincident occurrences at Site 300 of decreased Building 851 Firing Table activities and increased soil resuspension, attributable to an extensive wildfire in July.

Table 8 shows the facilities or sources that collectively accounted for 98% or more of the doses to the SW-MEI for the Livermore site and Site 300 in 2005. Although LLNL has more than 150 sources with potential for releasing radioactive material to air according to NESHAPs prescriptions, most are very minor. Each year, nearly the entire radiological dose to the public from LLNL operations comes from no more than a dozen sources.

Table 8. Ranked list of facilities or sources whose emissions collectively accounted for nearly 100% of the SW-MEI doses for the Livermore site and Site 300 in 2005.

Facility (Source Category)	CAP88-PC Dose in mrem/y	CAP88-PC Percentage Contribution to Total Dose
Livermore site		
Building 331 stacks (point source)	0.0026	40%
Building 612 Yard (diffuse source)	0.0020	31%
Building 331 outside (diffuse source)	0.0012	18%
Southeast Quadrant (diffuse source)	0.00061	9%
Site 300		
Soil resuspension (diffuse source)	0.0094	52%
Building 851 Firing Table (point source)	0.0088	48%

Table 9 compares 2005 doses with those of previous years. Diffuse source doses were not reported for the Livermore site for 1990 and 1991. In addition, no diffuse emissions were reported at Site 300 for years before 1993, so a comparison of the total Site 300 dose can only be made for 1993 and later.

Table 9. Doses (in mrem) calculated for the Site-Wide Maximally Exposed Individual (SW-MEI) for the Livermore site and Site 300, 1990 to 2005.

Year	Total Dose	Point Source Dose	Diffuse Source Dose
Livermore site			
2005	0.0065[a]	0.0027[a]	0.0038
2004	0.0079[a]	0.0021[a]	0.0058
2003	0.044[a]	0.024[a]	0.020
2002	0.023[a]	0.010[a]	0.013
2001	0.017[a]	0.0057[a]	0.011
2000	0.038[a]	0.017[a]	0.021
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]

Table 9. Continued

Year	Total Dose	Point Source Dose	Diffuse Source Dose
Site 300			
2005	0.018	0.0088	0.0094
2004	0.026	0.025	0.00086
2003	0.017	0.017	0.00034
2002	0.021	0.018	0.0033
2001	0.054	0.050	0.0037
2000	0.019	0.015	0.0037
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. Modeling HT emissions as such results in an overestimation of the dose. This methodology is used for purposes of compliance, as directed by EPA Region IX.

[b] Diffuse source doses were not reported for the Livermore site for 1990 and 1991.

[c] No diffuse emissions were evaluated at Site 300 for years before 1993.

Doses from Unplanned Releases

There were no unplanned atmospheric releases of radionuclides at the Livermore site or Site 300 in 2005.

Population Doses

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. This air dispersion and dose assessment model evaluates the four principal exposure pathways: ingestion through water (for tritium only) and food consumption, inhalation, air immersion, and irradiation by contaminated ground surface.

The CAP88-PC result for potential collective dose attributed to 2005 Livermore site operations was 1.2 person-rem (0.012 person-Sv); the corresponding collective EDE from Site 300 operations was 1.7 person-rem (0.017 person-Sv). For the Livermore site, this population dose is attributable to tritium, and for Site 300, the isotopes in depleted uranium (^{238}U, ^{235}U, and ^{234}U). The value for the Livermore site collective dose from tritium was slightly higher than in 2004 as anticipated from the higher release rate of tritium from the Tritium Facility in 2005. These potential collective dose values are both quite small and within the normal range of variation seen from year to year. By way of comparison, the collective dose to the roughly 7 million people within 80 km of LLNL's two sites from exposure to the average level of natural background radioactivity in the United States is two million person-rem (twenty thousand person-Sv).

The collective doses from LLNL are high relative to many other DOE facilities because of the large populations lying within 80 km of the Livermore site and Site 300. Although the collective doses may be the same, a large dose to a small number of people is not equivalent to a small dose to many people. A better way to present the collective doses from LLNL operations is to disaggregate them into categories of individual dose, which demonstrates the tiny doses received by all of the population.

For the Livermore site, population doses from stack and area releases of tritium may be broken down as shown in **Table 10**. It can be seen in the table that the individuals that make up more than 99% of the population received less than 0.001 mrem/y (0.01 μSv/y).

Table 10. Disaggregations of collective dose for the Livermore site, 2005.

Individual dose mrem/y	Collective dose person-rem/y	Percent total collective dose
0.001 to 0.01	0.005	0.4%
0.0001 to 0.001	0.72	61.0%
0.00001 to 0.0001	0.34	28.9%
0.000001 to 0.00001	0.11	9.7%
Total*	1.2	100%

* 0.05% of the individuals in the population received a dose of less than 0.000001 mrem/y.

Collective doses can be broken down similarly for the shots from the Building 851 Firing Table and the Contained Firing Facility at Site 300, as shown in **Table 11**. In this case individuals that make up about 94% of the population receive less than 0.001 mrem/y (0.01 μSv/y).

Table 11. Disaggregations of collective dose for Site 300, 2005.

Individual dose mrem/y	Collective dose person-rem/y	Percent total collective dose
0.001 to 0.01	0.11	6.3%
0.0001 to 0.001	1.06	62.0%
0.00001 to 0.0001	0.51	29.6%
0.000001 to 0.00001	0.03	2.0%
0.000000001 to 0.000001	0.003	0.2%
Total	1.7	100%

Compliance with 40 CFR 61 Subpart H (61.93)

Calculations of effective dose equivalents for Livermore site and Site 300 facilities having the potential to release or releasing radioactive material to the atmosphere were found to be well below the 10 mrem (100 μSv) NESHAPs dose standard for dose to the maximally exposed individual members of the public. Tritium accounted for 91% of the Livermore site calculated dose, while at Site 300 the entire calculated dose was due to the isotopes ^{238}U, ^{235}U, and ^{234}U, in depleted uranium.

In 2005, there were seven buildings (Buildings 235, 251, 331, 332, 491, 695, and 696) at the Livermore site and one (Building 801A, the Contained Firing Facility) at Site 300 that had radionuclide air effluent monitoring systems. (Buildings 695 and 696 in the DWTF complex vent through a common stack.) These buildings are listed, along with the number of samplers, the types of samplers, and the analytes of interest in **Table 2** of Section II.

LLNL remains committed to monitoring stack effluent air from its Tritium Facility (Building 331), Plutonium Facility (Building 332), Decontamination and Waste Treatment Facility (Buildings 695 and 696), Contained Firing Facility (Building 801A), and the seismically hardened area of its Heavy Element Facility (Building 251). In addition, other facilities are continuously monitored, as necessary, based on evaluations of potential emissions without control devices, as in the case of Building 235, or where classification or other issues prevent a usage-inventory-based evaluation.

SECTION V. Certification

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: William A. Bookless
Associate Director
Safety and Environmental Protection
Lawrence Livermore National Laboratory
7000 East Avenue, L-668
Livermore, CA 94550

Signature: _____ **Date:** 6/23/06
William A. Bookless

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. See 18 U.S.C. 1001.

Name: Phillip Hill
Technical Deputy
Safety and Environmental Programs
U.S. Department of Energy
7000 East Avenue, L-293
Livermore, CA 94550

Signature: _____ **Date:** 6/29/06
Phillip Hill

SECTION VI. Supplemental Information on NESHAPs Compliance and QA/QC Activities

Periodic Confirmatory Measurements

Results of NESHAPs periodic confirmatory measurements (PCM) are intended to support or confirm two objectives: (1) that those operations not continuously monitored do not, in fact, need to be continuously monitored and (2) that radionuclide usage-inventory-based estimates of emissions and their corresponding doses are conservative.

For sources evaluated to have a potential to result in a dose less than the regulatory value of 0.1 mrem/y that requires continuous monitoring under Subpart H, LLNL achieves the PCM objectives by fulfilling the requirements stated in 40 CFR 61.93 paragraph (e) with its ambient air monitoring program. The ambient air monitoring effort includes thirty sampling locations with more than forty samplers placed in strategic areas (see the Air Monitoring Programs section in the LLNL Site Annual Environmental Report [http://www.llnl.gov/saer] for a description of LLNL's ambient air radiological monitoring).

NESHAPs Quality Assurance (QA) Program

The LLNL NESHAPs quality assurance program is a multi-organizational effort. Its major components are the LLNL facilities/programs that have continuous stack effluent monitoring systems; the Radiological Measurements Laboratory (RML) and the Hazards Control Analytical Laboratory (HCAL), both in the Hazards Control Department (HCD); and the Environmental Protection Department (EPD). To coordinate the activities of these organizations, NESHAPs Agreement of Roles and Responsibilities (NARRs) documents are in place between EPD and the facilities and/or programs and HCD. NARRs formalize responsibilities and obligations of the organizations regarding many tasks for the air effluent sampling network. Tasks that are addressed in the NARRs 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 archiving of records.

The NESHAPs quality assurance project plan is included in the "NESHAPs Compliance Guidance Document and Quality Assurance Project Plan (G. Gallegos, EMP-NS-S, 2006). This document recites the key elements of the NESHAPs Quality Assurance Project Plan (QAPP) as specifically prescribed by 40 CFR 61, App. B, Method 114. Because LLNL's NESHAPs quality assurance activities are conducted by two LLNL departments, EPD and HCD, the documentation for the elements of a complete quality assurance project plan are independently maintained by these organizations. The NESHAPs QAPP presents a cross-walk between the requirements of a complete QAPP, the documents that meet those requirements, and the responsible organizations.

A general overview of these requirements and the responsible organizations is as follows. EPD is responsible for an annual assessment and demonstration of LLNL's compliance with NESHAPs, as documented in the present report. EPD's Terrestrial and Atmospheric Monitoring and Modeling (TAMM) Group is responsible for environmental monitoring; calibration, inspection, and maintenance of all stack sampling activities; air dispersion and dose assessment

by CAP88-PC are used as input. For the principal comparison of the total tritium contribution to the Livermore site SW-MEI dose in 2005 calculated using NEWTRIT instead of CAP88-PC, the result was 0.0051 mrem (0.051 μSv), about 15% lower than the CAP88-PC value of 0.0059 mrem (0.059 μSv). Both NEWTRIT and CAP88-PC doses for each significant source of tritium are presented in the data spreadsheet (columns 16 and 19) in Attachment 1.

In October 2001, LLNL sent a letter to EPA Region IX requesting consideration of NEWTRIT as an alternative methodology for calculating doses from atmospheric releases of tritiated water vapor (HTO) and tritiated gas (HT) for use in demonstrating compliance with radionuclide NESHAPs (40 CFR 61 Subpart H). In late 2003, the EPA had NEWTRIT coded into GENII-NESHAPs, a version of GENII that the EPA plans to approve as a regulatory model for evaluating radionuclide NESHAPs compliance (B.A. Napier, et al., GENII - The Hanford Environmental Radiation Dosimetry Software System. Richland, WA: Pacific Northwest Laboratory, PNL-6584 Vol. UC-60; 1988). At this writing, GENII-NESHAPs is undergoing peer review and should be approved soon. As well, DOE surveyed users of CAP88-PC (currently the code most-used for compliance) and determined that there is support to have NEWTRIT incorporated into EPA's CAP88-PC. However, NEWTRIT was not coded into CAP88-Pc Version 3.0, approved February 2006.

Comparison of 2005 Modeling Results with Tritium Surveillance Air Monitoring Data

A comparison was made between CAP88-PC-predicted concentrations of tritium in air and ambient air monitoring data for nine tritiated water vapor samplers on the Livermore site (designated POOL, CAFE, MET, CRED, VIS, DWTF, COW, B331, and B624). Other locations (MESQ, SALV, and ZON7) that have been used for the comparison in past years were sampled normally, but more than half of their biweekly concentrations were below the lower limits of analytical detection, making any comparison with predicted results meaningless. **Figure 5** shows the locations of the tritium air surveillance monitors. Modeled predictions have been compared with tritium monitoring data since 1997.

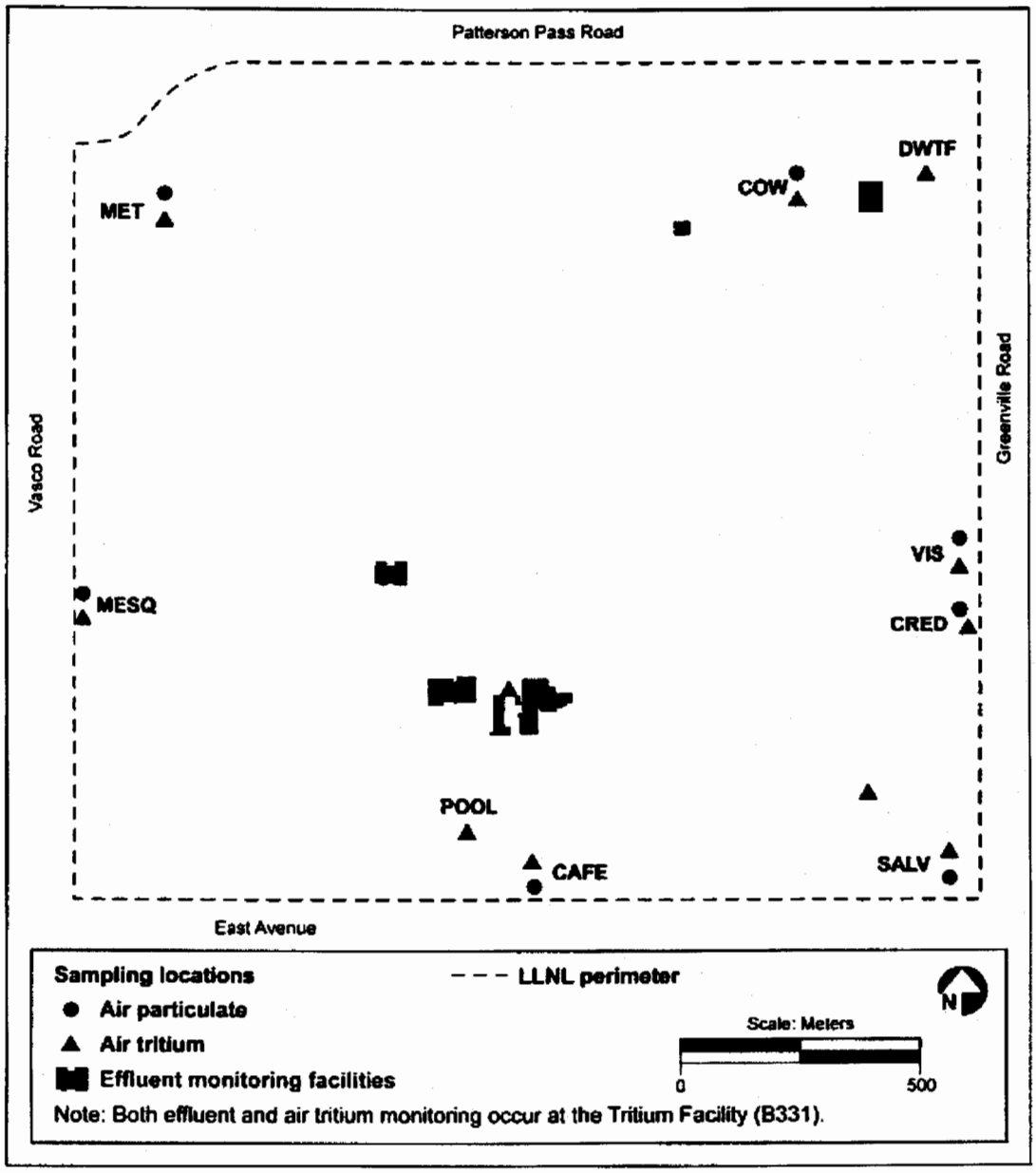

Figure 5. Radiological air monitoring at the Livermore site showing locations for air surveillance monitoring of tritiated water vapor (triangles) and radioactive particles (circles) and stack air effluent monitoring (indicated by building number and icon).

Only the four most significant sources of tritium releases to air at the Livermore site (B331 stacks, B331 Outside Yard, B612 Yard, and DWTF Stack) were included in the initial model-data comparison. The release of HTO from the two 30-m-high, continuously monitored stacks at the Tritium Facility (Building 331) was determined from stack monitoring data and emission reconstruction to be 30.2 Ci (1.1×10^{12} Bq) in 2005. (An estimated 1.57 Ci [5.8×10^{10} Bq] of

Table 12. Comparison of measured and modeled annual mean concentrations of tritiated water vapor (HTO) in air at selected Livermore site locations, 2005.

Air monitor (name)	Mean measured concentration (pCi/m^3)	Modeled* average concentration (pCi/m^3)	Ratio of modeled-to-measured concentrations	Modeled concentration of tritium in air contributed by the indicated source (pCi/m^3)				
				B331 Stacks	B612 Yard	B331 WAA	DWTF Stack	DWTF Outside
B331	21.7	22.9	1.1	0.041	0.75	22	0.058	0.019
B624	40.5	42.5	1.0**	1.2	40.5	0.26	0.027	0.0095
DWTF	3.75	5.29	1.4	0.95	0.14	0.17	0.23	3.8
POOL	3.37	4.78	1.4	1.5	0.63	2.6	0.039	0.014
COW	2.87	2.13	0.74	1.05	0.14	0.24	0.014	0.690
MET	1.30	0.802	0.62	0.43	0.088	0.21	0.044	0.03
CRED	1.29	2.71	2.1	1.10	1.3	0.26	0.031	0.016
VIS	1.27	2.21	1.7	1	0.94	0.22	0.029	0.022
CAFÉ	1.12	1.91	1.7	0.64	0.59	0.64	0.030	0.010

* This result takes into account the four most significant tritium sources and a minor source near the DWTF; it is the annual-mean concentration comprising the sum of the five contributions shown in the far right columns.

** This agreement was obtained by calibration.

SECTION VIII. Supplemental Information on Other Compliance

Status of Compliance with Other Regulations

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

LLNL does not have storage and disposal facilities for radium containing materials that would be a significant source of radon. Emissions of radon from LLNL research experiments did not occur in 2005.

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.

Attachment 1 - 2005 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)	0 mremy Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mremy Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Sc Cert
LIVERMORE SITE POINT SOURCES																			
Building 235 is part of the Chemistry and Materials Sciences Directorate. Operations in the facility include examination of material structure, surfaces, and subsurface; precision cutting, ion implanting, and metallurgical studies.																			
235	1130	FHE-1A/1B, FHE2A/2B, and FGBE-1A/1B through FHE-1000/2000	Preparation of plutonium samples for diamond anvil studies	Gross alpha Gross beta	* *	NA NA	10.7	0.30	7.2	Double HEPA	0.0001	0.0E+00 0.0E+00	1065	ENE	0.0E+00	*	*	*	
Building 251, the Heavy Element Facility, is managed by the Safety and Environmental Protection Directorate for the institution as a non-operational facility in which transuranic isotopes remain 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 sample filter systems.																			
	Unhardened Area[2]																		
251	1003	FHE-5	General chemistry	Gross alpha	*	NA	4.3	0.28	7.8	HEPA	0.01	0.0E+00	1188	E	5.8E-07	*	*	*	
	1003	FHE-4		Gross beta			4.3	0.27	7.8			0.0E+00							
	1142	FHE-8					4.3	0.32	3.6										
	1142	FHE-9					4.3	0.26	4.7										
	1142	FHE-10					4.8	0.28	5.1										
	1150	FGBE-33,34					6.0	0.13	2.4										
	1150	FFE-11					4.3	0.31	4.8										
	1166	FGBE-31,32					5.6	0.07	2.9										
	1211	FHE-6					6.4	0.25	6.0										
	1211	FHE-7					6.4	0.25	4.6										
	1212	FGBE-15,16					5.6	0.10	7.4										
	1232	FGBE-38,39					7.2	0.15	5.2										
	1234	FFE-9					4.3	0.19	2.6										
	1236	FFE-12					4.3	0.28	7.4										
	1236	FGBE-39,50					5.6	0.13	9.3										
	1363	FHE-12					4.3	0.32	9.3										
	1363	FHE-13					6.4	0.28	7.8										
	1364	FFE-23					4.3	0.34	11.9										
	1364	FGBE-55,56					4.3	0.13	5.4										
	1314, 1364	FGBE-44,45					10.2	0.16	2.6										
	Hot cells	FGBE-40,41					5.5	0.23	3.4										
	Hot cells	FGBE-42,43					5.5	0.38	9.6										
	1150	FFE-13					5.6	0.28	4.8										
	Hardened Area																		
251	Glove Boxes[1]	FGBE-1000 FGBE-2000	Previous transuranic research	Gross alpha Gross beta	*	NA	7.8 7.8	0.30 0.30	5.5 5.5	Triple HEPA	0.000001	0.0E+00 0.0E+00	1188	E	0.0E+00	*	*	*	
	Room Exhaust[2]	FFE-1000 FFE-2000		Gross alpha Gross beta	*	NA	7.8 7.8	0.50 0.60	11.2 10.8	Double HEPA	0.0001	0.0E+00 0.0E+00	1188	E	0.0E+00	*	*	*	
Building 331 is operated by the Defense and Nuclear Technologies Directorate. The building houses the tritium research facility and associated laboratories.																			
331	All[2]	Stack 1 Stack 2	Tritium research and development Decontamination of parts	H-3 H-3	* *	1.0E+00 1.0E+00	30.0 30.0	1.22 1.22	5.4 7.4	None None	1 1	3.2E-01 3.1E+01	957	ENE	2.6E-03 2.2E-03[a]	573	SW	2.9E-03 2.4E-03[a]	
Building 332 is operated by the Defense Sciences Program for plutonium research. Exhausts from glove box operations and the workplace are triple 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).																			
332	Increment 1 Rooms	FHE-1000/2000	Plutonium research	Transuranics	*[1]	NA	5.6	0.8±1.1	16.7	Double HEPA	0.0001	0.0E+00	912	ENE	0.0E+00	*	*	*	
332	Increment 1 Glove boxes	FGBE-1000/2000	Plutonium research	Transuranics	*[1]	NA	11	0.3	5.2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	*	*	*	
332	Lab	FE-4,SW FE-4,SE	Lab exhaust Lab exhaust	Transuranics Transuranics	*[1] *[1]	NA NA	11 11	0.6±0.9 0.6±0.9	3.8 3.3	HEPA HEPA	0.01 0.01	0.0E+00 0.0E+00	912 912	ENE ENE	0.0E+00 0.0E+00	* *	* *	* *	
332	Increment 1 Glove boxes	FGBE-3000/4000	Plutonium research	Transuranics	*[1]	NA	11	0.3	5.4	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	*	*	*	
332	Increment 3	FFE-1000/2000	Plutonium research	Transuranics	*[1]	NA	10.1	0.9	10.4	com--Double HEP	0.0001	0.0E+00	912	ENE	0.0E+00	*	*	*	
	Room and Glove boxes	FGBE-7000/8000	Plutonium research	Transuranics	*[1]	NA	10.1	0.27	2.9	ng Box--Triple HE	0.000001	0.0E+00			0.0E+00	*	*	*	
Building 491 is operated by the Space Action Team as an area for the storage of contaminated parts. Isotope separation activities that previously occurred in this building have been discontinued. Stack sampling is continuous. The facility operates with two in-series high efficiency particulate (HEPA) filter banks to control emissions.																			
491	All	FFE-1	Storage	Gross alpha Gross beta	*	NA	5.1	0.9	5.1	Double HEPA	0.0001	0.0E+00	1000	SSE	0.0E+00	*	*	*	
Building 695/696 is the Decontamination Waste Treatment Facility operated by Radiological and Hazardous Waste Management Division. All operations are HEPA filtered and have pre-filters in place; some operations have additional HEPA filtration.																			
695/696	DWTF	FHE 1000/2000/3000	Waste treatment	Gross alpha Gross beta	* *	NA NA	20.0	1.96	10.6	HEPA Pre-filter	0.01 0.1	0.0E+00 0.0E+00	953	S	8.4E-08 7.2E-08[a]	198	ENE	0.00074[a] 8.7E-04[a]	

Attachment 1 - 2005 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Releases (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)	Sys Calc
				Tritium	*	NA						2.7E+00							
SITE 300 POINT SOURCES																			
Building 801 is the Contained Firing Facility, where explosives tests are conducted. This facility and the 851 Firing Table are operated by the Defense and Nuclear Technologies Directorate.																			
801	Contained Firing Facility	FEFH-1, FE-2	Explosive tests	U-238	*	NA	16.8	1.60	7.8	HEPA	0.01	4.2E-07	3170	S	7.9E-07				
				U-235	*	NA				Pre-filter	0.1	8.4E-10							
				U-234	*	NA						2.1E-12							
Explosive tests in which radionuclides may be present are conducted on open-air firing tables located at Bunker 851. These tests have depleted uranium material as part of the material inventory. There are multiple tests per year.																			
851	Firing Table	None	Explosive tests	U-238	8.9E-03	1	NA	NA	NA	None	1	8.9E-03	3170	SSE	8.8E-03	1396	WSW	8.9E-03	
				U-235	1.1E-04	1						1.1E-04							
				U-234	8.3E-04	1						8.3E-04							
LIVERMORE SITE DIFFUSE SOURCES																			
Building 331 - Contaminated equipment outside the facility is awaiting transport and storage by Radioactive and Hazardous Waste Management.																655	W	1.8E-05	
331	Outside	None	Storage of contaminated parts	Tritium	NA	1	NA	NA	NA	None	1	4.8E+00	957	ENE	1.2E-03	441	SSW	3.0E-03	
															1.0E-03			4.5E-03	
The Building 612 Yard is operated by the Radioactive and 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.																			
612	Yard	Area Source	Storage of low level waste	Tritium	NA	NA	NA	NA	NA	None	1	1.5E+00	444	NE	2.0E-03	212	SSW	6.1E-03	
															1.0E-03			6.4E-03	
Building 695/696 is the Decontamination Waste Treatment Facility operated by Radiological and Hazardous Waste Management Division.																			
695	Yard	Transportainer	Temporary storage of waste	Tritium	NA	1	NA	NA	NA	None	1	2.1E-01	676	S	3.7E-06	191	ENE	2.9E-03	
															3.3E-05			2.9E-03	
The Southeast Quadrant of the Livermore Site has slightly elevated levels of Pu-239 in the surface soil and air. 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	NA	NA	6.1E-04	NA	NA	NA	
SITE 300 DIFFUSE SOURCES																			
Diffuse sources consist of resuspension of depleted uranium from historical explosive tests.																			
Site 300	All	Area Source	Soil resuspension	U-238	NA	NA	NA	NA	NA	None	1	NA	NA	NA	9.4E-03	NA	NA	NA	
				U-235	NA	NA						NA							
				U-234	NA	NA						NA							
EMISSION SOURCES THAT ACCOUNT FOR NEARLY 100% OF THE POTENTIAL EFFECTIVE DOSE EQUIVALENT AT EACH SITE.																			
LIVERMORE SITE SOURCES																			
331	All*	Stack 1	Tritium research and development	H-3	*	1.0E+00	30.0	1.22	5.4	None	1	5.2E-01	957	ENE	2.0E-03	373	SW	2.9E-03	
		Stack 2	Decontamination of parts	H-3	*	1.0E+00	30.0	1.22	7.4	None	1	3.1E+01			3.2E-03*			2.4E-03*	
612	Yard	Area Source	Storage of low level waste	Tritium	NA	NA	NA	NA	NA	None	1	1.5E+00	444	NE	2.0E-03	212	SSW	6.1E-03	
															1.8E-03			6.4E-03	
331	Outside	None	Storage of contaminated parts	Tritium	NA	1	NA	NA	NA	None	1	4.8E+00	957	ENE	1.2E-03	441	SSW	3.0E-03	
															1.0E-03			4.5E-03	
Southeast Quadrant		Area Source	Resuspension	Pu-239	NA	NA	NA	NA	NA	None	1	NA	NA	NA	6.1E-04	NA	NA	NA	
SITE 300 SOURCES																			
Site 300	All	Area Source	Soil resuspension	U-238	NA	NA	NA	NA	NA	None	1	NA	NA	NA	9.4E-03	NA	NA	NA	
				U-235	NA	NA						NA							
				U-234	NA	NA						NA							
851	Firing Table	None	Explosive tests	U-238	8.9E-03	1	NA	NA	NA	None	1	8.9E-03	3170	SSE	8.8E-03	1396	WSW	8.9E-03	
				U-235	1.1E-04	1						1.1E-04							
				U-234	8.3E-04	1						8.3E-04							

NOTE: 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.

*Gross alpha and Gross beta emissions are continuously monitored at the stack.

*Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion in Section II, subsection "Stack Monitoring for Gross Alpha and Gross Beta Radiation.").

*Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.

*Tritium HT and HTO emissions from the stack are continuously monitored.

*The dose from HT and HTO emissions calculated using the NEWTRIT model; see discussion in Section VII, "Modeling Dose.

*The air monitoring data for all emission points show no detectable released alpha activity, i.e., the measurements are at or below the limit of sensitivity of the analytical method.

*Air emissions are continuously sampled at the post-HEPA-filter atmospheric discharge points, although potential emissions are low enough that stack monitoring is not required per the NESHAPs 40 C

*The unabated EDE shown is only for the tritium source term.

*Except for high-bay exhaust that is not HEPA-filtered, monitoring takes place after HEPA filtration, and an unabated EDE cannot be determined (see discussion in Section II, "Stack Monitoring for Gross Alpha and G

*The dose from HTO emissions calculated using the NEWTRIT model; see discussion in Section VII, "Modeling Dose from T.