Chapter 4

Air Monitoring Programs

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Lawrence Livermore National Laboratory performs continuous air sampling to evaluate its compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected. Federal environmental air quality laws and U.S. Department of Energy (DOE) regulations include Title 40 of the *Code of Federal Regulations Part 61* (40 CFR Part 61)—the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act; applicable portions of DOE Order 5400.5, Radiation Protection of the Public and the Environment; and American National Standards Institute (ANSI) standards. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) provides the guidance for implementing DOE Order 5400.5.

The U.S. Environmental Protection Agency (EPA) Region IX has enforcement authority for LLNL compliance with radiological air emissions regulations. Enforcement authority for the Clean Air Act regulations pertaining to nonradiological air emissions belongs to two local air districts, the Bay Area Air Quality Management District (BAAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD).

LLNL conducts air effluent monitoring of atmospheric discharge points to measure the quantity of radionuclides released from individual facilities during routine and nonroutine operations. LLNL also conducts ambient air monitoring at on- and off-site locations to determine whether airborne radionuclides or beryllium are being released to the environs in measurable quantities by LLNL operations. Ambient air monitoring also serves to verify the air concentrations predicted by air dispersion modeling and to determine compliance with NESHAPs regulations. See Larson et al. (2007).

4.1 Air Effluent Monitoring

For research purposes, LLNL uses a variety of radioisotopes including uranium, transuranic radionuclides, biomedical tracers, tritium, and mixed-fission products. The principal radionuclide released to the atmosphere from the Livermore site is tritium. A number of facilities at the Livermore site have air effluent samplers to detect the release of tritium, uranium, and transuranic aerosols. The air effluent samplers described in this section apply to stationary point source discharges.

Air effluent monitoring of atmospheric discharge points is used to determine the actual radionuclide releases from individual facilities during routine and nonroutine operations and to confirm the operation of facility emission control systems. Air effluent and ambient air monitoring measurements are compared to confirm their expected relationship and to help resolve unexpected ambient air monitoring results when necessary. Air effluent monitoring involves the extraction of a measured volume of air from the exhaust of a facility and subsequent collection of particles by filters or of vapors and gas by a collection medium. After collection, the various radionuclides in the sample are measured by appropriate analytical methods.

Currently, the air effluent sampling program measures only radiological emissions. For LLNL operations with nonradiological discharges, LLNL obtains permits from local air districts (i.e., BAAQMD and SJVAPCD) when applicable. Current permits do not require monitoring of air effluent but do require monitoring of equipment usage, material usage, and record keeping during operations. Based on air toxics emissions inventory and risk assessment required by the California Air Toxics "Hot Spots" Information and Assessment Act of 1987, BAAQMD and SJVAPCD have ranked LLNL as a low-risk facility for nonradiological air emissions.

4.1.1 Methods

LLNL evaluates all discharge points with the potential to release radionuclides to the air according to 40 CFR Part 61, Subpart H, of the NESHAPs regulations. Subpart H regulations require continuous monitoring of facility radiological air effluents if the potential off-site dose

Table 4-1. Air effluent sampling locations, analytes, sampler types, and number of samplers at the Livermore site and Site 300 in 2006.

Site	Facility	Analytes	Sampler type	No. of samplers
Livermore site	Chemistry, Materials, and Life Sciences	Gross α, β on particles	Filter	1
	Heavy Element Facility	Gross α, β on particles	Stack CAM[a,b]	2
		Gross α, β on particles	Filter	28
	Tritium Facility	Tritium	Stack ionization chamber[a]	4
		Gaseous tritium and tritiated water vapor	Molecular sieves	2
			Glycol bubbler	2
	Plutonium Facility	Gross α, β on particles	Stack CAM[a,b]	12
		Gross α, β on particles	Filter	15
	Laser Isotope Separation Facility[c]	Gross α, β on particles	Filter	1
	Decontamination and Waste Treatment Facility	Gross α, β on particles	Filter	1
		Gaseous tritium and tritiated water vapor	Glycol bubbler	1
Site 300	Contained Firing Facility	Gross α, β on particles	Filter	1

(a) Alarm systems (real-time).

(b) CAM = Eberline continuous air monitor (real-time).

(c) Isotopic separation operations have been discontinued; area now used for storage of contaminated parts.

equivalent is greater than 1 microsievert per year (μSv/y) (0.1 millirem per year [mrem/y]), as calculated using the EPA-mandated air dispersion dose model and assuming there are no emission control devices. Results of monitoring air discharge points provide the actual emission source information for modeling, which is used to ensure that the NESHAPs standard, 100 μSv/y (10 mrem/y) total site effective dose equivalent, is not exceeded (see **Chapter 7** for further information on radiological dose assessment). Monitoring of radionuclide air effluents at LLNL has been implemented according to the DOE as low as reasonably achievable (ALARA) policy. This policy is meant to ensure that DOE facilities are capable of monitoring routine and nonroutine radiological releases so that the dose to members of the public can be assessed and the doses are ALARA.

In 2006, LLNL measured releases of radioactivity from air exhausts at six facilities at the Livermore site and at one facility at Site 300. The Livermore site has a total of 69 samplers and Site 300 has one. **Table 4-1** lists the facilities, analytes, sampler type, and number of samplers at each facility. Air monitoring locations at the Livermore site and Site 300 are shown in **Figures 4-1** and **4-2**, respectively. LLNL periodically reassesses the need for continuous monitoring at these facilities and also assesses new operations or changes in operations for the need for continuous monitoring.

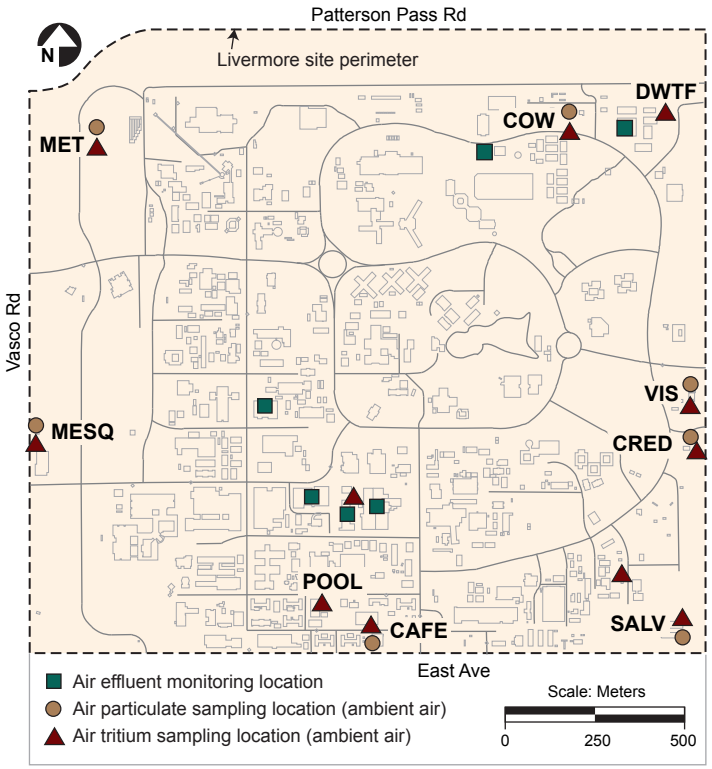

Figure 4-1. Air effluent and ambient air monitoring locations at the Livermore site, 2006.

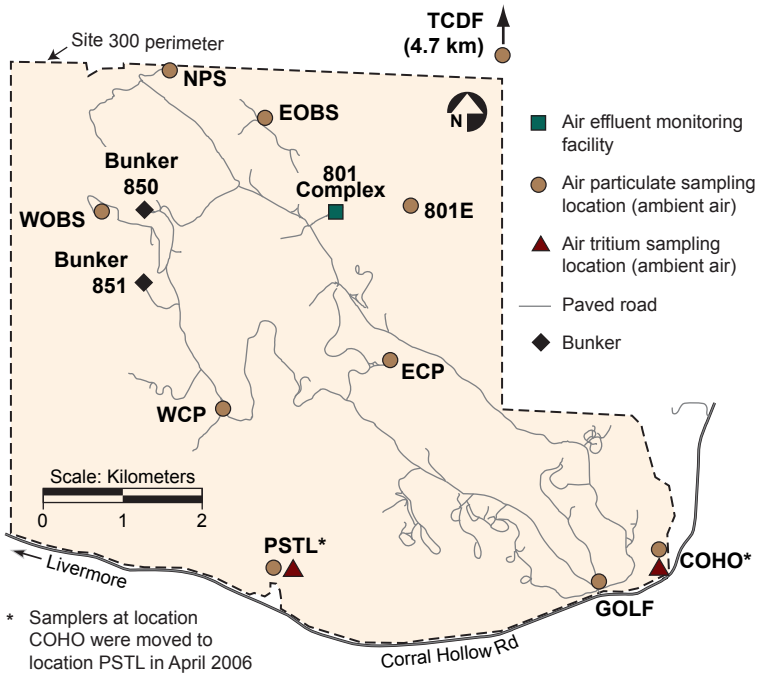

Figure 4-2. Air effluent and ambient air monitoring locations at Site 300, 2006.

Sampling for radioactive particles was conducted in all facilities except the Tritium Facility, where only tritium was measured. Both radioactive particulates and tritium were sampled at the Decontamination and Waste Treatment Facility (DWTF). All sampling systems operated continuously. Samples were collected weekly or biweekly, depending on the facility. Most air samples for particulate emissions were extracted downstream of high-efficiency particulate air (HEPA) filters and before the emissions were discharged to the atmosphere. Particles in the extracted air were collected on sample filters and analyzed for gross alpha and beta activity. Tritium was collected using molecular sieves and glycol bubblers.

In addition to continuous samplers for environmental reporting, some facilities used real-time alarm monitors (listed in **Table 4-1**) at discharge points to provide faster notification in the event of a release of radioactivity. Analytical results from the continuous samplers were reported as a measured concentration per volume of air or as less than the minimum detectable concentration (MDC) when no activity was detected. In all cases, the MDC was more than adequate for demonstrating compliance with the pertinent regulatory requirements for radionuclides that may be or are present in the sampled air. Air effluent samples were obtained in accordance with written, standardized procedures that are summarized in Woods (2005).

To establish the background levels of gross alpha and beta activity that are used to determine whether a particulate release has occurred from monitored stacks, LLNL operated three low-volume radiological air particulate samplers at locations HOSP and FCC in the Livermore Valley (see **Figure 4-3**) and at location NPS at Site 300 (see **Figure 4-2**). These samplers

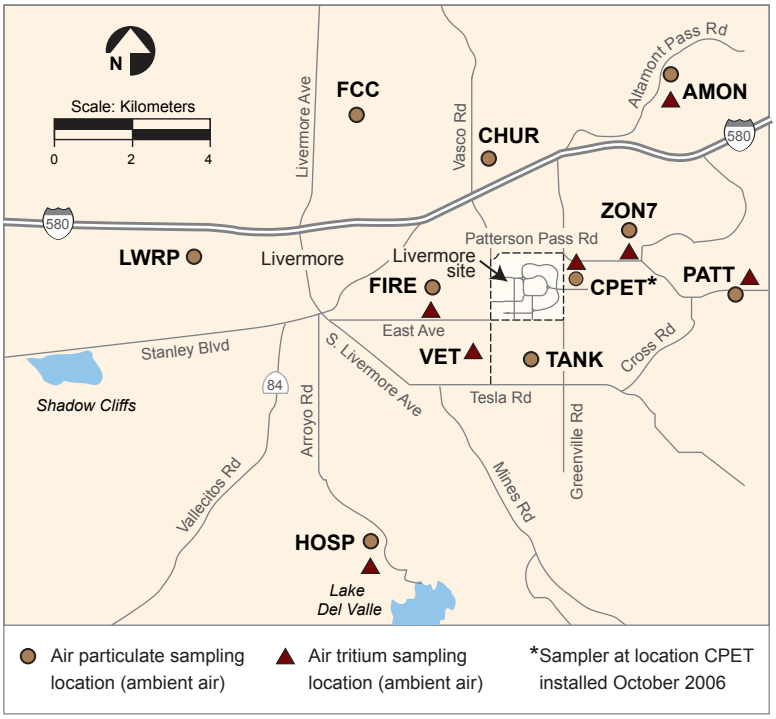

Figure 4-3. Air particulate and tritium sampling locations in the Livermore Valley, 2006.

collected particulate on membrane filters at a continuous rate of 0.03 cubic meters per minute (m^3/min).

The following sections discuss the radiological air emissions from facilities that have continuously monitored discharge points. All effluent air analytical results are summarized in **Appendix B**, **Section B.1**.

4.1.2 Air Effluent Radiological Monitoring Results

In 2006, a total of 0.67 terabecquerel (TBq) (18 curie [Ci]) of tritium was released from the Tritium Facility. Of this, approximately 0.41 TBq (11 Ci) was released as tritiated water vapor (HTO). The remaining released tritium, 0.26 TBq (7.1 Ci), was gaseous tritium (HT). The highest single stack emission occurred over a two-week sample interval and was 0.16 TBq (4.2 Ci), of which approximately 85% was HTO. Emissions from the Tritium Facility for 2006 continued to remain considerably lower than those during the 1980s. **Figure 4-4** illustrates the combined HTO and HT emissions from the facility over the last 23 years.

Continuous monitoring of the stack effluent of the DWTF for the potential release of tritium began in February 2005. In 2006, a total of 1.0×10^{-4} TBq (2.8 millicurie [mCi]) of measured tritium was released as HT. There were no reportable HTO emissions from the DWTF in 2006. Similar to the previous year, the tritium emissions from the DWTF were more than 100 times below the level of regulatory requirement for monitoring. The monitoring is in place as part of a best management practice and also for potential tritium waste from planned activities at the National Ignition Facility intended for treatment at the DWTF.

In 2006, most results from the continuously sampled discharge points that have the potential for releasing particulate radionuclides were below the MDC of the gross alpha and gross beta analysis. Some sampling systems exhibited as few as one to four values (out of 26 to 52 samples per year) greater than the MDC. Generally, these samples are only marginally above the MDC. In addition, due to the way some of the exhaust systems are configured, the sampling systems sometimes sample air from the atmosphere in addition to HEPA-filtered air from facility

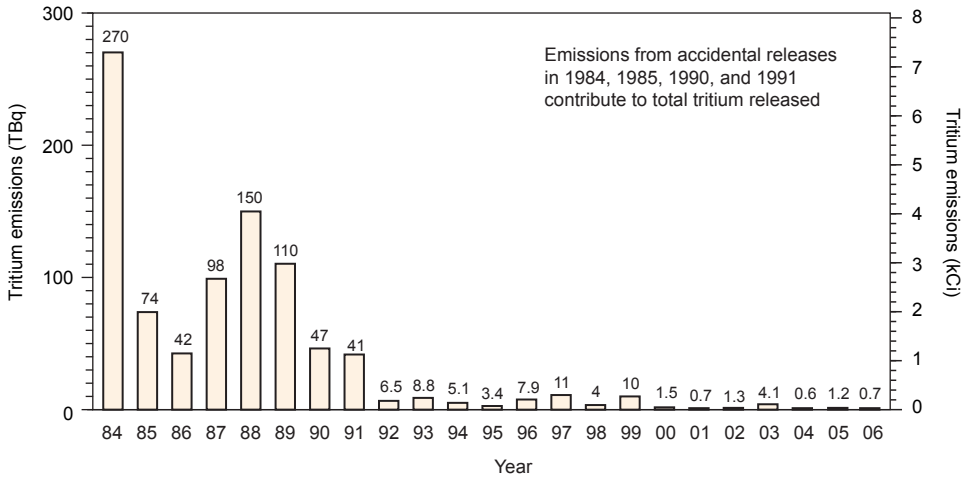

Figure 4-4. Tritium Facility combined HTO and HT emissions for the last 23 years (1984–2006).

operations, thereby collecting background atmospheric radioactivity. LLNL uses zero values for these results based on knowledge of the facility, the use of HEPA filters in all significant release pathways, and alpha-spectroscopy-based isotopic analyses of selected air sampling filters. These analyses demonstrate the presence of naturally occurring radionuclides such as radon daughters like polonium. Additionally, ambient monitoring locations are placed upwind from the site and are used to demonstrate comparable results to effluent alpha and beta detections. Even if LLNL used the MDC values to calculate the emission estimates for these facilities (which would be an extremely conservative approach), the total dose to a member of the public attributable to LLNL activities would not be affected significantly.

None of the facilities monitored for gross alpha and gross beta had reportable emissions in 2006.

4.1.3 Nonradiological Results

In 2006, the Livermore site emitted approximately 141 kilograms per day (kg/day) of regulated air pollutants as defined by the Clean Air Act, including nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM-10), carbon monoxide (CO), and reactive organic gases/precursor organic compounds (ROGs/POCs) (see **Table 4-2**). The stationary emission sources that released the greatest amount of regulated pollutants at the Livermore site were natural gas fired boilers, internal combustion engines (such as diesel generators), solvent cleaning, and surface coating operations (such as painting). In 2006, the ROGs/POCs emissions from the Livermore site decreased a significant 8.8 kg/day from 2005 due primarily to the intentional elimination of several ROGs/POCs solvent cleaning operations, as well as the active substitution of solvents, paints, and adhesives with reduced concentrations of ROGs/POCs constituents.

Table 4-2. Nonradioactive air emissions, Livermore site and Site 300, 2006.

	Estimated releases (kg/day)	
Pollutant	**Livermore site**	**Site 300**
ROGs/POCs	16.1	0.44
Nitrogen oxides	67.2	1.20
Carbon monoxide	50.3	0.27
Particulates (PM-10)	5.4	0.32
Sulfur oxides	1.6	0.15
Total	140.6	2.48

LLNL air pollutant emissions were very low in 2006 compared to the daily releases of air pollutants from all sources in the entire Bay Area. For example, the average daily emission of NOx in the Bay Area was approximately 4.52×10^5 kg/day, compared to the estimated daily release from the Livermore site of 67.2 kg/day, which is 0.015% of total Bay Area source emissions for nitrogen oxides. The 2006 BAAQMD estimate for ROGs/POCs daily emissions throughout the Bay Area was 3.35×10^5 kg/day, while the daily emission estimate for 2006 from the Livermore site was 16.1 kg/day, or 0.005% of the total Bay Area source emissions for ROGs/POCs.

Certain operations at Site 300 require permits from the SJVAPCD. The estimated daily air pollutant emissions during 2006 from operations (permitted and exempt stationary sources) at Site 300 are listed in **Table 4-2**. The stationary emission sources that release the greatest

amounts of regulated air pollutants at Site 300 include internal combustion engines (such as diesel generators), a gasoline-dispensing facility, paint spray booths, drying ovens, and soil vapor extraction equipment. Combustion pollutant emissions, such as NOx, CO, and SOx, increased at Site 300 in 2006 primarily from the operations of five emergency stand-by diesel generators (at approximately 12 hours each for the year) during unplanned electrical power outages.

4.1.4 Impact of Air Effluent and Nonradiological Releases on the Environment

In 2006, the dose to the hypothetical, maximally exposed member of the public caused by the measured air emissions from the Tritium Facility (modeling HT emissions as HTO as required by EPA) was 1.4×10^{-2} μSv/y (1.4×10^{-3} mrem/y), and the dose from DWTF (modeling HT emissions as HTO) was 8.7×10^{-6} μSv/y (8.7×10^{-7} mrem/y). As shown in **Chapter 7**, the estimated radiological dose caused by measured air emissions from LLNL operations was minimal.

Estimated nonradioactive air emissions are small compared to local air district emission criteria for the surrounding areas, and as such, have little impact on the environment or public health.

4.2 Ambient Air Monitoring

LLNL monitors ambient air to determine whether radionuclides or beryllium are being released by Laboratory operations, what the concentrations are, and what the trends in the environs are. Beryllium is the only nonradiological emission from LLNL that is monitored in ambient air. LLNL requested and was granted a waiver by the BAAQMD for source-specific monitoring and record keeping for beryllium operations, provided that LLNL can demonstrate that monthly average beryllium concentrations in air are well below regulatory limits of 10,000 picograms per cubic meter (pg/m^3) at perimeter locations.

In 2003, the EPA approved use of air surveillance monitoring data from the location of the site-wide maximally exposed individual (SW-MEI) to demonstrate compliance with NESHAPs for minor emission point sources (Harrach et al. 2004). In addition, the derived concentration guides (DCGs) in DOE Order 5400.5 specify the concentrations of radionuclides that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 millisievert per year (mSv/y) (100 mrem/y) effective dose equivalent. The data tables in **Appendix B** that are referred to in this chapter present the DCG and the percentage of the DCG for the given isotope.

4.2.1 Sampling Locations

Monitoring networks are established for air surveillance of radioactive particulates, HTO, and beryllium. Sampling locations for each monitoring network are listed in **Table 4-3** and shown in **Figures 4-1**, **4-2**, and **4-3**. The particulate and tritium sampling systems in 2006 were:

- particulate samplers: Livermore site (7), Livermore Valley (10), Site 300 (8), just west of the outskirts of Tracy (1)
- tritium samplers: Livermore site (11), Livermore Valley (7), Site 300 (1)

The above total number of samplers include the following additions and changes:

- samplers for particulate (1) and tritium (1) at location CPET in the Livermore Valley, installed October 2006
- one sampler each for particulate and tritium moved in April 2006 from location COHO to location PSTL (Site 300)

Beryllium is monitored at six Livermore site perimeter locations as required by the BAAQMD. Although there is no requirement to monitor beryllium at Site 300, as a best management practice, it is monitored at three on-site locations and one off-site location north of Site 300. All monitoring networks use continuously operating samplers.

Air sampling locations are grouped into the following categories: site perimeter, upwind, downwind, diffuse sources on site, areas of known contamination on site, and special interest locations.

At the Livermore site, the mean air monitoring results for values greater than zero at locations CRED and VIS are used to calculate dose from minor sources to the SW-MEI for NESHAPs compliance; at Site 300, because resuspension of soil is the minor source of greatest interest, the mean concentrations of all on-site air samplers are used to calculate dose to the SW-MEI (see **Chapter 7**). Based on dispersion modeling using site-specific meteorological data, the ambient air samplers, particularly those on the site perimeters, have been placed to monitor locations where elevated air concentrations due to LLNL operations are expected. Before startup of a new operation, the need for a new sampling location is assessed.

4.2.2 Sample Collection and Analysis

The air particulate networks use high-volume air sampling units, which collect airborne particulate on Whatman 41 cellulose filters. Air flows through the filters at a continuous rate of 0.42 m^3/min, and samples are collected weekly.

Tritium samplers, operating at a flow rate of 500 cubic centimeters per minute (cm^3/min), draw air through sampling flasks containing silica gel that absorbs the air moisture. The flasks are changed every two weeks.

Throughout the year at varied locations, additional samplers are placed next to permanent samplers. Duplicate samples thus obtained provide quality control of the data. Trip blanks are also taken on the air particulate sampling routes to help identify any contaminant introduced

Table 4-3. Ambient air sampling locations with type and frequency of analysis at the Livermore site and Site 300, 2006.

			Ambient air analysis frequency and type				
			Network: Air particulate Collection medium: Cellulose filter				Network: HTO Collection medium: Silica gel
Site	**Location**	**Target location**	**Weekly gross α, β (high volume)**	**Monthly $^{239+240}$Pu**	**Monthly γ and $^{235, 238}$U(a)**	**Monthly beryllium**	**Biweekly tritium**
Livermore site	SALV, MET, MESQ, COW, CAFE, VIS(b)	On site	X	X	X	X	X
	DWTF, POOL	On site					X
	Tritium Facility, B624	Diffuse/on site					X
	CRED(b)	SW-MEI(c)	X	X			X
	ZON7, PATT, AMON, CPET	Downwind	X	X			X
	CHUR, FCC(d), TANK	Upwind	X	X			
	FIRE, HOSP(d)	Upwind	X	X			X
	VET	Upwind					X
	LWRP	Historical interest	X	X			
				Monthly γ and $^{239+240}$Pu(a)	**Monthly $^{235, 238}$U**		
Site 300	EOBS, GOLF, 801E	On site(b)	X	X	X	X	
	ECP, WCP, NPS(d), WOBS	On site(b)	X	X	X		
	COHO(e), PSTL	On site(b)	X		X		X
	TCDF	Off site	X		X	X	

(a) Perimeter composite samples include portions of weekly filters from the specified locations.

(b) On the Livermore site, samplers VIS and CRED represent the location of the site-wide maximally exposed individual (SW-MEI), and concentrations obtained from them are averaged for compliance with minor sources; at Site 300, the average of all locations is applied.

(c) SW-MEI for NESHAPs compliance based on air dispersion modeling for 2006.

(d) Low-volume sampler also operated at this location; particles are collected on millipore filters. These samplers are operated to provide background values for the air effluent monitoring program.

(e) Samplers at location COHO were moved to location PSTL in April 2006 due to difficult access at PSTL (see **Figure 4.2**).

during the sampling process. Ambient air samples are obtained in accordance with written, standardized procedures that are summarized in Woods (2005).

An LLNL state-certified analytical laboratory performs all sample analyses. Gross alpha and gross beta activities are determined by gas flow proportional counting, plutonium isotopes by alpha spectrometry, uranium isotopes by inductively coupled plasma-mass spectrometry, gamma emitters by gamma spectroscopy, and tritium by freeze-dried vacuum distillation followed by liquid scintillation counting. Details about the analyses and the associated quality control are summarized in Woods (2005). Beryllium concentration is determined by inductively coupled plasma-mass spectrometry. See **Table 4-3** for the frequency of analysis at each location.

Because plutonium research occurs at the Livermore site, plutonium analyses are performed individually for all Livermore locations. Because plutonium is not used at Site 300, a composite from all locations is analyzed.

Emissions from uranium use at the Livermore site are minimal so a composite from all the Livermore site perimeter locations is created and analyzed for uranium activity. However, at Site 300, where depleted uranium is used in explosives testing, all sampling locations are analyzed for uranium activity.

4.2.3 Results

As outlined in *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991), gross alpha, gross beta, and gamma emitters on air filters are used as indicators. Radionuclides known to be released from a facility must be analyzed for specifically; at LLNL the radionuclides are plutonium, uranium, and tritium. Radiological analytical results are reported as a measured activity per volume of air. Regardless of whether any activity is considered to have been detected, the result of the analysis is reported. The activities are listed in **Appendix B**, **Section B.2**.

4.2.3.1 Gross Alpha and Gross Beta Concentrations

The primary sources of alpha and beta activities are naturally occurring radioisotopes. Routine isotopic gamma results of site composite samples indicate the activities are the result of naturally occurring isotopes (uranium, thorium, potassium, and lead), which are also routinely found in local soils.

The gross alpha activity (annual median value) in 2006 was as follows:

- Livermore site perimeter: 14 microbecquerels per cubic meter ($\mu Bq/m^3$) (0.38 femtocurie per cubic meter [fCi/m^3])
- upwind and downwind Livermore Valley stations: 14 $\mu Bq/m^3$ (0.38 fCi/m^3)
- Site 300: 14 $\mu Bq/m^3$ (0.38 fCi/m^3)

The gross beta activity (annual median value) in 2006 was as follows:

- all upwind and downwind locations: 273 μBq/m^3 (7.4 fCi/m^3)
- Livermore site perimeter: 251 μBq/m^3 (6.8 fCi/m^3)
- Site 300: 304 μBq/m^3 (8.2 fCi/m^3)

These values are all typical annual median values. All ambient air analytical results are summarized in **Appendix B**, **Section B.2**.

4.2.3.2 Gamma-Emitting Radionuclides

By analyzing air samples for gamma-emitting radionuclides, LLNL verifies that there is no evidence of release of the small inventories of mixed-fission products and radiochemical tracers used by LLNL. This analysis can also reveal emissions from global fallout sources such as above-ground tests and the Chernobyl accident (Holland et al. 1987). Composite samples for the Livermore site and Site 300 are analyzed for an environmental suite of gamma-emitting radionuclide concentrations in air. Site composite samples are scanned for 47 isotopes, which contain over 350 different gamma ray energies. The isotopes include fission products, activation products, actinides, and naturally occurring products. Of these isotopes, beryllium-7 (cosmogenic), lead-210, and potassium-40, all of which are naturally occurring in the environment, were consistently detected at both sites in 2006. The results are within known background levels.

4.2.3.3 Plutonium Concentrations

Environmental plutonium-239+240 activity for the past 23 years is shown in **Figure 4-5**. Locations HOSP and VIS represent typical upwind and on-site sampling locations, respectively. Plutonium concentrations at both of these sites have been decreasing as fallout diminishes and on-site surface areas of potential resuspension have been covered with pavement or buildings.

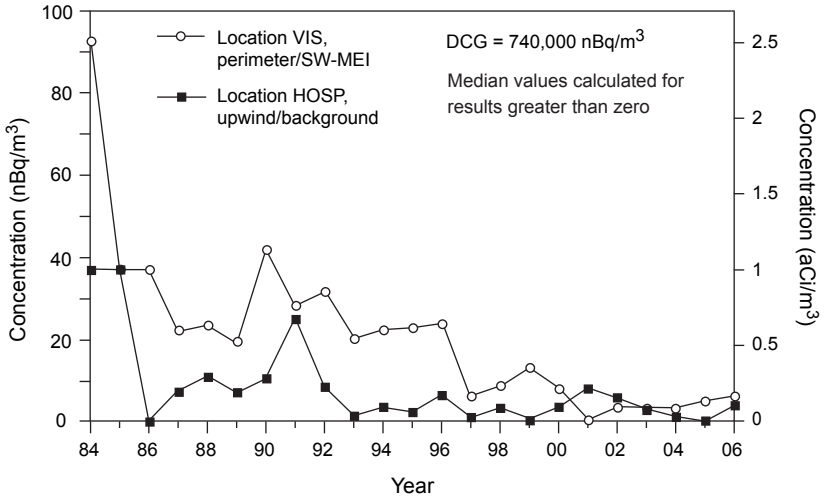

Figure 4-5. Calculated annual median concentrations of plutonium-239+240 at locations VIS and HOSP for the past 23 years (1984–2006).

Plutonium-239+240 was detected in 3 of the 195 samples tested in Livermore area air samples in 2006; 2 of the positive samples came from on-site samplers. The highest recorded on-site plutonium-239+240 detection of 26 nanobecquerels per cubic meter (nBq/m^3) (0.70 attocurie per cubic meter [aCi/m^3]) was at location CRED and was 0.0035% of the DCG (see **Section 4.2** for a description of DCGs), while the highest off-site plutonium value of 12 nBq/m^3 (0.32 aCi/m^3) was recorded at location FCC and was 0.0016% of the DCG. Plutonium was detected in 3 of the 12 composite samples collected from Site 300 with the highest detection of 17 nBq/m^3 (0.46 aCi/m^3), which was 0.0023% of the DCG. See **Appendix B**, **Section B.2**.

4.2.3.4 Uranium Concentrations

Uranium ratios are used to determine the type of uranium present in the environment. Natural uranium (NU) has a mathematical uranium-235/uranium-238 ratio of 0.00725, and depleted uranium (DU) has a uranium-235/uranium-238 ratio of 0.002. Uranium isotopes are naturally occurring.

In 2006, all of the uranium-235 and uranium-238 samples had positive detections for both the Livermore site and Site 300. The Livermore site monthly composites had a uranium-235 median concentration of 0.12 pg/m^3 (0.00026% of the DCG; see **Section 4.2** for a description of DCGs) and a uranium-238 median concentration of 17 pg/m^3 (0.0057% of the DCG). The uranium-235/uranium-238 median ratio was 0.0073, which is considered NU and typical of what has been recorded in the past.

For all Site 300 on-site locations, the annual median uranium-235 concentration was 0.15 pg/m^3 (0.00032% of the DCG) and the uranium-238 median concentration was 27 pg/m^3 (0.009% of the DCG). The annual median for the uranium-235/uranium-238 ratio for all Site 300 locations was 0.0071, which is indicative of NU.

In 2006, seven DU atmospheric shot experiments were conducted on Site 300 at Bunker 851. In March, the sampling station TCDF, located 4.7 kilometers (km) off site in Tracy (see **Figure 4-2**), had a uranium-235/uranium-238 isotopic ratio of 0.0058. This ratio corresponds to approximately 72% NU and 28% DU. The measured concentration of uranium-235 during March was 0.11 pg/m^3 (0.00023% of the DCG), and the measured concentration of uranium-238 was 18.9 pg/m^3 (0.0063% of the DCG).

The measurements at on-site locations at Site 300 in March also indicated the presence of DU. The median uranium-235/uranium-238 isotopic ratio of these locations during March was 0.0042, or approximately 41% NU and 59% DU. The highest measured uranium-235 value was 0.53 pg/m^3 (0.0011% of the DCG), and the highest measured uranium-238 value was 246 pg/m^3 (0.082% of the DCG). Both values were from the 801E sample location.

However, the highest measured uranium-235 concentration for the off-site TCDF location in 2006 occurred in July and was 0.65 pg/m^3 (0.0014% of the DCG), and the highest uranium-238 concentration also occurred in July and was 88 pg/m^3 (0.029% of the DCG). The uranium-235/uranium-238 isotopic ratio for July at the TCDF location was 0.0074 and

is indicative of NU from resuspension of naturally occurring uranium in soil (there were no atmospheric DU shots at Site 300 in July 2006). This illustrates that the potential dose from the small amount of DU present in March at TCDF is actually less than the potential dose at the same location from NU in July.

The highest measured uranium-235 value for all on-site sampled locations at Site 300 in 2006 was 0.82 pg/m^3 (0.0017% of the DCG) at location WCP in January. The highest measured uranium-238 value was 246 pg/m^3 (0.082% of the DCG) at 801E in March. See **Appendix B**, **Section B.2**.

4.2.3.5 Tritium Concentrations

Table 4-4 is a summary of the biweekly data for tritium in air that are provided in **Appendix B**, **Section B.2**. (Inhalation doses, calculated for each ambient air tritium monitoring location, are included in **Appendix B**, **Section B.2**.) Locations (see **Figures 4-1**, **4-2**, and **4-3**) are grouped by expected concentrations of tritium. In 2006, the highest concentrations of tritium were found near area (diffuse) sources near the Tritium Facility and in the Building 612 yard on the Livermore site. Area sources include stored containers of tritium waste or tritium-contaminated equipment from which HTO diffuses into the atmosphere. Concentrations at the area source monitored at the Tritium Facility were higher and more variable in 2006 than in recent years because of the ongoing cleanup of the Tritium Facility.

Air concentrations measured at sampler locations near the Livermore site perimeter were the next highest after those near diffuse sources; the concentrations near the perimeter were, on average, less than 5% of those near the diffuse sources. Location CAFE exhibited the highest biweekly concentration of the perimeter locations. This concentration was correlated with a release from the Tritium Facility when winds were blowing towards the CAFE sampler. Median concentrations for 2006 for perimeter locations were somewhat lower than in 2005. The effect of lower emissions from the Tritium Facility in 2006 compared with 2005 was seen particularly at locations VIS and CRED, which are downwind.

Table 4-4. Tritium in air samples at on- and off-site locations, 2006.

Sampling locations	Detection frequency	Concentration (mBq/m^3)				Median percent of DCG[a]
		Mean	Median	IQR	Maximum	
Diffuse on-site sources	50 of 50	2940	802	1120	36,900	0.022%
Livermore site perimeter[b]	170 of 231	54.3	34.5	56.6	1150	0.00093%
Livermore Valley	50 of 161	9.27	7.62	18.4	62.2	0.00021%
Site 300	7 of 26	7.83	3.36	15.1	65.1	0.000091%

(a) DCG = derived concentration guide of 3.7 x 10^6 mBq/m^3 for tritium in air.

(b) Locations COW, DWTF, MET, and POOL are not strictly on the perimeter of the site.

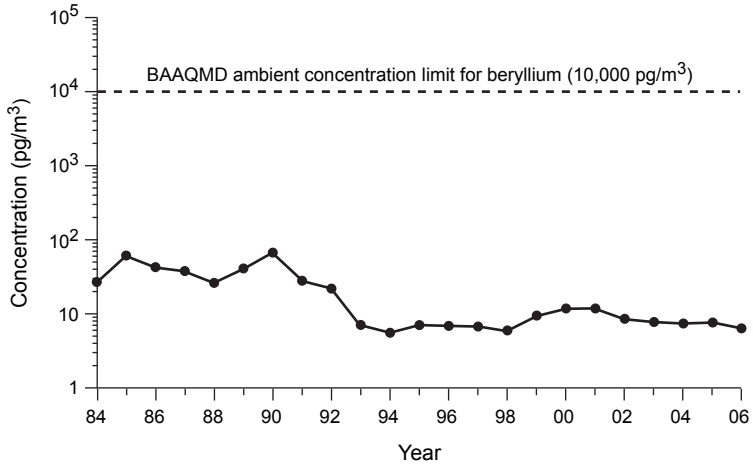

Figure 4-6. Median concentration of beryllium in air particulate samples taken at the Livermore site perimeter over the last 23 years (1984–2006).

All of the median concentrations in the Livermore Valley and at Site 300 were below the MDC in 2006 (see **Table 4-4** and **Appendix B**, **Section B.2**). Given the low tritium concentrations observed at the Livermore site perimeter, all samples from locations distant from the Livermore site are expected to exhibit tritium background concentrations that are below the MDC. Similarly, because no operations at Site 300 released tritium to the environment in 2006, concentrations at locations COHO or PSTL are expected to be below the MDC. Detections that occurred at these sampling locations are artifacts of scintillation counting with a high counter background.

4.2.3.6 Beryllium Concentrations

LLNL measures the monthly concentrations of airborne beryllium at the Livermore site, Site 300, and the off-site sampler north of Site 300 (see **Appendix B**, **Section B.2**). The highest value at the Livermore site in 2006 for airborne beryllium was 20 pg/m^3, which was recorded at two locations, CAFE and VIS, both in October. This value is only 0.20% of the BAAQMD ambient concentration limit for beryllium (10,000 pg/m^3). These data are similar to data collected from previous years.

Figure 4-6 is a plot of the median beryllium concentrations at the Livermore site perimeter over the last 23 years (1984–2006). The decrease in 1993 and the slight increase in 1999 are likely the result of a change in the analytical laboratory used to perform the analysis.

There is no regulatory requirement to monitor beryllium in San Joaquin County; however, LLNL analyzes samples from several Site 300 locations as a best management practice. The monthly median beryllium concentration for all Site 300 locations was 7 pg/m^3. The highest value for Site 300 area sampling occurred at the off-site location TCDF in October with a value of 29 pg/m^3.

4.2.4 Environmental Impact of Ambient Air

LLNL operations involving radioactive materials had minimal impact on ambient air during 2006. Radionuclide particulate concentrations in air at the Livermore site and in the Livermore Valley were well below the levels that would cause concern for the environment or public health.

The diffuse tritium sources at the Tritium Facility and the Building 612 yard had a small, localized effect with no direct impact on the public. Any potential dose received by a member of the public from the diffuse sources is accounted for when doses are calculated based on tritium concentrations at the Livermore site perimeter. Furthermore, doses calculated from air concentrations at the perimeter will be higher than any dose that could be received by a member of the public. Both mean and median annual concentrations of tritium in the Livermore Valley and at Site 300 were all well below MDCs. For a location at which the mean concentration is at or below the MDC, inhalation dose from tritium is assumed to be less than 5 nanosievert per year (nSv/y) (0.5 microrem per year [μrem/y]) (i.e., the annual dose from inhaling air with a concentration at the MDC of about 25 mBq/m^3 [0.675 pCi/m^3]).

Two Livermore site locations have public access during working hours (CRED and VIS). If it were assumed that a member of the public inhaled air continuously for a year at the maximum biweekly concentration at CRED (86.2 mBq/m^3) or VIS (79.2 mBq/m^3), the resulting doses would still be tiny (18.1 nSv/y [1.81 μrem/y] and 16.6 nSv/y [1.66 μrem/y], respectively). Put another way, the maximum concentration at CRED is just 0.16% of concentration limits for minor sources (see **Section 7.6.1**).

The concentrations of beryllium at both the Livermore site and Site 300 can be attributed to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 part per million (ppm) of beryllium, and the air of the Livermore area and the San Joaquin Valley typically contains 10 to 100 $\mu g/m^3$ of particulates. Using a value of 50 $\mu g/m^3$ for an average dust load and 1 ppm for beryllium content of dust, a conservative airborne natural beryllium concentration of approximately 50 pg/m^3 can be predicted. The overall medians for the on-site locations at the Livermore site and Site 300 are 6 pg/m^3 and 7 pg/m^3, respectively. These data are lower than estimated for natural background, well below standards, and do not indicate the presence of a threat to the environment or public health from LLNL operations.