4. Air Monitoring

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Introduction

Air surveillance monitoring is performed to evaluate compliance with local, state, and federal regulations and to ensure that human health and the environment are protected from hazardous and radioactive air emissions. LLNL complies with local, state, and federal environmental air quality laws and DOE regulations including 40 CFR 61, the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act and DOE Orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991) provides the guidance for implementing DOE Orders 5400.1 and 5400.5. Other laws governing air quality include 22 CCR 67264.700 and 66265.710, Environmental and Compliance Monitoring, and the California Air Toxics "Hot Spots" Information and Assessment Act of 1987 (AB2588). In general, LLNL analyzes for most constituents at levels that are far below regulatory standards in order to determine any environmental impact.

LLNL monitors ambient air to determine if airborne radionuclides or hazardous materials are being released by Laboratory operations, what the concentrations are, and what the trends are in the LLNL environs. In our air monitoring, particles are collected on filters and vapor is chemically trapped on a collection medium. Concentrations of various airborne radionuclides (including particles and tritiated water vapor) and beryllium are measured at the Livermore site, Site 300, at off-site locations throughout the Livermore Valley, and at an off-site location in Tracy. Point sources as well as diffuse, or nonpoint sources, are monitored to fulfill NESHAPs requirements.

Methods

For air surveillance monitoring, two networks monitor the air particulates in the environs of the Livermore site; and one network monitors particulates in the environs of Site 300, including one sampler in the city of Tracy. All these networks use continuously operating, high volume samplers located as shown in **Figures 4-1, 4-2,** and **4-3**. The Livermore site perimeter network consists of six samplers at the perimeter and two at areas of special interest (diffuse sources). The Livermore Valley network consists of samplers located in all wind directions. For the purposes of data analysis, samplers located in the least prevalent wind directions (FCC, FIRE, HOSP, RRCH, and ERCH) are considered to be upwind or background and four samplers located in the most prevalent

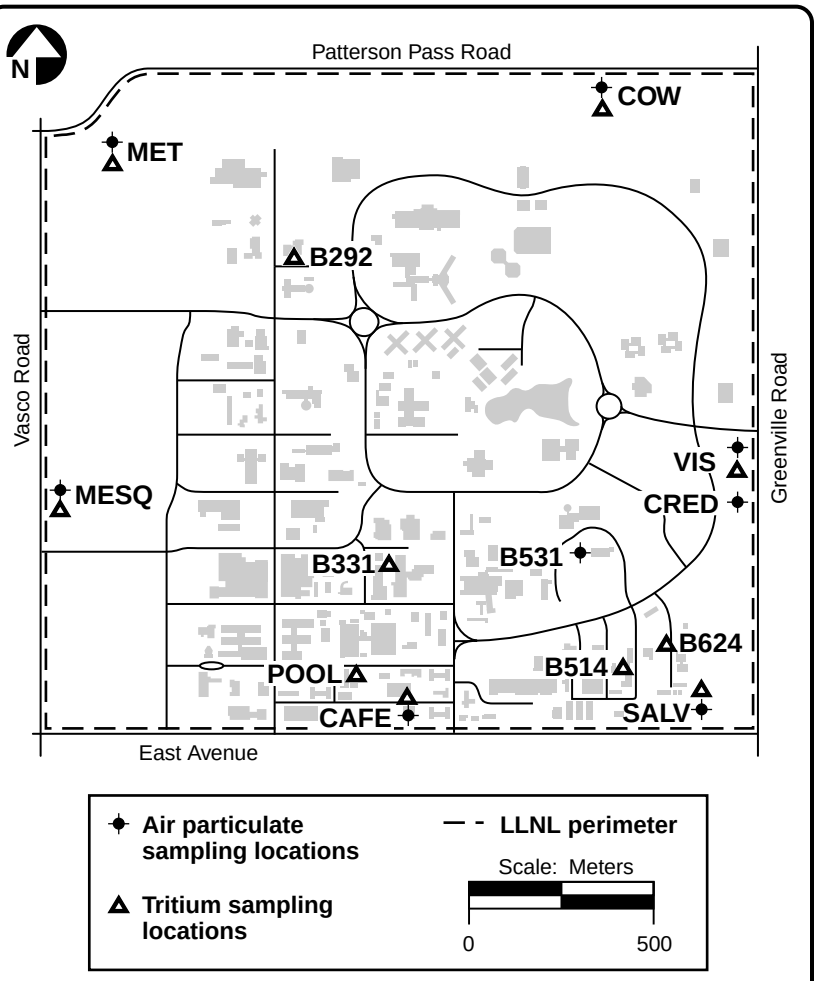

Figure 4-1. Air particulate and tritium sampling locations, Livermore site, 1995.

directions (PATT, ZON7, TANK, and ALTA) are considered downwind. An additional sampler is located in an area of special interest (LWRP) because of a plutonium release to the sanitary sewer system in 1967 (see Results section below). These air samplers are positioned to provide reasonable probability that any significant concentration of radioactive particulate effluents from LLNL operations will be detected should it occur.

One of the sampling locations, ERCH, was removed from service in October of 1995 because of logistical problems at the location, and will not be replaced at this time. The geographical details of the particulate sampling locations are outlined in a procedure in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995).

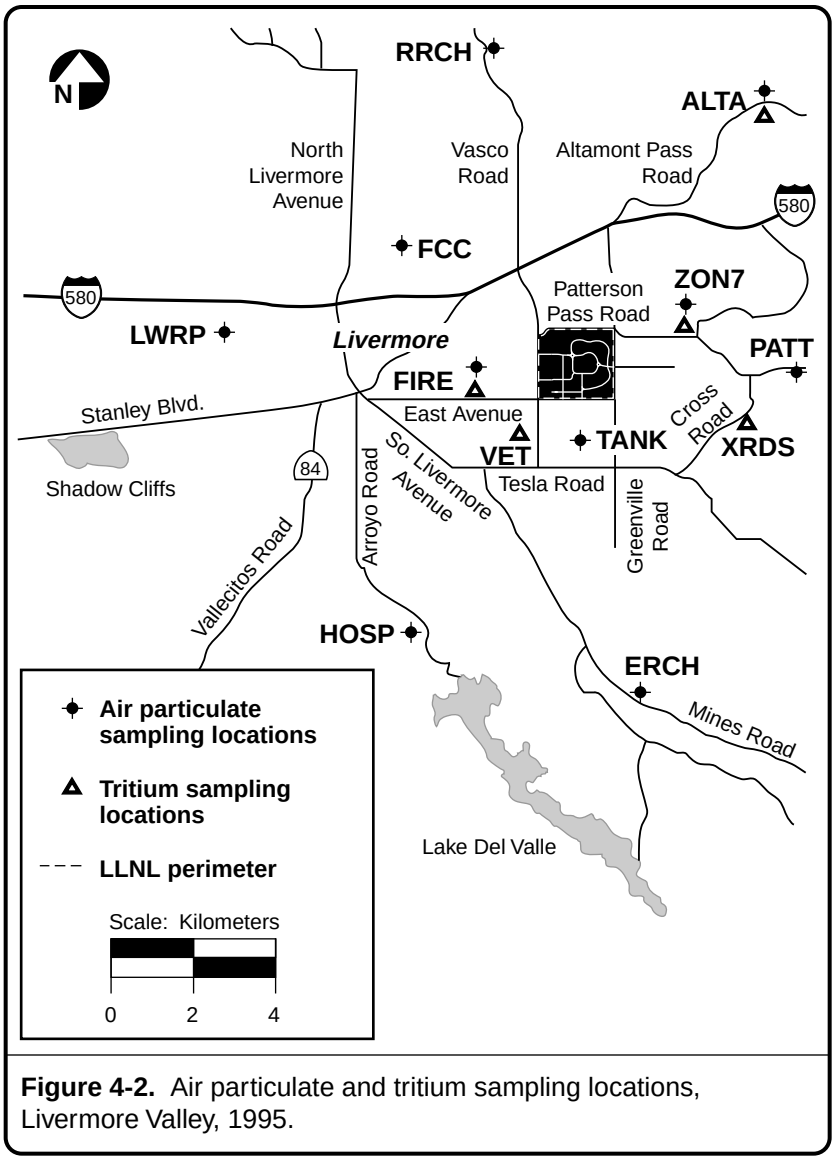

Figure 4-2. Air particulate and tritium sampling locations, Livermore Valley, 1995.

LLNL also maintains 11 continuously operating airborne tritium samplers on the Livermore site (**Figure 4-1**) and 5 samplers in the Livermore Valley (**Figure 4-2**). Four of the Livermore site locations (B331, B292, B514, and B624) monitor diffuse tritium emissions. The tritium sample locations are detailed in Appendix A of the *Environmental Monitoring Plan*(Tate et al. 1995).

Particulate filters are changed each week at all locations, and tritium samples are changed every two weeks. Duplicate quality control samplers are operated for 2 months in parallel with the permanent sampler at a given site, and samples are analyzed to confirm results.

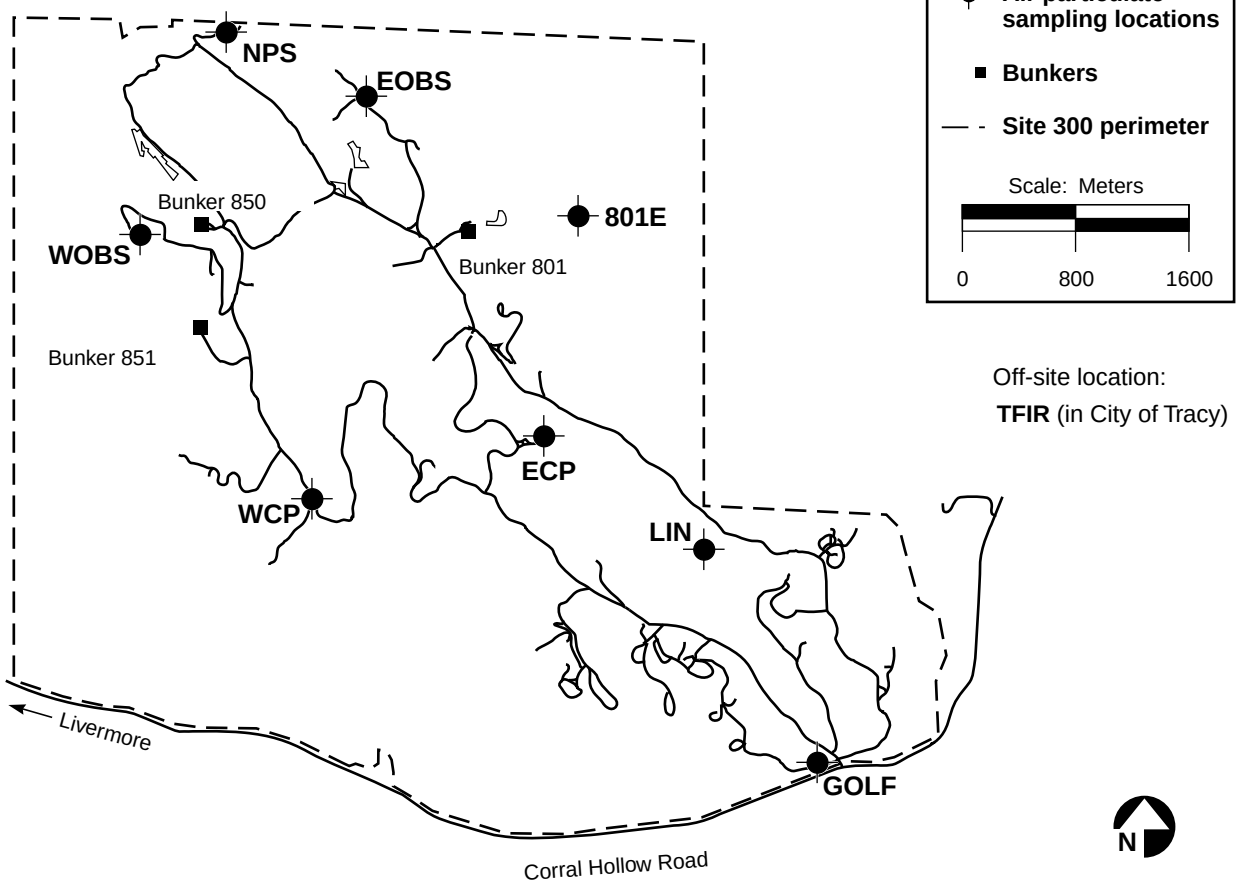

Figure 4-3. Air particulate sampling locations, Site 300, 1995.

As outlined in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991), gross alpha and gross beta air filter results are used as trend indicators; specific radionuclide analysis is done for plutonium, uranium, and gamma emitters. All analytical results are reported as a measured concentration per volume of air, or at the minimum detection limit (MDL) when no activity is detected. In all cases, the MDL is more than adequate for demonstrating compliance with the pertinent regulatory requirements for radionuclides that may be or are present in the air sample and for evaluating LLNL-induced environmental impacts. Particle size distributions are not determined because the estimated effective dose equivalent to the maximally exposed individual is well below the 0.01 mSv (1 mrem) allowable limit as discussed in the above mentioned *Environmental Regulatory Guide*. Further details of the surveillance monitoring methods are included in Volume 2, Chapter 4.

Results

This section discusses the air monitoring results at the Livermore site and at Site 300.

Livermore Site

Airborne Radioactivity

Table 4-1 summarizes the monthly gross alpha and gross beta results for the LLNL perimeter, Livermore Valley, and Site 300 sampling locations. Medians, interquartile ranges (IQR), and maximum values for each network are included. (See Volume 2, Tables 4-1 and 4-2 for detailed location results for all networks for gross alpha and gross beta concentrations.) The monthly median gross alpha and gross beta concentrations are plotted in **Figures 4-4** and **4-5**, respectively. The gross beta results are slightly higher during the fall and winter, which is a similar pattern to the 1992, 1993, and 1994 data; however, the maximum values have decreased possibly because of the decrease in global fallout.

The gross alpha data are much more variable because of the nature of the standard analytical method capabilities, and most of the data are at or below the detection limit of the method.

Typical gross alpha activity (median value) for the LLNL perimeter network is 2.2×10^{-13} Bq / mL (6.0×10^{-24} Ci / mL); for the upwind Livermore Valley stations the value is -1.1×10^{-11} Bq / mL (-3.0×10^{-22} Ci / mL); and for the downwind Livermore Valley stations the value is -4.1×10^{-12} Bq / mL (-1.1×10^{-22} Ci / mL). Negative values occur when the activity of the analytical background filters is higher than the activity on the filters being analyzed. Typical gross beta activity (median value) for the LLNL perimeter is 4.1×10^{-10} Bq / mL (1.1×10^{-20} Ci / mL); for the upwind Livermore Valley stations the value is 3.7×10^{-10} Bq / mL (1.0×10^{-20} Ci / mL);. and for the downwind Livermore stations the value is 3.9×10^{-10} Bq / mL (1.0×10^{-20} Ci / mL). These values are similar to those obtained from previous monitoring data during the past several years. The primary sources of the alpha and beta activities are the naturally occurring radioisotopes of uranium and thorium, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident in 1986.

Gamma-emitting radionuclide concentrations in air that contribute to the activity in the Livermore site perimeter samples are summarized in **Table 4-2**. (See Volume 2, Table 4-4 for monthly gamma data.) Of the nuclides tabulated, ^{7}Be, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th occur naturally. The primary source of ^{137}Cs is long-term global fallout and fallout resuspension.

Table 4-1. Gross alpha and gross beta in air particulate samples summarized by month, 1995.[a]

	Gross alpha (Bq/mL)			Gross beta (Bq/mL)		
	Median	Interquartile range	Maximum	Median	Interquartile range	Maximum
LLNL perimeter						
Jan	-1.7×10^{-11}	3.4×10^{-11}	2.4×10^{-11}	2.3×10^{-10}	2.8×10^{-10}	1.1×10^{-9}
Feb	-3.2×10^{-11}	4.6×10^{-11}	7.2×10^{-11}	7.0×10^{-10}	4.4×10^{-10}	1.9×10^{-9}
Mar	4.6×10^{-12}	2.9×10^{-11}	6.8×10^{-11}	2.6×10^{-10}	2.6×10^{-10}	9.5×10^{-10}
Apr	-9.7×10^{-12}	4.0×10^{-11}	1.1×10^{-10}	2.5×10^{-10}	1.9×10^{-10}	5.4×10^{-10}
May	-9.5×10^{-12}	3.3×10^{-11}	8.3×10^{-11}	2.6×10^{-10}	1.5×10^{-10}	5.7×10^{-10}
June	1.3×10^{-11}	2.3×10^{-11}	8.3×10^{-11}	2.3×10^{-10}	2.7×10^{-10}	5.3×10^{-10}
July	-1.6×10^{-11}	5.5×10^{-11}	6.4×10^{-11}	2.6×10^{-10}	1.9×10^{-10}	4.9×10^{-10}
Aug	-1.8×10^{-11}	5.4×10^{-11}	6.2×10^{-11}	4.9×10^{-10}	1.7×10^{-10}	9.1×10^{-10}
Sept	1.5×10^{-11}	8.2×10^{-11}	6.9×10^{-11}	7.7×10^{-10}	5.8×10^{-10}	1.1×10^{-9}
Oct	4.6×10^{-11}	8.3×10^{-11}	1.6×10^{-10}	8.1×10^{-10}	2.6×10^{-10}	2.0×10^{-9}
Nov	3.1×10^{-11}	5.9×10^{-11}	1.5×10^{-10}	7.4×10^{-10}	3.9×10^{-10}	1.7×10^{-9}
Dec	-2.4×10^{-11}	6.4×10^{-11}	6.0×10^{-11}	4.5×10^{-10}	6.5×10^{-10}	2.4×10^{-9}
Livermore Valley upwind						
Jan	-1.8×10^{-11}	2.6×10^{-11}	7.1×10^{-11}	2.1×10^{-10}	1.5×10^{-10}	4.3×10^{-10}
Feb	-2.3×10^{-11}	3.9×10^{-11}	5.6×10^{-11}	6.8×10^{-10}	5.0×10^{-10}	2.0×10^{-9}
Mar	-3.1×10^{-12}	5.0×10^{-11}	5.5×10^{-11}	2.2×10^{-10}	1.6×10^{-10}	6.9×10^{-10}
Apr	-1.1×10^{-11}	5.1×10^{-11}	9.0×10^{-11}	2.0×10^{-10}	1.2×10^{-10}	5.0×10^{-10}
May	-9.9×10^{-12}	6.0×10^{-11}	5.1×10^{-11}	2.2×10^{-10}	1.9×10^{-10}	5.6×10^{-10}
June	-8.0×10^{-12}	4.0×10^{-11}	5.9×10^{-11}	1.3×10^{-10}	1.4×10^{-10}	4.3×10^{-10}
July	-7.5×10^{-12}	5.8×10^{-11}	7.2×10^{-11}	2.6×10^{-10}	1.6×10^{-10}	5.0×10^{-10}
Aug	-2.8×10^{-11}	4.0×10^{-11}	2.2×10^{-11}	4.5×10^{-10}	1.3×10^{-10}	7.0×10^{-10}
Sept	-9.9×10^{-12}	4.1×10^{-11}	1.0×10^{-10}	6.6×10^{-10}	6.0×10^{-10}	1.2×10^{-9}
Oct	3.9×10^{-11}	4.7×10^{-11}	1.2×10^{-10}	7.7×10^{-10}	3.3×10^{-10}	1.1×10^{-9}
Nov	1.6×10^{-11}	8.9×10^{-11}	1.2×10^{-10}	7.2×10^{-10}	2.9×10^{-10}	1.7×10^{-9}
Dec	-1.6×10^{-11}	6.5×10^{-11}	3.9×10^{-11}	4.6×10^{-10}	5.7×10^{-10}	2.1×10^{-9}

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Table 4-1. Gross alpha and gross beta in air particulate samples summarized by month, 1995[a] (concluded).

	Gross alpha (Bq/mL)			Gross beta (Bq/mL)		
	Median	**Interquartile range**	**Maximum**	**Median**	**Interquartile range**	**Maximum**
Livermore Valley downwind						
Jan	-1.4×10^{-11}	3.6×10^{-11}	3.0×10^{-11}	1.9×10^{-10}	1.8×10^{-10}	4.8×10^{-10}
Feb	-5.6×10^{-11}	6.5×10^{-11}	3.1×10^{-11}	6.7×10^{-10}	4.2×10^{-10}	1.7×10^{-9}
Mar	-1.1×10^{-12}	3.6×10^{-11}	4.8×10^{-11}	2.8×10^{-10}	2.1×10^{-10}	8.1×10^{-10}
Apr	3.3×10^{-13}	4.8×10^{-11}	3.5×10^{-11}	2.5×10^{-10}	1.2×10^{-10}	5.9×10^{-10}
May	-9.9×10^{-12}	3.9×10^{-11}	4.9×10^{-11}	2.8×10^{-10}	1.9×10^{-10}	4.7×10^{-10}
June	4.9×10^{-12}	5.2×10^{-11}	4.9×10^{-11}	2.4×10^{-10}	1.6×10^{-10}	4.4×10^{-10}
July	-1.3×10^{-11}	6.6×10^{-11}	5.2×10^{-11}	2.7×10^{-10}	1.4×10^{-10}	5.8×10^{-10}
Aug	-2.0×10^{-11}	7.0×10^{-11}	1.2×10^{-10}	4.4×10^{-10}	1.4×10^{-10}	6.6×10^{-10}
Sept	-3.1×10^{-11}	6.4×10^{-11}	8.4×10^{-11}	6.2×10^{-10}	5.4×10^{-10}	10.0×10^{-10}
Oct	3.4×10^{-11}	7.9×10^{-11}	1.2×10^{-10}	7.3×10^{-10}	3.9×10^{-10}	1.2×10^{-9}
Nov	4.0×10^{-11}	4.0×10^{-11}	1.2×10^{-10}	6.0×10^{-10}	5.1×10^{-10}	1.4×10^{-9}
Dec	-2.3×10^{-11}	5.5×10^{-11}	4.0×10^{-11}	3.6×10^{-10}	5.0×10^{-10}	2.4×10^{-9}
Site 300						
Jan	-1.2×10^{-11}	2.9×10^{-11}	3.1×10^{-11}	1.6×10^{-10}	1.9×10^{-10}	5.3×10^{-10}
Feb	-2.3×10^{-11}	4.1×10^{-11}	4.9×10^{-11}	5.8×10^{-10}	2.6×10^{-10}	1.0×10^{-9}
Mar	-1.5×10^{-11}	4.3×10^{-11}	5.1×10^{-11}	2.8×10^{-10}	4.3×10^{-10}	1.9×10^{-9}
Apr	-1.8×10^{-11}	3.4×10^{-11}	6.9×10^{-11}	2.2×10^{-10}	2.0×10^{-10}	5.1×10^{-10}
May	1.8×10^{-11}	4.4×10^{-11}	1.5×10^{-10}	2.8×10^{-10}	1.7×10^{-10}	5.5×10^{-10}
June	7.7×10^{-12}	4.3×10^{-11}	1.1×10^{-10}	2.1×10^{-10}	3.3×10^{-10}	7.1×10^{-10}
July	4.4×10^{-12}	3.8×10^{-11}	9.3×10^{-11}	2.8×10^{-10}	1.4×10^{-10}	5.4×10^{-10}
Aug	-2.6×10^{-11}	6.4×10^{-11}	6.1×10^{-11}	5.2×10^{-10}	1.2×10^{-10}	8.4×10^{-10}
Sept	2.3×10^{-12}	7.4×10^{-11}	1.5×10^{-10}	7.1×10^{-10}	3.1×10^{-10}	1.2×10^{-9}
Oct	4.3×10^{-11}	5.5×10^{-11}	1.6×10^{-10}	7.1×10^{-10}	3.2×10^{-10}	1.0×10^{-9}
Nov	3.5×10^{-11}	6.3×10^{-11}	2.0×10^{-10}	7.4×10^{-10}	6.0×10^{-10}	1.9×10^{-9}
Dec	-1.8×10^{-11}	5.0×10^{-11}	1.2×10^{-10}	4.9×10^{-10}	5.3×10^{-10}	1.7×10^{-9}

[a] Negative values indicate that the activity of the background is greater than that of the sample.

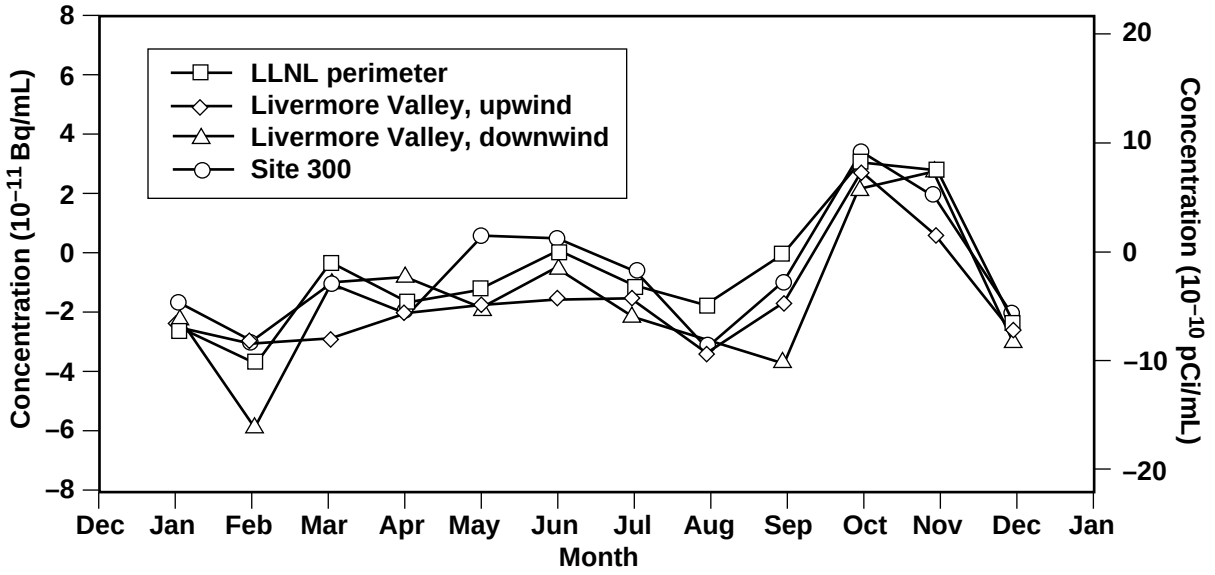

Figure 4-4. Monthly median gross alpha concentrations in particulate air samples from LLNL perimeter, Livermore Valley, and Site 300 sampling locations, 1995.

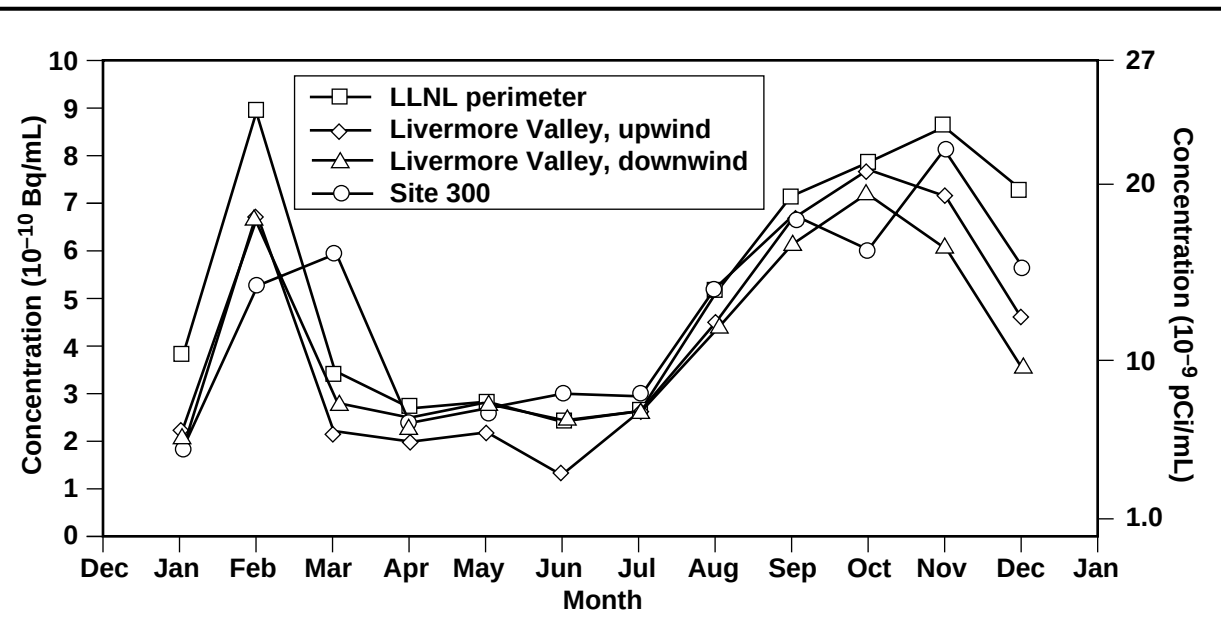

Figure 4-5. Monthly median gross beta concentrations in particulate air samples from LLNL perimeter, Livermore Valley, and Site 300 sampling locations, 1995.

Table 4-2. Gamma activity in air particulate samples, Livermore site perimeter and Site 300, 1995.

	(10^{-9} Bq/mL)	(10^{-12} Bq/mL)					
	^{7}Be	^{40}K	^{137}Cs	^{22}Na	^{226}Ra	^{228}Ra	^{228}Th
Livermore perimeter							
Median	4.4	<11.3	<0.2	<0.3	<0.5	<1.4	<0.6
Interquartile range	1.3	<23.4	—[a]	—[a]	—[a]	—[a]	—[a]
Maximum	6.6	41.4	1.3	0.6	3.0	3.2	2.3
Median fraction of DCG[b]	3.0×10^{-6}	$<3.4 \times 10^{-7}$	$<1.2 \times 10^{-8}$	$<6.8 \times 10^{-9}$	$<1.3 \times 10^{-5}$	$<1.3 \times 10^{-5}$	$<4.0 \times 10^{-4}$
Site 300							
Median	4.5	<5.8	<0.2	<0.5	<0.4	<0.6	<0.4
Interquartile range	1.8	<17.5	—[a]	<0.24	—[a]	—[a]	—[a]
Maximum	7.2	34.9	0.5	0.8	2.2	2.3	1.9
Median fraction of DCG[b]	3.0×10^{-6}	$<1.7 \times 10^{-7}$	$<1.0 \times 10^{-8}$	$<1.4 \times 10^{-8}$	$<1.0 \times 10^{-5}$	$<5.6 \times 10^{-6}$	$<2.7 \times 10^{-4}$
DCG[b] (Bq/mL)	1.5×10^{-3}	3.3×10^{-5}	1.5×10^{-5}	3.7×10^{-5}	3.7×10^{-8}	1.1×10^{-7}	1.5×10^{-9}

a No measure of dispersion calculated. See Chapter 15, Quality Assurance.

b Derived Concentration Guide.

In addition to providing baseline data on global fallout, analysis of these radionuclides enables LLNL to monitor the containment of the small inventories of mixed fission products and radiochemical tracers used at LLNL. The Derived Concentration Guides (DCGs) for these radionuclides are also shown in **Table 4-2**. For air, DCGs specify the concentrations of radionuclides that could be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 mSv/y (100 mrem/y) effective dose equivalent (DOE Order 5400.5). (Chapter 13 on Radiological Dose Assessment provides an explanation of this and other units of dose.) Finally, the fraction of the DCGs is presented. These values demonstrate that levels of gamma activity present in air at the Livermore site perimeter are low.

Table 4-3 shows the detection frequency, median, IQR, maximum, and fraction of DCG for concentration of plutonium on air filter samples collected in the Livermore Valley. (See Volume 2, Table 4-6 for monthly data.) The highest off-site median concentration of ^{239}Pu occurred at the Livermore Water Reclamation Plant (LWRP). Soils near the LWRP contain some detectable plutonium, principally resulting from sludge-spreading operations following an estimated 1.2×10^{9} Bq (32 mCi) release to the sewer in 1967 (see Chapter 10, Soil and

Table 4-3. Plutonium activity in air particulate samples (in 10^{-15} Bq/mL), 1995.

Sampling location[a]	Median	Interquartile range	Maximum	Median fraction of DCG[b]
Livermore Valley downwind locations				
ALTA	9.4	14.6	118.0	1.3×10^{-5}
PATT	6.1	14.1	61.4	8.2×10^{-6}
TANK	7.3	14.0	22.5	9.9×10^{-6}
ZON7	6.0	6.2	43.7	8.1×10^{-6}
Livermore Valley upwind locations				
ERCH[c]	9.3	7.0	13.2	1.3×10^{-5}
FCC	3.7	7.0	13.3	4.9×10^{-6}
FIRE	0.9	16.7	45.5	1.2×10^{-6}
HOSP	2.2	8.1	10.8	3.0×10^{-6}
RRCH	1.4	5.4	20.1	1.8×10^{-6}
Special interest				
LWRP	12.8	21.8	132.0	1.7×10^{-5}
LLNL perimeter				
SALV	22.0	14.0	544.0	3.0×10^{-5}
MESQ	22.7	10.0	38.5	3.1×10^{-5}
CAFE	24.5	23.4	49.6	3.3×10^{-5}
MET	22.7	23.4	273.0	3.1×10^{-5}
VIS	22.9	17.8	105.0	3.1×10^{-5}
COW	35.1	50.0	758.0	4.8×10^{-5}
Diffuse on-site sources				
B531	136	494	1062	1.8×10^{-4}
CRED	7.9	14.9	29.9	1.1×10^{-5}
Site 300	4.8	1.9	12.2	6.5×10^{-6}
Tracy	3.7	10.7	14.8	5.2×10^{-6}

a See **Figures 4-1, 4-2,** and **4-3** for sampling locations.

b DCG = 7.4 x 10^{-10} Bq/mL (2 x 10^{-14} μCi/mL) for ^{239}Pu activity in air.

c Station was discontinued in October because of logistical problems.

Sediment Monitoring). Resuspension of these soils probably accounts for the slightly higher average ^{239}Pu in air concentrations observed. However, the median observed value is <0.0001 of the DCG.

Table 4-3 also shows the concentrations of airborne ^{239}Pu on air filters from the LLNL perimeter locations. (See Volume 2, Table 4-7 for the detailed location monthly data.) The highest concentration was registered at location COW in June 1995; the concentration value is reported as 7.6×10^{-13} Bq / mL (2.1×10^{-23} Ci / mL), which represents 0.001 of the DCG. This concentration may be due to the construction activities in the area, which included significant grading and dirt movement, thereby increasing the resuspension probability. The median concentration at location COW is 3.5×10^{-14} Bq / mL (9.5×10^{-25} Ci / mL), which is just slightly higher than the previous year. Other locations that may have been impacted by higher concentrations for a single month because of construction activities in their vicinity included SALV and MET; however, the median concentrations at all LLNL site perimeter locations were similar to those in 1994.

Figure 4-6 shows the annual median concentrations of ^{239}Pu for locations SALV (on site) and FCC (off site) from 1982 to 1995. Location FCC represents a typical upwind background location, and SALV represents the perimeter location having the highest annual average for most of this 13-year period. The higher values in the past at SALV may be attributed to historical activities at LLNL; improvements in operational processes in the immediate work area have contributed to the observed downward trend of the data.

In June 1991, two air particulate sampling locations (B531 and CRED) were added as part of a special study to investigate the somewhat elevated levels of plutonium in air and surface soil in the southeast quadrant of the Livermore site (see Chapter 10, Soil and Sediment Monitoring, for general background on this study). These sampling locations are now part of our routine monitoring network and provide data for diffuse source dose assessments. **Table 4-3** shows the median concentrations of airborne ^{239}Pu at these two locations. (See Volume 2, Table 4-8 for monthly data.) The median concentration of 1.4×10^{-13} Bq / mL (3.7×10^{-24} Ci / mL) at location B531 is higher than the median concentration for any of the other air particulate sampling locations but is still only 0.0002 of the DCG.

The median ^{235}U and ^{238}U concentrations in air samples from the Livermore site perimeter are shown in **Table 4-4**. (See Volume 2, Table 4-10 for monthly data.) The maximum measured concentrations of ^{238}U are less than 0.0005 of the DCG (DOE Order 5400.5). All ^{235}U / ^{238}U median ratios are as expected for naturally occurring uranium; however, monthly data in Volume 2 shows some unexpected

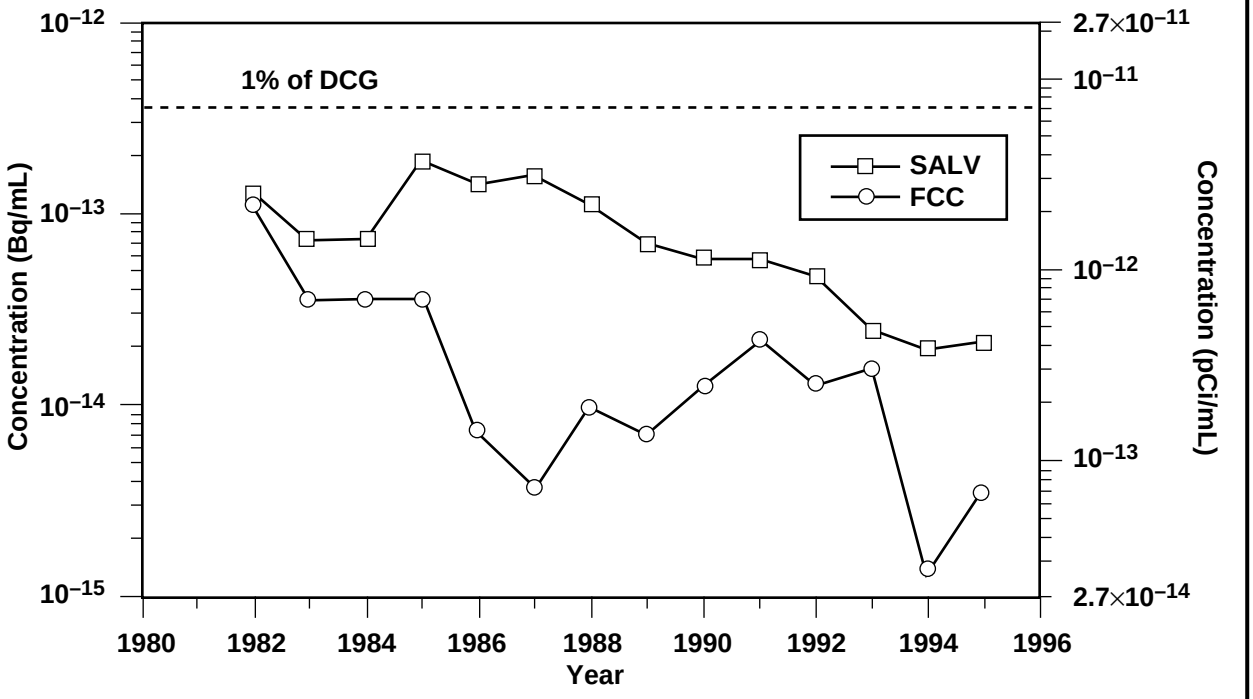

Figure 4-6. Median plutonium concentrations in air particulate samples at two locations, SALV and FCC, 1982–1995 (DCG = 7.4×10^{-10} Bq/mL).

$^{235}U/^{238}U$ ratios, indicating other than natural uranium around the Livermore site perimeter. While no significant environmental impact stems from the observed ratios, their cause is not known but may be attributed to construction activities near the sampling locations causing increased resuspension of historical contamination and an increase in the mass loading of the filters.

Table 4-5 shows the median concentrations of tritiated water vapor for the Livermore Valley sampling locations. (See Volume 2, Table 4-12 for biweekly data for each location.) The highest annual median concentration was observed at location ZON7. At approximately 2.2×10^{-8} Bq/mL (5.9×10^{-19} Ci/mL), this concentration represents 0.000006 of the DCG. The highest biweekly concentration was observed in January at VET. If it were a yearly average, this concentration, 3.6×10^{-7} Bq/mL (9.7×10^{-18} Ci/mL), would be 0.0001 of the DCG. The 1995 tritium values generally are similar to those reported last year.

Table 4-5 also shows the median concentrations of tritiated water vapor that were observed at the Livermore site perimeter sampling locations. (See Volume 2, Table 4-13 for biweekly data.) The highest annual median concentration was observed at location POOL, which was 1.4×10^{-7} Bq/mL (3.8×10^{-18} Ci/mL), or 0.00004 of the DCG.

Table 4-4. Uranium activity in air particulate samples, 1995.

Sampling location[a]	^{238}U[b] [10^{-5} μg/m^3]	^{235}U[c] [10^{-7} μg/m^3]	$^{235}U/^{238}U$[d] [10^{-3}]
LLNL perimeter			
SALV			
Median	4.1	2.9	7.28
Interquartile range	5.8	4.3	0.28
Maximum	13.9	10.3	—[e]
Median fraction of DCG	1.40×10^{-4}	6.20×10^{-6}	
MESQ			
Median	4.5	3.2	7.3
Interquartile range	4.4	3.2	0.23
Maximum	13.4	9.9	—[e]
Median fraction of DCG	1.50×10^{-4}	6.80×10^{-6}	
CAFE			
Median	4.5	3.3	7.24
Interquartile range	4	2.9	0.29
Maximum	14.2	10.5	—[e]
Median fraction of DCG	1.50×10^{-4}	7.10×10^{-6}	
VIS			
Median	2.8	3.4	7.36
Interquartile range	3.9	3.7	0.92
Maximum	12.1	16	—[e]
Median fraction of DCG	9.50×10^{-5}	7.10×10^{-6}	
COW			
Median	5.5	4.1	7.25
Interquartile range	10.3	6.7	0.29
Maximum	19.4	143	—[e]
Median fraction of DCG	1.80×10^{-4}	8.70×10^{-6}	
MET			
Median	3.7	2.7	7.28
Interquartile range	5.5	4.4	0.39
Maximum	14.3	10.5	—[e]
Median fraction of DCG	1.22×10^{-4}	5.60×10^{-6}	
Site 300 (composite)			
Median	4.2	2.7	6.1
Interquartile range	6.6	4.1	2.2
Maximum	14.5	10.3	—[e]
Median fraction of DCG	1.40×10^{-4}	5.70×10^{-6}	

a See **Figures 4-1** and **4-3** for sampling locations.

b Derived Concentration Guide (DCG) = 0.3 μg/m^3 for ^{238}U activity in air.

c Derived Concentration Guide (DCG) = 0.047 μg/m^3 for ^{235}U activity in air.

d Naturally occurring uranium has a $^{235}U/^{238}U$ ratio of 7.1 X 10^{-3}.

e Maximum not computed for $^{235}U/^{238}U$ ratio; maximum for each isotope may not occur in same month.

Table 4-5. Tritium in air samples (in 10^{-9} Bq/mL), 1995.

Sampling location[a]	Detection frequency	Median	IQR[b]	Maximum	Median fraction of DCG[c]	Median dose (mSv)[d]
Livermore Valley						
ZON7	17/23	22.1	<37.7	318.9	6.0×10^{-6}	4.7×10^{-6}
ALTA	8/22	<15.3	—[e]	24.1	$<4.1 \times 10^{-6}$	3.3×10^{-6}
FIRE	11/25	<16.0	<23.5	74.0	$<4.3 \times 10^{-6}$	3.4×10^{-6}
XRDS	6/25	<13.1	—[e]	87.7	$<3.6 \times 10^{-6}$	2.8×10^{-6}
VET	16/25	21.7	<35.6	357.1	5.9×10^{-6}	4.7×10^{-6}
Livermore perimeter						
SALV	26/26	78.6	85.3	558.7	2.1×10^{-5}	1.7×10^{-5}
MESQ	19/25	32.3	<39.2	141.0	8.7×10^{-6}	6.9×10^{-6}
CAFE	26/26	77.5	81.6	555.0	2.1×10^{-5}	1.7×10^{-5}
MET	20/26	<39.2	—[e]	148.4	$<1.1 \times 10^{-5}$	8.4×10^{-6}
VIS	26/26	73.8	48.7	373.7	2.0×10^{-5}	1.6×10^{-5}
COW	24/26	61.2	35.3	392.2	1.7×10^{-5}	1.3×10^{-5}
POOL	25/25	143.9	142.1	921.3	3.9×10^{-5}	3.1×10^{-5}
Diffuse on-site sources						
B292	24/24	128.4	76.1	359.3	3.5×10^{-5}	2.8×10^{-5}
B331	25/25	1931.4	4780.4	43660.0	5.2×10^{-4}	4.1×10^{-4}
B514	25/25	152.1	85.5	525.4	4.1×10^{-5}	3.3×10^{-5}
B624	25/25	921.3	762.2	3540.9	2.5×10^{-4}	2.0×10^{-4}

a See **Figures 4-1** and **4-2** for sample locations.

b Interquartile range.

c DCG = 3.7×10^{-3} Bq/mL (1×10^{-7} μCi/mL).

d 1 mSv = 100 mrem.

e Interquartile range not calculated. See Chapter 15, Quality Assurance.

Diffuse sources of tritium on the Livermore site are monitored at air tritium sampling locations B331, B292, B514, and B624. **Table 4-5** shows the median concentrations of tritiated water vapor for these sampling locations. (See Volume 2, Table 4-14 for biweekly data.) The highest median concentration was observed at location B331. This concentration was 1.9×10^{-6} Bq / mL (5.2×10^{-17} Ci / mL) and represents 0.0005 of the DCG. The highest biweekly tritium concentration, 4.4×10^{-5} Bq / mL (1.2×10^{-15} Ci / mL), was observed in August. If it were a yearly average, this concentration would represent 0.01 of the DCG. The median concentration at the B331 sampling location is almost three times higher than in previous years.

The B331 location is near the Tritium Facility (Building 331), in which LLNL personnel have reduced operations in recent years and performed significant

inventory reduction and cleanup activities. During this process, tritium-contaminated equipment slated for disposal is stored in a waste accumulation area before being sent to Hazardous Waste Management facilities. During 1995, outgassing from such waste processing released an estimated 0.15×10^{12} Bq/L (4 Ci) of tritium to the atmosphere outside of Building 331.

The B624 location is situated in the Building 612 yard, which is dedicated to hazardous waste, radioactive waste, and mixed-waste management activities. The yard consists of several areas where waste containers that are outgassing tritium are stored outdoors. The 1995 median concentrations at B292 and B624 are similar to the median concentrations in 1994.

The B292 location is near an underground retention tank that had previously leaked and the B514 sampling location is in a hazardous waste management area where tritium-contaminated waste is treated.

Beryllium in Air

The median concentrations of airborne beryllium for the Livermore site perimeter sampling locations are shown in **Table 4-6**. (See Volume 2, Table 4-15 for monthly data.) The highest value of 54.8 pg/m^3 occurred in the October composite at location SALV. The median concentration for this location is 0.0006 of the monthly ambient concentration limit of 10,000 pg/m^3 established by the Bay Area Air Quality Management District (BAAQMD) and the EPA.

Figure 4-7 is a plot of the median beryllium concentration at the Livermore site perimeter from 1974 through 1995. The overall median concentration was calculated to be 0.002 of the ambient concentration guide. Unless there is a change in LLNL's operations, it is expected that the beryllium levels will remain unchanged.

Site 300

Airborne Radioactivity

Most gross alpha determinations at Site 300 were at or near the analytical limit of detection for the method. **Table 4-1** shows the monthly gross alpha and gross beta detection frequency, median, IQR, and maximum for sampling locations at Site 300. (See Volume 2, Table 4-3 for monthly data.) The monthly median gross alpha and gross beta concentrations are shown in **Figures 4-4** and **4-5**. The Site 300 gross beta results show a similar pattern to those found at the Livermore site. Typical gross alpha activity is -5.8×10^{-12} Bq/mL (-1.6×10^{-23} Ci/mL), or below the detection limit.

Table 4-6. Beryllium in air particulate samples (in pg/m^3), Livermore site perimeter and Site 300, 1995.

Sampling location[a]	Detection frequency	Median	Interquartile range	Maximum
Livermore perimeter				
SALV	12/12	6.1	10.3	54.8
MESQ	12/12	7.0	8.3	25.6
CAFE	12/12	8.0	10.9	23.5
MET	12/12	8.1	11.6	47.5
VIS	12/12	5.2	8.4	23.7
COW	12/12	9.5	11.8	34.2
Site 300				
EOBS	12/12	5.9	7.2	44.7
ECP	12/12	4.9	6.8	33.7
WCP	12/12	4.1	7.0	38.6
LIN	12/12	7.2	12.2	21.6
GOLF	12/12	6.1	8.4	20.0
TFIR	12/12	11.9	16.4	73.9
NPS	12/12	5.7	8.5	29.0
WOBS	12/12	4.4	11.6	57.1
801E	12/12	11.6	12.6	43.5

[a] See **Figures 4-1** and **4-3** for sampling locations.

Typical gross beta activity is 4.1×10^{-10} Bq / mL (1.1×10^{-20} Ci / mL). The primary sources of observed gross alpha and gross beta activity are naturally occurring radioisotopes of uranium and thorium and their decay products, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident (1986).

Table 4-2 lists the annual median activities, IQR, the fraction of the DCG, as well as the DCGs, of gamma-emitting radionuclides in samples from Site 300 and Tracy. (See Volume 2, Table 4-5 for monthly data.) All these radionuclides were measured at concentrations significantly below the DCGs. Of the nuclides tabulated, ^{7}Be, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th are naturally occurring. The primary source of ^{137}Cs normally is long-term global fallout and resuspension.

Table 4-3 shows the median concentration of ^{239}Pu on air-filter samples collected from Site 300. (See Volume 2, Table 4-9 for monthly data.) The highest concentration of ^{239}Pu was observed in the October composite at a level of 1.2×10^{-14} Bq / mL (3.2×10^{-25} Ci / mL), or 0.00002 of the DCG. **Table 4-5** shows the median concentration of ^{238}U, ^{235}U, and the ^{235}U / ^{238}U ratio on air samples from Site 300. (See Volume 2, Table 4-11 for monthly data.) The highest

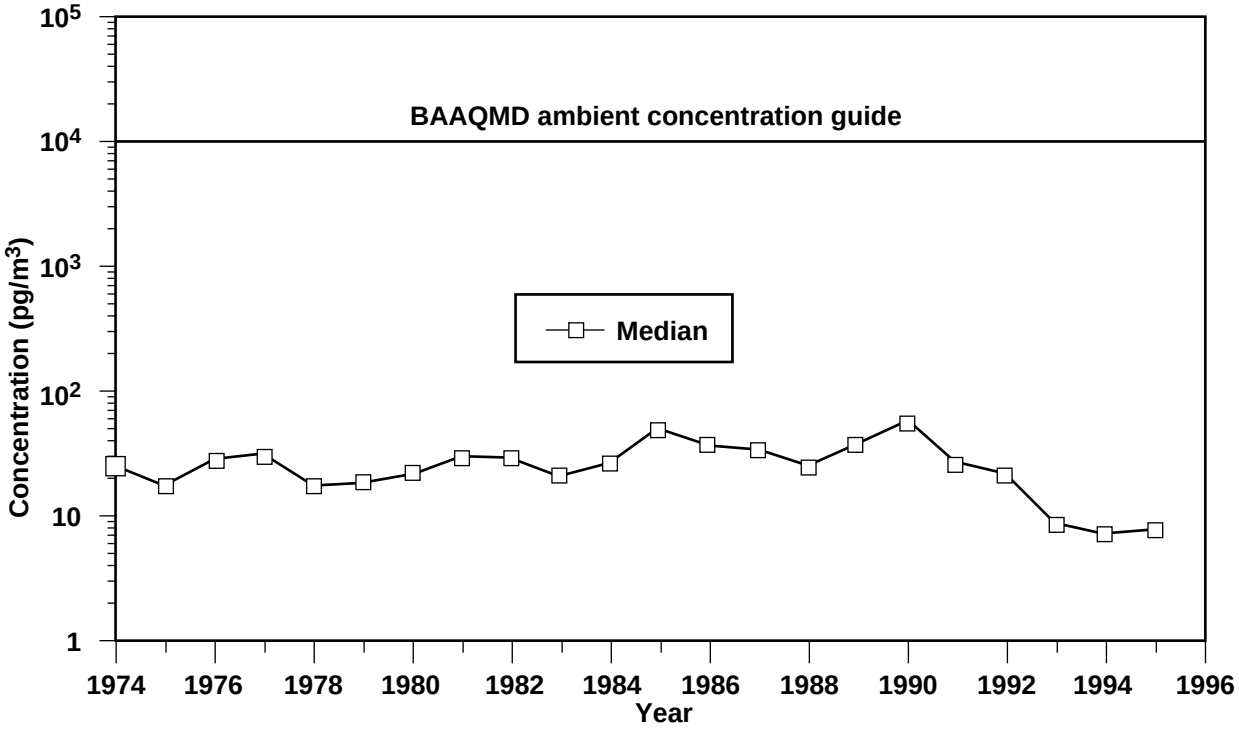

Figure 4-7. Median concentration of beryllium in air particulate samples, Livermore site perimeter, 1974 to 1995.

concentration of ^{238}U was observed in the October composite at a level of 1.5×10^{-4} μg / m^3 (0.0005 of the DCG). The highest concentration of ^{235}U was observed in the October composite at a level of 1.0×10^{-6} μg / m^3 (0.00002 of the DCG). No other significant differences between locations or samples were noted. The overall levels were essentially the same as those reported in previous years.

The ratio of ^{235}U to ^{238}U can be used to identify the source of the uranium. Both ^{235}U and ^{238}U occur naturally in the area, but only 0.7% of the naturally occurring uranium is ^{235}U, and the remainder is almost entirely ^{238}U. Because Site 300 operations use depleted uranium that contains very little ^{235}U, it follows that if the ratio remains constant and near 0.7% (within the limit of sampling and analytical error), then the ^{238}U measured is from natural sources. The $^{235}U / ^{238}U$ ratios in January and February are slightly less than expected for natural sources, which may be a result of the increased variability in the measurements at the reported values. The deviations from the natural ratio in March, May, June, and August indicate some impact from operations at Site 300. The median concentration of ^{238}U for 1995, however, is only 0.00014 of the DCG (DOE Order 5400.5).

Beryllium in Air

The detection frequency, median, IQR, and maximum concentrations of airborne beryllium for the Site 300 sampling locations are shown in **Table 4-6**. (See Volume 2, Table 4-16 for monthly data.) The highest beryllium concentration of

73.9 pg/m^3 occurred in October at location TFIR. The concentration median for this location is 0.0006 of the federal ambient concentration limit, which is 10,000 pg/m^3.

Environmental Impact

The environmental impacts from both radioactive and nonradioactive effluents are described in this section.

Radioactive Materials

LLNL operations involving radioactive materials had little impact on radionuclide concentration in ambient air in 1995. Radionuclide concentrations in air at the Livermore site and in the Livermore Valley are well below levels that would cause concern to the environment or public health according to existing regulatory standards.

The diffuse tritium sources at B292, B331, B514, and B624 have a localized effect; no elevated tritium concentrations were detected at the site perimeter or off site.

The concentrations of radionuclides measured around Site 300 and in the City of Tracy were well below all standards and, except for uranium isotopes, reflect background or naturally occurring levels of these chemicals. (See Chapter 13, Dose Assessment, for discussion of estimated dose from these data.) The $^{235}U/^{238}U$ ratios in October and December are less than the ratio of naturally occurring concentrations of these isotopes, which suggests that LLNL-introduced depleted uranium is present in air samples from Site 300. These kinds of results can occur when tests using depleted uranium are conducted at Site 300.

Nonradioactive Materials

The concentrations of beryllium at both sites can be attributed to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 ppm of beryllium, and the air of the Livermore area and Central 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, an airborne beryllium concentration of 50 pg/m^3 can be calculated. The overall annual medians for the Livermore site and Site 300 are 7.1 pg/m^3 and 6.2 pg/m^3, respectively. These data are well below standards and do not indicate the presence of a threat to the environment or public health.