5

# Ambient Air Monitoring

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## Introduction

Lawrence Livermore National Laboratory performs ambient air monitoring to evaluate its compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected from hazardous and radioactive air emissions. Federal environmental air quality laws and U.S. Department of Energy (DOE) regulations include Title 40 of the Code of Federal Regulations (CFR) Part 61, the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act, and applicable portions of DOE Orders 5400.1 and 5400.5. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) provides the guidance for implementing DOE Orders 5400.1 and 5400.5. In general, the airborne substances for which LLNL monitors are at levels far below regulatory standards.

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 the air monitoring program, LLNL collects particles on filters and chemically traps vapors on a collection medium. Concentrations of various airborne radionuclides (including particles and tritiated water vapor) and beryllium metals are measured at the Livermore site, Site 300, and at off-site locations throughout the Livermore Valley and in the City of Tracy. In addition, some point sources and diffuse, or nonpoint sources, are monitored to fulfill NESHAPs requirements (Harrach et al. 2003).

## Methods

Monitoring networks are established for surveillance of air particulates and tritium in the environs of the Livermore site and Site 300, as well as in the surrounding Livermore Valley and in the City of Tracy. The sampling locations for each monitoring network are listed in **Table 5-1** and shown on **Figures 5-1** to **5-3**. All monitoring networks use continuously operating samplers. The air particulate sampling network uses glass-fiber, cellulose, and membrane filters, while the collection medium for tritium is silica gel.

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

### Air Particulate Sampling Locations

All air samplers are positioned to provide reasonable probability that any significant concentration of radioactive or beryllium effluents from LLNL operations will be detected.

The Livermore site radiological air particulate sampling network (see **Figure 5-1**) consists of seven samplers at the perimeter with one (CRED) serving as the sitewide maximally exposed individual (SW-MEI) for NESHAPs reporting purposes. CRED is also located in the southeast quadrant in an area of known plutonium contamination attributed to historic operations, which included the operation of solar evaporators for plutonium-containing liquid waste.

The Livermore Valley network (see **Figure 5-2**) consists of air particulate samplers located in all directions from the Livermore site. For the purposes of data analysis, four samplers (FCC, FIRE, HOSP, and CHUR) located in the least prevalent wind directions are considered to be upwind or representative of background locations. An additional upwind sampler is located in another area of special interest, the Livermore Water Reclamation Plant (LWRP), because of plutonium releases in 1967 and earlier to the sanitary sewer system with subsequent soil contamination and potential resuspension (see the "Livermore Valley Surface Soil Results" section of Chapter 10 for a discussion of this). Four samplers (PATT, ZON7, TANK, and AMON) are located in the most prevalent downwind directions that are considered most likely to be affected by Laboratory operations.

Livermore site beryllium monitoring continued in 2002 at all perimeter locations except CRED. To satisfy beryllium reporting requirements and determine the effects of the LLNL's beryllium operations, LLNL conducted a technical assessment of the beryllium monitoring locations at Site 300 in 1997. Although there is no requirement to sample for beryllium at Site 300, LLNL has decided, as a best management practice, to continue beryllium monitoring at three locations on site (801E, EOBS, GOLF) and at one location in the City of Tracy (TFIR) (see **Figure 5-3**).

The Site 300 air particulate monitoring network includes eight sampling units placed around the site and near firing tables and one in downtown Tracy (see **Figure 5-3**). Due to the remoteness of Site 300 and the difficulties with weekly access, monitoring sites were chosen based on safety, power, and access considerations. COHO serves as the SW-MEI for NESHAPs reporting purposes.

Two sampling systems were added in the Livermore Valley in July 1997 as part of the new low-volume radiological air particulate sampling network. The samplers are situated at FCC and HOSP and are generally upwind of the Livermore site. The results are used to establish background levels of gross

**Table 5-1. Sampling locations and type and frequency of analyses for ambient air**

| Livermore site | | | | | | |
|---|---|---|---|---|---|---|
| | Weekly gross alpha & beta (low volume) | Weekly gross alpha & beta (high volume) | Monthly $^{239+240}$Pu | Monthly Gamma & $^{235, 238}$U[a] | Monthly beryllium | Biweekly tritium |
| Network | Air particulate | | | | | Air vapor |
| Collection Media | Membrane | Cellulose | | | | Silica gel |
| SALV | | X | X | X | X | X |
| MESQ | | X | X | X | X | X |
| CAFE | | X | X | X | X | X |
| MET | | X | X | X | X | X |
| VIS | | X | X | X | X | X |
| COW | | X | X | X | X | X |
| CRED | | X | X | | | |
| DWTF | | | | | | X |
| B292 | | | | | | X |
| B331 | | | | | | X |
| B514 | | | | | | X |
| B624 | | | | | | X |
| POOL | | | | | | X |
| VET | | | | | | X |
| ZON7 | | X | X | | | X |
| PATT | | X | X | | | X |
| CHUR | | X | X | | | |
| AMON | | X | X | | | X |
| FCC | X | X | X | | | |
| HOSP | X | X | X | | | X |
| LWRP | | X | X | | | |
| FIRE | | X | X | | | X |
| TANK | | X | X | | | |
| Site 300 | | | | | | |
| | | Weekly gross alpha & beta (high volume) | Monthly Gamma & $^{239+240}$Pu[a] | Monthly $^{235, 238}$U | Monthly beryllium | Biweekly tritium |
| Network | | Air particulate | | | | Air vapor |
| Collection Media | | Cellulose | | | | Silica gel |
| EOBS | | X | X | X | X | |
| ECP | | X | X | X | | |
| WCP | | X | X | X | | |
| GOLF | | X | X | X | X | |
| NPS | | X | X | X | | |
| WOBS | | X | X | X | X | |
| 801E | | X | X | X | | |
| COHO | | X | | X | | X |
| TFIR | | X | | X | X | |

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

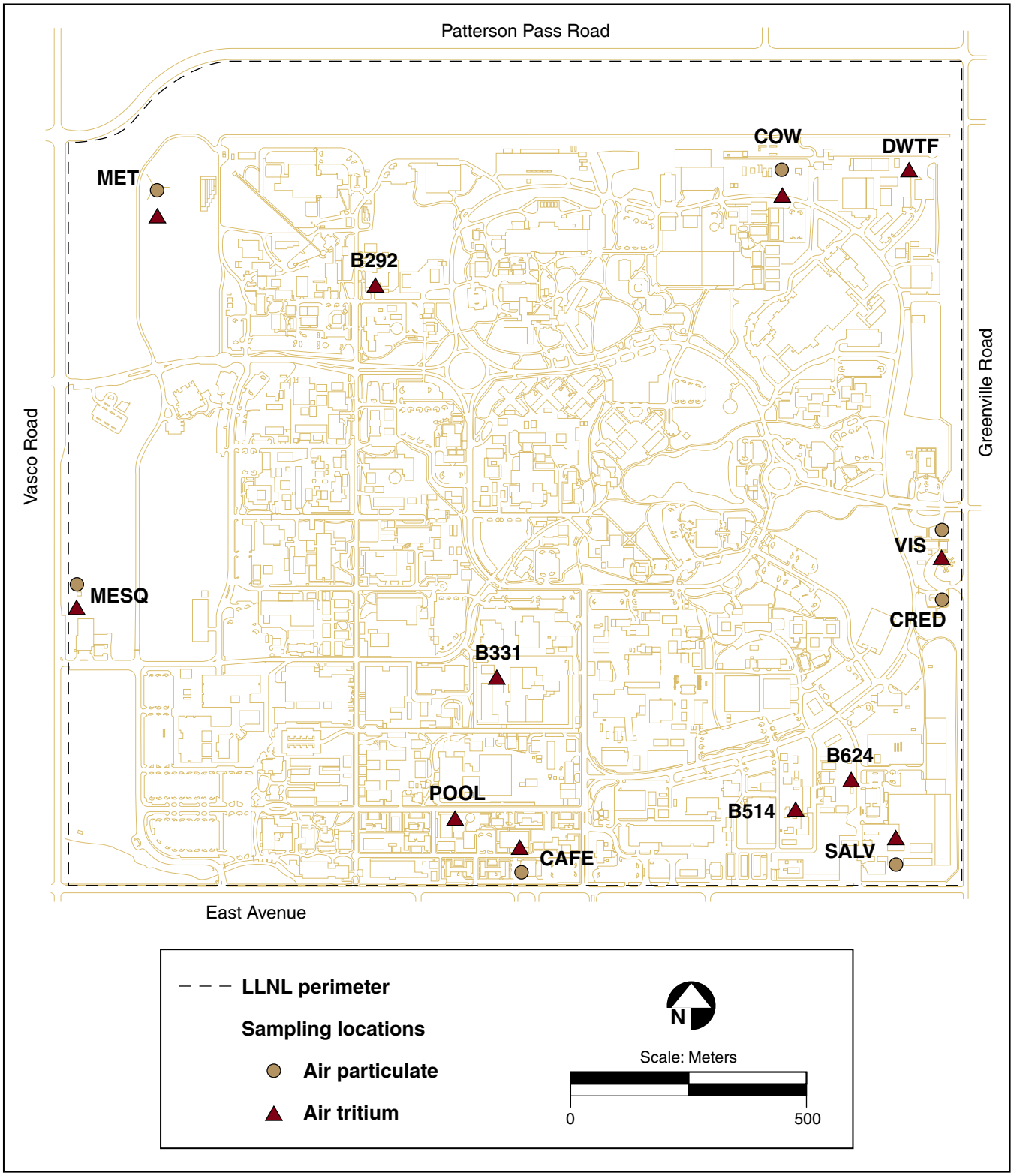


**Figure 5-1. Air particulate and tritium sampling locations on the Livermore site, 2002**

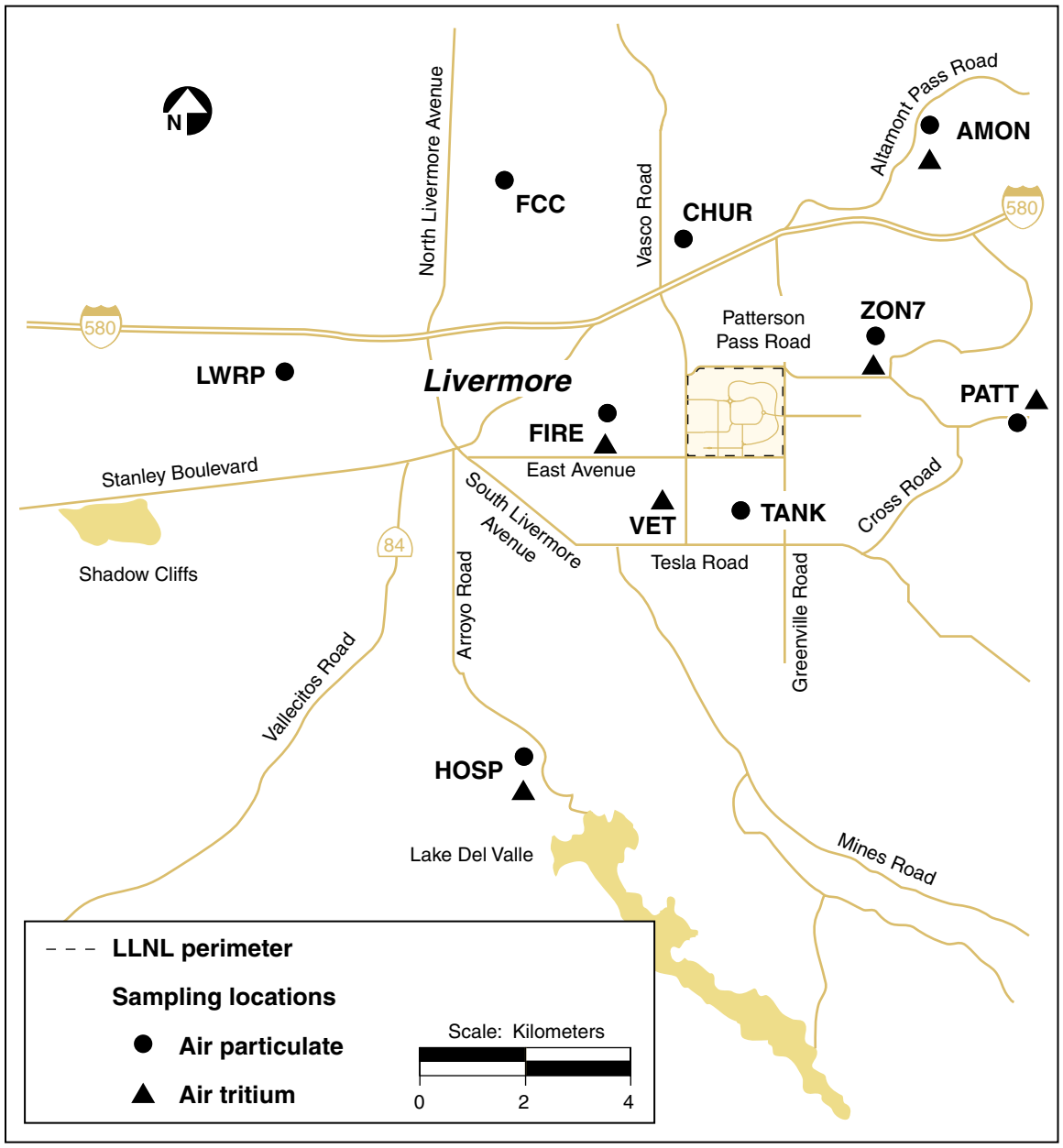


**Figure 5-2. Air particulate and tritium sampling locations in the Livermore Valley, 2002**

alpha and beta activity for direct comparison to emissions from the air effluent samplers (see Chapter 4). The low-volume sampling systems are very similar to the air-effluent samplers used in facilities, including sampling system design, sampler operation, sampler flow rate, filter media, sample tracking, sample analysis, and processing of results.

## Air Tritium Sampling Locations

LLNL also maintains 12 continuously operating airborne tritium samplers on the Livermore site (see **Figure 5-1**), 6 samplers in the Livermore Valley (see **Figure 5-2**), and 1 sampler at Site 300 (see **Figure 5-3**) to assess current activities that

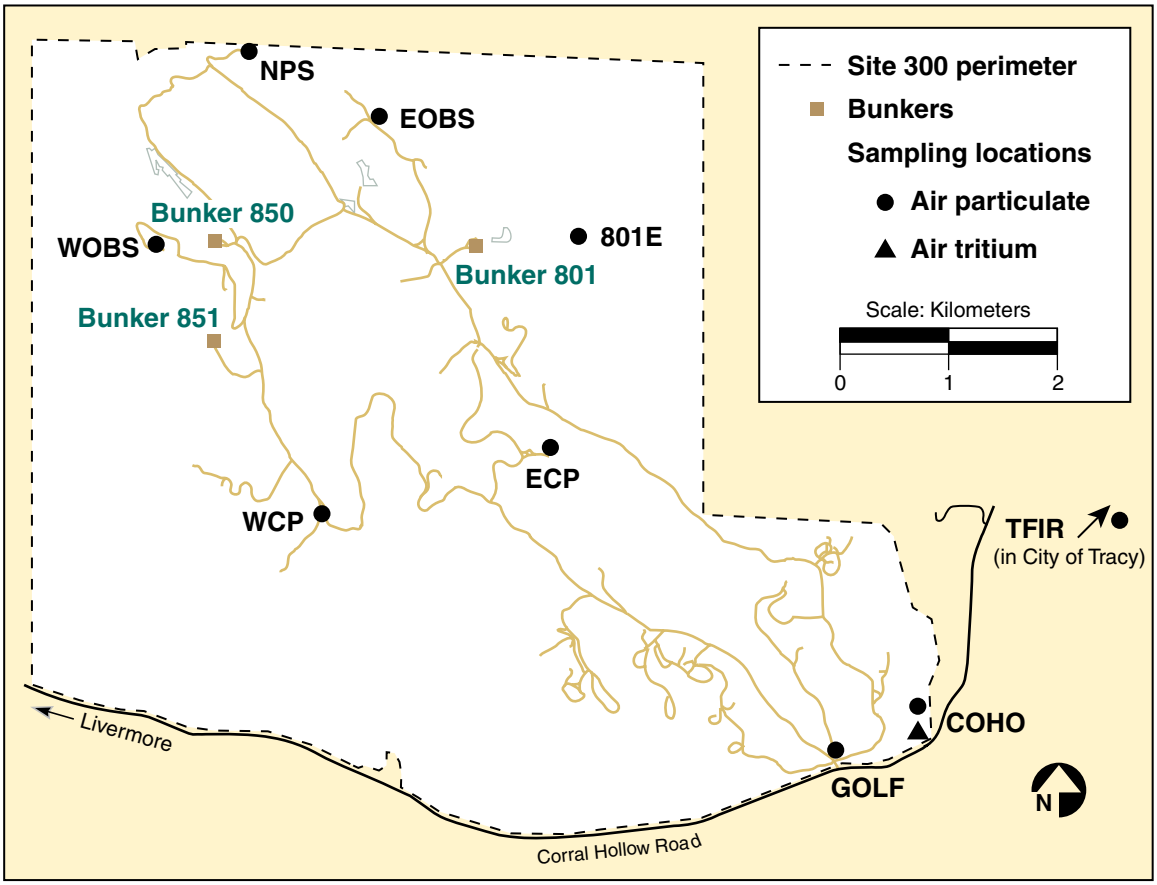


**Figure 5-3. Air particulate and tritium sampling locations at Site 300 and off-site, 2002**

influence environmental impacts. Four of the Livermore site locations (B331, B292, B514, and B624) monitor diffuse tritium emissions.

## Radiological Analysis

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 trend indicators; specific radionuclide analysis is done for plutonium and uranium. 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.

Particle size distribution on air samples is not determined because the estimated effective dose equivalent to the maximally exposed individual (from the total particulate) is well below the 0.01-mSv (1-mrem) allowable limit as discussed in the above-mentioned environmental regulatory guide.

Gross alpha and gross beta activities are determined by gas flow proportional counting; plutonium isotopes by alpha spectrometry; uranium isotopes by mass spectrometry; gamma emitters by gamma spectroscopy; and tritium by liquid scintillation. Further details of the monitoring and analytical methods for ambient air are provided in Chapter 5 of the Data Supplement.

For air, Derived Concentration Guides (DCGs) 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 mSv/y (100 mrem/y) effective dose equivalent (DOE Order 5400.5). (Chapter 13 provides an explanation of this and other units of dose.) Each data table in this chapter presents the DCG and the percent of the DCG for the given isotope.

## Results

This section discusses the air monitoring results from all air surveillance locations at the Livermore site, Site 300, and all off-site ambient air monitoring locations.

In April 1997, the radiological air particulate sampling filter media were changed from cellulose to glass fiber; however, blank glass-fiber filters contain nontrivial amounts of some naturally occurring radiological isotopes (Althouse 1998) including uranium-235, uranium-238, potassium-40, radium-226, radium-228, and thorium-228. In fact, the amounts of these naturally occurring isotopes contained in these filters is often greater than the amounts of the isotopes being filtered from the air. Given this background activity and the difficulty the analytical laboratories have in digesting glass fiber filters, LLNL determined that the data had less uncertainty using cellulose than glass filters. In 2001, LLNL made a request to DOE to switch the filter medium back to cellulose. This request was granted and in January 2002 high-volume air particulate samplers were once again collecting particulate on cellulose filters.

Another significant change in 2002 involved the analysis of the filters. From January through May, the analysis was performed off site by a commercial laboratory. In June, the analysis for the high-volume air particulate filters was brought to an on-site laboratory with improved methods of detection. For all samples the counting time was extended and for uranium the method changed from alpha spectrometry to inductively coupled mass spectrometry. These changes resulted in less uncertainty and more reliable data results.

### Livermore Site

#### Airborne Radioactivity

**Figure 5-4** shows the three-year history of monthly gross alpha and gross beta median activities for the Livermore site perimeter, Livermore Valley, and Site 300 sampling locations. Detailed location results for the high-volume network for gross alpha and gross beta concentrations for 2002 are found in the Data Supplement Tables 5-1, 5-2, and 5-3 along with the summary statistics. The gross alpha and gross beta values are similar to historical values and tend to increase in September and decrease once the winters rains begin.

In 2002 the typical gross alpha activity (annual median value) for the Livermore site perimeter is 24 $\mu Bq/m^3$ (0.65 $fCi/m^3$); for the upwind Livermore Valley stations, the value is 54 $\mu Bq/m^3$ (1.5 $fCi/m^3$); and for the downwind Livermore Valley stations the value is 55 $\mu Bq/m^3$ (1.5 $fCi/m^3$).

The gross beta activity ranged from the lowest annual median value recorded at an onsite location (MESQ) at 288 $\mu Bq/m^3$ (7.8 $fCi/m^3$) to the highest median value of 409 $mBq/m^3$ (11 $fCi/m^3$) at a another Livermore site station (MET). There were two weeks where the gross beta values were significantly higher in all air particulate samples (including the low-volume network where samples are analyzed by a different laboratory). These data reflected the sampling period ending December 3 and December 10. No other isotopic data (plutonium, uranium, or gamma) increased during this

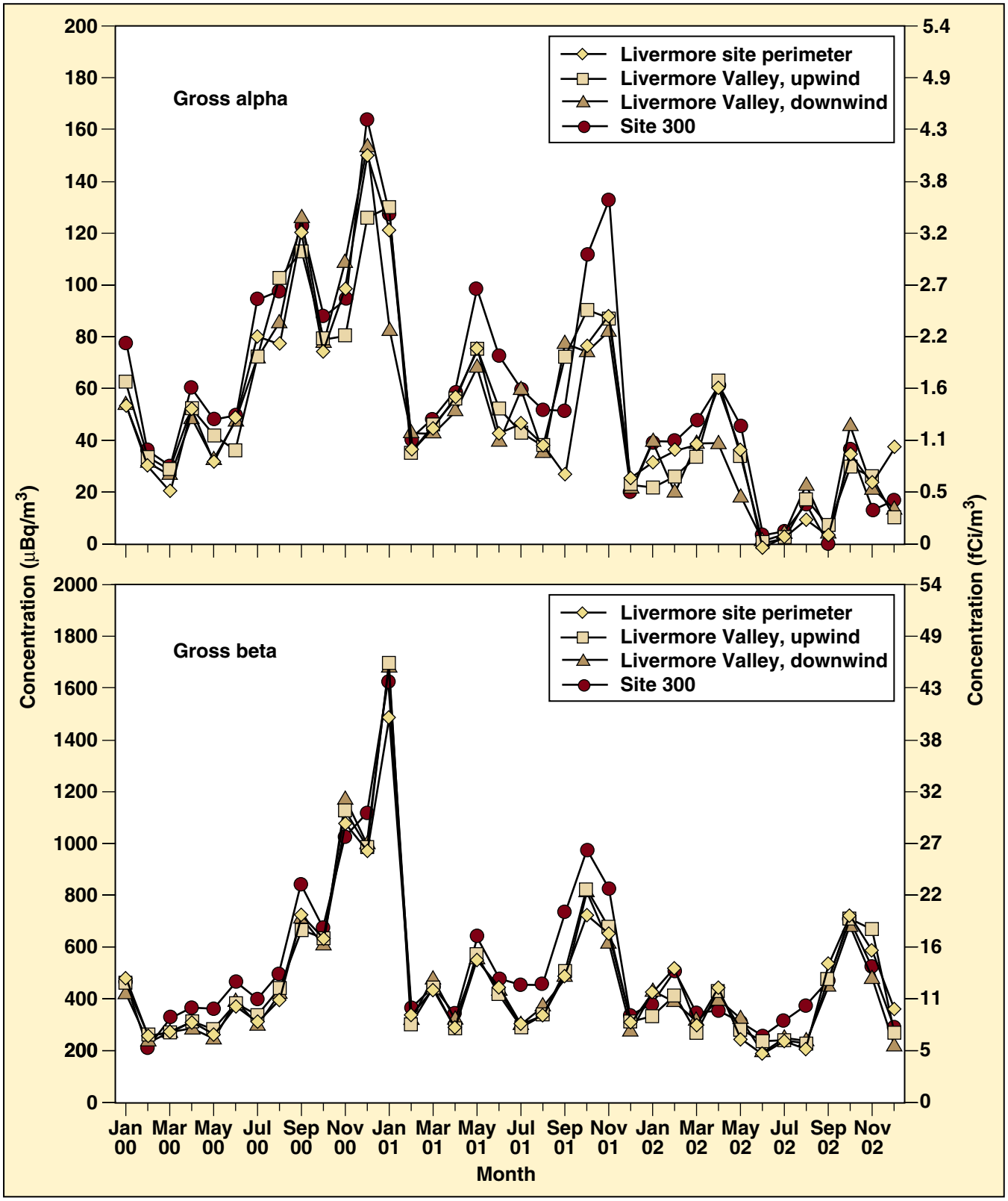


**Figure 5-4. Three-year history of the median gross alpha and gross beta activities for all particulate samples grouped by area, 2000-2002**

period and these occasional high values are routinely detected during winters months (see **Figure 5-4**). The trend is being investigated and is likely the result of meteorological factors.

The primary sources of the alpha and beta activities are the naturally occurring radioisotopes of uranium and thorium, primarily from resuspension from soils and any residual fallout from atmospheric weapons testing and the 1986 Chernobyl reactor accident. The high-volume data follow a similar pattern to the low-volume gross alpha and gross beta data.

Composite samples for the Livermore site and Site 300 are analyzed for an environmental suite of gamma-emitting radionuclide concentrations in air. Of those isotopes, beryllium-7 and potassium-40, both naturally occurring in the environment, were consistently detected. These data are shown in **Table 5-2**. No other significant gamma isotopes were detected in the Livermore site composite samples. 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 at LLNL and also obtains baseline data on global fallout.

Table 5-4 in the Data Supplement shows the concentrations of airborne plutonium-239+240 on air filters from the Livermore site perimeter locations. Of the over 80 samples analyzed for plutonium along the perimeter in 2002, 13 showed positive detections. Of these samples, the highest value was detected during September at MET, a location along the west perimeter of the Livermore site. This value of 245 nBq/m$^3$ (6.6 aCi/m$^3$) is still only 0.033% of the DCG. The MET sample for the following month was well within the historical range for this location. The annual median plutonium activity for the perimeter locations was 6.14 nBq/m$^3$ (0.16 aCi/m$^3$) or 0.0008% of the DCG.

Table 5-5 in the Data Supplement shows the monthly plutonium-239+240 data for the Livermore Valley samples. Plutonium was detected in 13 of the 108 samples analyzed at off-site locations. The location LWRP, a special interest location due to previous localized contamination, had six of these detections with the highest overall detection of 0.17 µBq/m$^3$ (4.6 aCi/m$^3$), which is 0.0054% of the DCG. The median value for all off-site locations (excluding LWRP) was 2.1 nBq/m$^3$ (0.05 aCi/m$^3$) or 0.0002% of the DCG.

**Figure 5-5** shows the monthly median plutonium-239+240 results for the Livermore site perimeter, Livermore Valley (downwind and upwind), Site 300 composite, and the special interest location (LWRP) that possessed the highest overall median for the year. There were twice as many plutonium detections in 2002 than in 2001, which is the result of the improvement in the analytical method resulting in a lower achievable detection limit in the second half of the year. The median off-site value was lower in 2002 (2.1 nBq/m$^3$) than in 2001 (7.5 nBq/m$^3$).

**Figure 5-6** compares twenty years (from 1982 to 2002) of historical annual medians of plutonium-239+240 concentrations for a perimeter location (SALV) and an off-site location (FCC). The graph also plots the DCG for plutonium. Data below the detection limit are estimated activity values, meaning the values are somewhere between the reported estimated value and zero.

**Figure 5-6** uses a log scale, and for the years when a negative median concentration was calculated, the lowest positive value was plotted. The higher values in the past at SALV may be attributed to

**Table 5-2. Beryllium-7 and potassium-40 activity in air particulate samples for the Livermore site and Site 300 gamma composites, 2002**

| Month | LLNL Composite[a] ($mBq/m^3$) | Site 300 Composite[b] ($mBq/m^3$) | LLNL Composite[a] ($mBq/m^3$) | Site 300 Composite[b] ($mBq/m^3$) |
|---|---|---|---|---|
| | Beryllium-7 | | Potassium-40 | |
| Jan | 2.09 ± 0.24 | 2.12 ± 0.25 | 12.8 ± 30.3 | 4.3 ± 31.7 |
| Feb | 2.19 ± 0.24 | 2.41 ± 0.26 | 0.0[c] | 0.0[c] |
| Mar | 2.94 ± 0.33 | 2.87 ± 0.33 | 33.4 ± 20.8 | 26.2 ± 28.3 |
| Apr | 2.15 ± 0.25 | 2.40 ± 0.27 | 18.5 ± 41.9 | 9.6 ± 30.2 |
| May | 3.49 ± 0.40 | 5.61 ± 0.61 | 43.8 ± 29.5 | 13.0 ± 42.6 |
| Jun[d] | 0.44 ± 0.05 | 4.33 ± 0.49 | 2.0 ± 0.6 | 11.5 ± 9.5 |
| Jul | 0.99 ± 0.11 | 4.22 ± 0.48 | <3.7 | <22.6 |
| Aug | 2.76 ± 0.31 | 2.74 ± 0.32 | 11.0 ± 3.2 | 7.4 ± 2.9 |
| Sep | 3.09 ± 0.36 | 4.03 ± 0.46 | 18.3 ± 4.8 | 10.3 ± 3.4 |
| Oct | 3.32 ± 0.38 | 4.07 ± 0.46 | 7.4 ± 1.0 | 9.1 ± 3.2 |
| Nov | 3.63 ± 0.41 | 4.07 ± 0.46 | 11.6 ± 10.0 | 10.9 ± 9.2 |
| Dec | 1.86 ± 0.21 | 2.04 ± 0.23 | 7.6 ± 3.4 | 7.0 ± 9.8 |
| Median | 2.48 | 3.45 | 12.2 | 10.0 |
| IQR[e] | 1.11 | 1.70 | 10.0 | 3.5 |
| Maximum | 3.63 | 5.61 | 43.8 | 26.2 |
| Percent of DCG | $1.65 \times 10^{-4}$ | $2.30 \times 10^{-4}$ | $3.70 \times 10^{-5}$ | $3.02 \times 10^{-5}$ |
| DCG ($Bq/m^3$) | 1500 | | 33 | |

Note: < sign indicates result is less than the limit of sensitivity.

a Livermore composite consists of samples from SALV, MESQ, CAFE, MET, VIS, and COW. See **Figure 5-2**.

b Site 300 composite consists of samples from 801E, EOBS, ECP, GOLF, NPS, WCP, and WOBS. See **Figure 5-3**.

c Actual reported zero as reported by analytical laboratory

d Analytical laboratory change resulting in a longer counting time and a reduction in the uncertainty

e IQR= Interquartile range

historical activities at the Livermore site. The general downward trend at both locations is likely the result of decreasing residual global fallout.

As the result of a network assessment that was done in January 2000, Livermore site perimeter uranium analysis was changed because the activities involving uranium at the Livermore site were reduced. Instead, a composite from six perimeter locations (CAFE, COW, MESQ, MET, SALV, and VIS) is created to determine uranium activities at the Livermore site while specific locations at Site 300 receive uranium analysis. The Livermore site composite and Site 300 data are shown in **Table 5-3**. The Livermore site composite had a uranium-235 median value of 0.344 $pg/m^3$ which represents 0.0007% of the DCG. The uranium-238

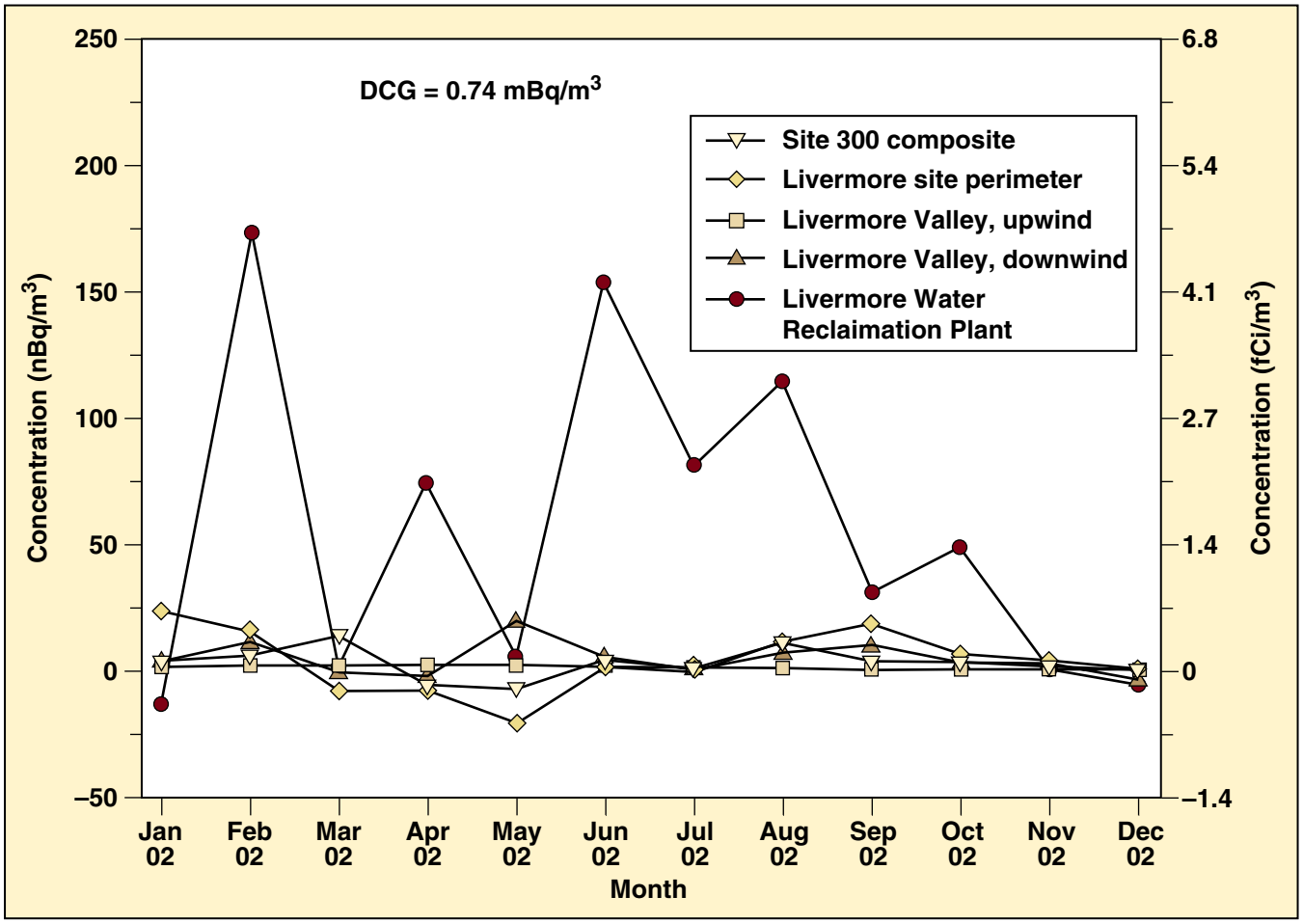


**Figure 5-5. Monthly median concentrations of plutonium-239+240 in air particulate samples, 2002**

median was 38.8 pg/$m^3$, representing 0.013% of the DCG. This composite had a median ratio (using June–December data) of 0.0080 which is slightly higher than natural background activity (0.0074).

The low-volume radiological air sampling locations FCC and HOSP have annual medians for gross alpha and gross beta activity of 85 µBq/$m^3$ (2.3 fCi/$m^3$) and 784 µBq/$m^3$ (21.0 fCi/$m^3$), respectively. (See Data Supplement Table 5-6 for monthly median data.) These gross alpha values are similar to those reported from the high-volume sampling systems at the same locations.

Tritium data presented in **Table 5-4** summarize the biweekly tritium data presented in Tables 5-7, 5-8, 5-9 and 5-15 of the Data Supplement. Locations are grouped by expected concentrations of tritium. The highest concentrations of tritium are from samplers on the Livermore site near locations of diffuse tritium (B292, B331, B514, and B624). The sources of tritium in these locations are mostly stored containers of tritium waste or tritiated contaminated equipment; B292 is near a pine tree that acts as a diffuse source of tritium because its roots are growing in water contaminated with tritium from an underground retention tank that

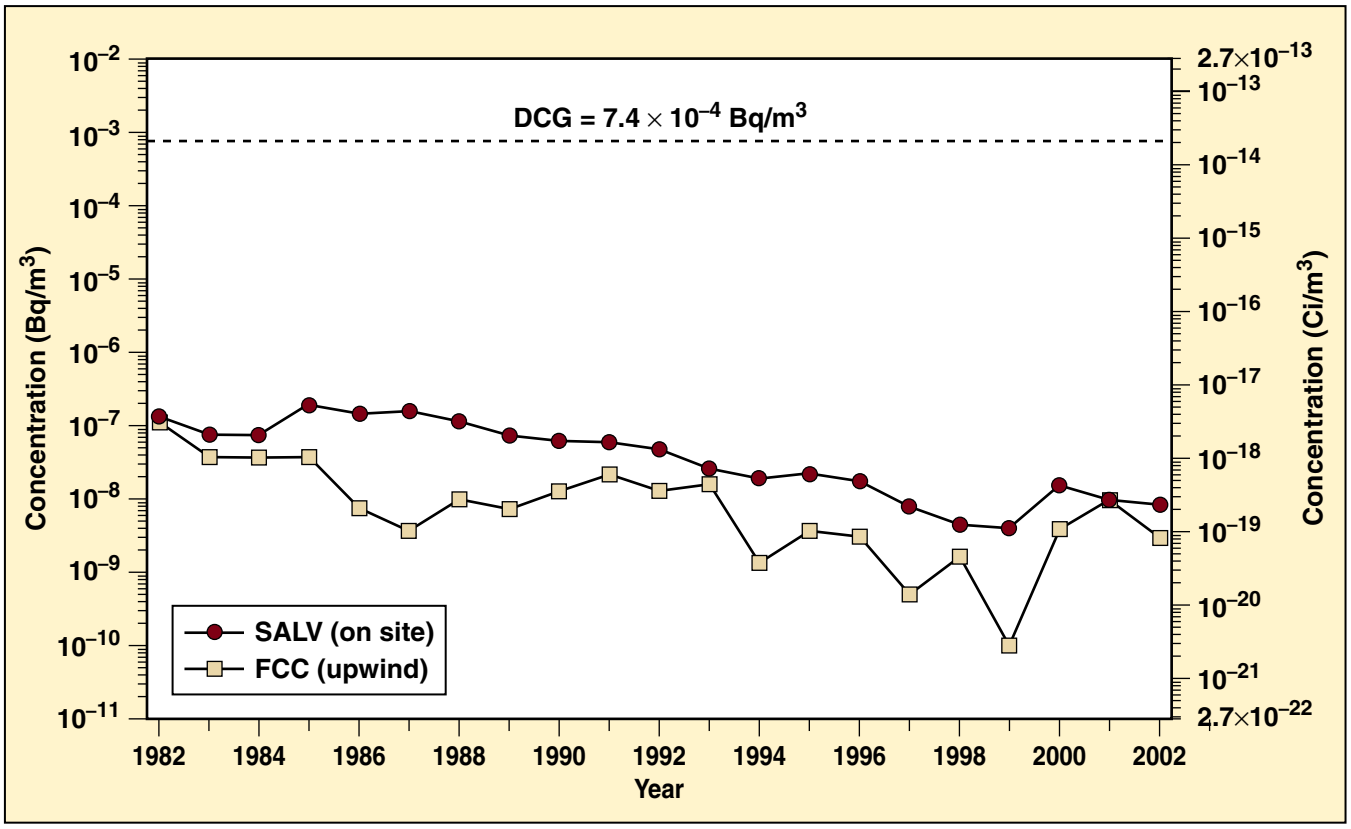


**Figure 5-6. Calculated annual median concentrations of plutonium-239+240 for SALV and FCC with the DCG identified, 2002**

previously leaked (see Chapter 11). Median concentrations for 2002 from all the diffuse-source samplers are comparable to those from 2001.

Samplers on the perimeter of the Livermore site exhibit the next highest air tritium concentrations, which are much lower than those at the locations of the diffuse sources. Of the perimeter locations, POOL exhibits the highest concentrations (which is 0.0026% of the DCG, calculated using the median concentration, as shown in Table 5-8, Data Supplement), and yet the POOL results are statistically different at the 5% significance level (Games-Howell 1976) from those of the sampler at B292, which has the lowest concentrations of the diffuse-source samplers. Median concentrations for 2002 for all the perimeter locations are slightly more than those for 2001 except for locations MESQ and VIS. The increases correspond to higher emissions from the Tritium Facility (see Chapter 4).

Perimeter concentrations for 2002 (even when data from POOL are omitted) are statistically higher than concentrations of tritium in air from the Livermore Valley. Sampling locations in the Livermore Valley demonstrate that LLNL tritium has only a small impact past the perimeter fence. Sixty-nine percent of the Valley samples had concentrations indistinguishable from zero. The median concentrations for the Valley locations for 2002 are comparable to those for 2001 except for ZON7.

**Table 5-3. Summary of uranium mass concentration in air samples, 2002**

| Location[a] | Uranium-235 (pg/m$^3$)[b] | | | | Uranium-238 (pg/m$^3$)[c] | | | | Median Uranium-235 to Uranium-238 ratio[d] |
|---|---|---|---|---|---|---|---|---|---|
| | Median | IQR[e] | Maximum | Percent of DCG[f] | Median | IQR[e] | Maximum | Percent of DCG[f] | |
| 801E | 0.352 | 0.282 | 1.00 | 0.00075 | 38.0 | 22.3 | 270 | 0.013 | 0.0066 |
| COHO | 0.357 | 0.203 | 0.932 | 0.00076 | 38.3 | 21.7 | 61.7 | 0.013 | 0.0072 |
| ECP | 0.239 | 0.201 | 1.11 | 0.00051 | 28.9 | 18.3 | 56.1 | 0.0096 | 0.0071 |
| EOBS | 0.260 | 0.463 | 1.05 | 0.00055 | 35.5 | 16.1 | 57.0 | 0.012 | 0.0070 |
| GOLF | 0.282 | 0.206 | 1.55 | 0.0006 | 37.5 | 13.4 | 60.9 | 0.012 | 0.0073 |
| NPS | 0.257 | 0.0797 | 0.979 | 0.00055 | 34.7 | 13.9 | 55.8 | 0.012 | 0.0073 |
| TFIR | 0.857 | 0.459 | 1.56 | 0.0018 | 90.8 | 69.7 | 178 | 0.030 | 0.0074 |
| WCP | 0.411 | 0.292 | 0.913 | 0.00087 | 33.2 | 10.4 | 155 | 0.011 | 0.0067 |
| WOBS | 0.245 | 0.251 | 1.32 | 0.00052 | 30.7 | 11.9 | 49.9 | 0.010 | 0.0072 |
| Livermore composite | 0.344 | 0.428 | 1.87 | 0.00073 | 38.8 | 25.8 | 168 | 0.013 | 0.0080 |

a See **Figure 5-3** for sampling locations at Site 300. Livermore composite consists of samples from CAFE, COW, MESQ, MET, SALV, and VIS (**Figure 5-1**).

b Uranium-235 activities in Bq/m$^3$ can be determined by dividing the mass by the specific activity of 12,445 Bq/g.

c Uranium-238 activities in Bq/m$^3$ can be determined by dividing the mass by the specific activity of 80,011 Bq/g.

d Uranium 235/238 ratios median was determined from June-December data. Naturally occurring uranium has a ratio of 0.0073; values less than that indicate the presence of depleted uranium, which has a ratio of 0.002.

e IQR = Interquartile range

f Derived Concentration Guides (DCG) for activity in air are 0.3 $\mu$g/m$^3$ for uranium-238 and 0.047 $\mu$g/m$^3$ for uranium-235. Percent DCG was calculated from median value.

**Table 5-4. Tritium in air samples, 2002**

| Sampling locations [a] | Detection frequency [b] | Median (mBq/m$^3$) | Interquartile range (mBq/m$^3$) | Maximum (mBq/m$^3$) | Percent of DCG [c] | Mean (mBq/m$^3$) | Mean Dose[d] (nSv) |
|---|---|---|---|---|---|---|---|
| Diffuse on-site sources | 97/101 | 180 | 640 | 6600 | $4.9 \times 10^{-3}$ | 640 | 130 |
| Livermore perimeter | 163/197 | 41 | 44 | 430 | $1.1 \times 10^{-3}$ | 53 | 11 |
| Livermore Valley | 48/154 | 8.2 | 20 | 94 | $2.2 \times 10^{-4}$ | 11 | 2.3 |
| Site 300 | 4/25 | 0.24 | 17 | 38 | $6.5 \times 10^{-6}$ | 0.70 | 0.15 |

a See **Figures 5-1**, **5-2,** and **5-3** for sample locations.

b Detection frequency is shown as the number of samples with measured concentrations greater than their associated uncertainty relative to the total number of samples.

c DCG = Derived Concentration Guide of 3.7 x $10^6$ mBq/m$^3$ for tritium in air. Percent is calculated from the median concentration.

d Dose is calculated for inhalation and skin absorption (see Appendix C).

### Beryllium in Air

The median concentrations of airborne beryllium for the Livermore site, Site 300, and the downtown Tracy sampling locations are plotted in **Figure 5-7**. (See Data Supplement Table 5-10 for monthly data.) The highest value at the Livermore site was 27.8 pg/$m^3$ which was recorded at location COW in October. This value is only 0.28% of the Bay Area Air Quality Management District ambient concentration limit for beryllium (10,000 pg/$m^3$). All data were similar to data collected from previous years.

**Figure 5-8** is a plot of the median beryllium concentration at the Livermore site perimeter from 1975 through 2002. The decrease in median concentration in 1993 and the slight increase in 1999 were likely the result of a change in the analytical laboratory used to perform this analysis.

## Site 300

### Airborne Radioactivity

Table 5-11 in the Data Supplement shows the weekly gross alpha and gross beta values as well as the median, interquartile range (IQR), and maximum for sampling locations at Site 300. The monthly median gross alpha and gross beta concentrations are plotted in **Figure 5-4** along with the Livermore areas of interest.

The Site 300 gross alpha and gross beta results show a similar pattern to those found at the Livermore site. Generally, Site 300 has the highest median values for both gross alpha and gross beta. This is attributed to a greater abundance of uncovered soils found at the site. Site 300 has fewer structures and buildings and less pavement, compared to Livermore locations, thereby enabling greater mass loading of resuspended particles on air filters. In 2002 the median gross alpha activity is 23.8 µBq/$m^3$ (0.64 fCi/$m^3$); the median gross beta activity is 3.8 mBq/$m^3$ (0.10 pCi/$m^3$). These values are similar to those obtained from monitoring data during the past several years.

The primary sources of observed gross alpha and gross beta activity are naturally occurring radioisotopes of uranium and thorium, their decay products, and any residual fallout from atmospheric weapons testing and the 1986 Chernobyl reactor accident.

Like the Livermore site perimeter samples, the monthly Site 300 composite samples are scanned for an environmental suite of gamma-emitting nuclides, and only beryllium-7 and potassium-40 were consistently detected. **Table 5-2** lists the annual median activity, IQR, maximum, the percent of the DCG, as well as the DCG, for beryllium-7 and potassium-40 from Site 300.

The monthly median value for beryllium-7 from Site 300 composites was 3.5 mBq/$m^3$ (94.5 fBq/$m^3$). There were a few detections for cesium-137 at Site 300, all very close to the detection limit, with the highest concentration detected at 1.5 µBq/$m^3$ (0.04 aCi/$m^3$). This value is 0.00001% of the DCG. Cesium is periodically detected in air samples at Site 300 and is the result of resuspension from cesium in the soils. (See Chapter 10 for annual soil data). Cesium is a product of global fallout and fallout resuspension.

A composite of all Site 300 onsite locations is analyzed for plutonium-239+240 (see Data Supplement Table 5-12 for monthly data). The highest concentration (and the only positive detection) of plutonium-239+240 was recorded in the August composite at a level of 10.4 nBq/$m^3$ (0.28 aCi/$m^3$). The median value for plutonium 239+240 at Site 300 represented less than 0.0005% of the DCG.

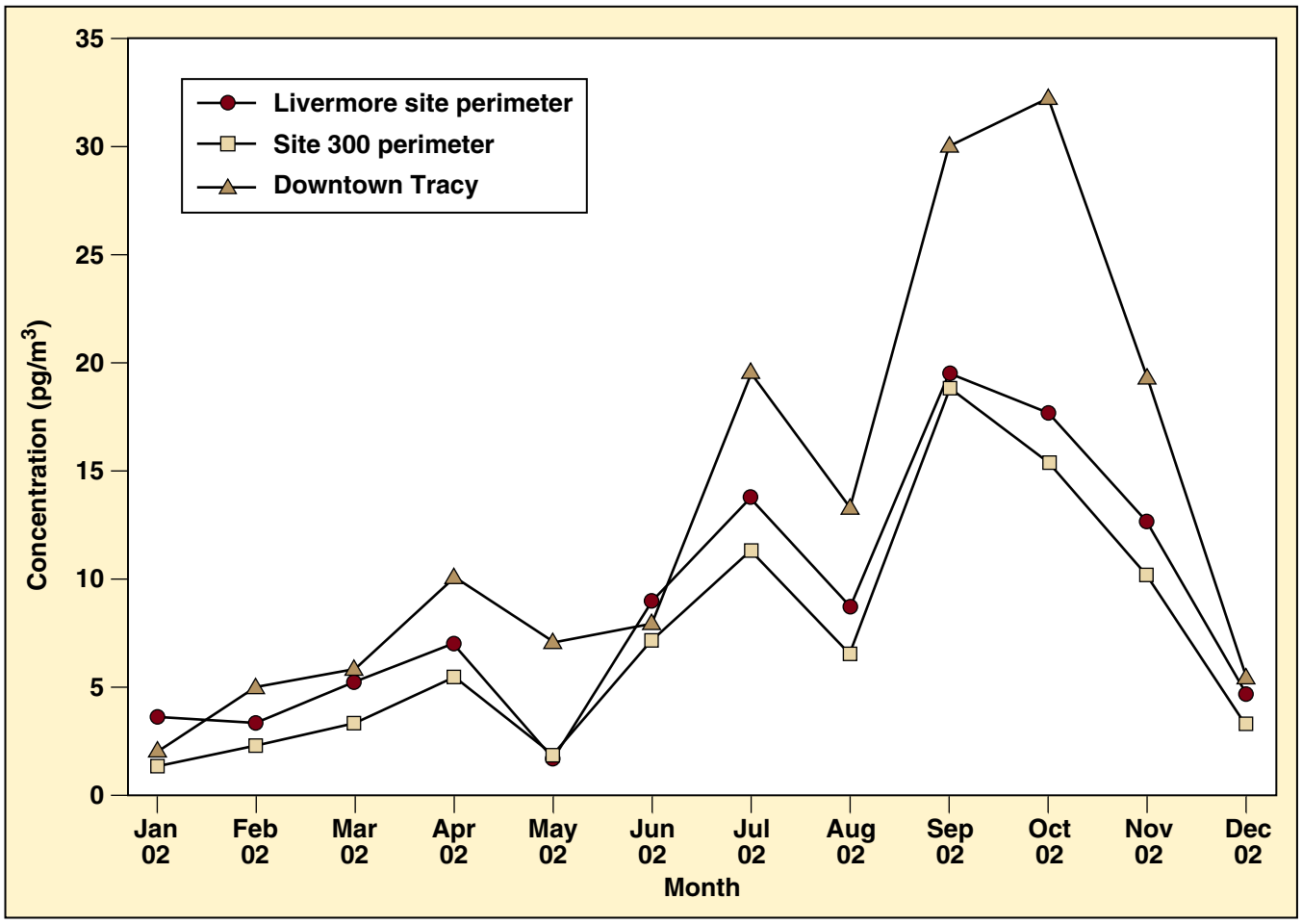


**Figure 5-7. Monthly median concentration of beryllium in air particulate samples from the Livermore site perimeter, Site 300, and Tracy, 2002**

**Table 5-3** shows the summarized data for uranium-235 and uranium-238 for all the air samples. (See Data Supplement Table 5-13 for monthly data.) The highest median concentration were reported at TFIR. These were 0.86 pg/m$^3$ for uranium-235 and 91 pg/m$^3$ for uranium-238, which represent less than 0.03% of the DCG for both isotopes. The analytical change implemented in June 2002 resulted in lower uncertainty for these data making the uranium-235 to uranium-238 ratios a useful tool. Site 300 uranium ratios displayed typical natural background ratios at 0.007 uranium-235 to uranium-238.

**Table 5-4** shows the median concentration of tritium in air that was observed at the sampling location at Site 300 (see Data Supplement Table 5-14 for biweekly data). Site 300 concentrations are mostly below the detection limit and most likely represent background levels of tritium unaffected by local sources of tritium.

### Beryllium in Air

The monthly median beryllium concentrations for Site 300 are shown in **Figure 5-7** with the Livermore site perimeter locations. (See Data Supplement Table 5-15 for monthly data.) The highest value in **Figure 5-7** of 32.3 pg/m$^3$ was

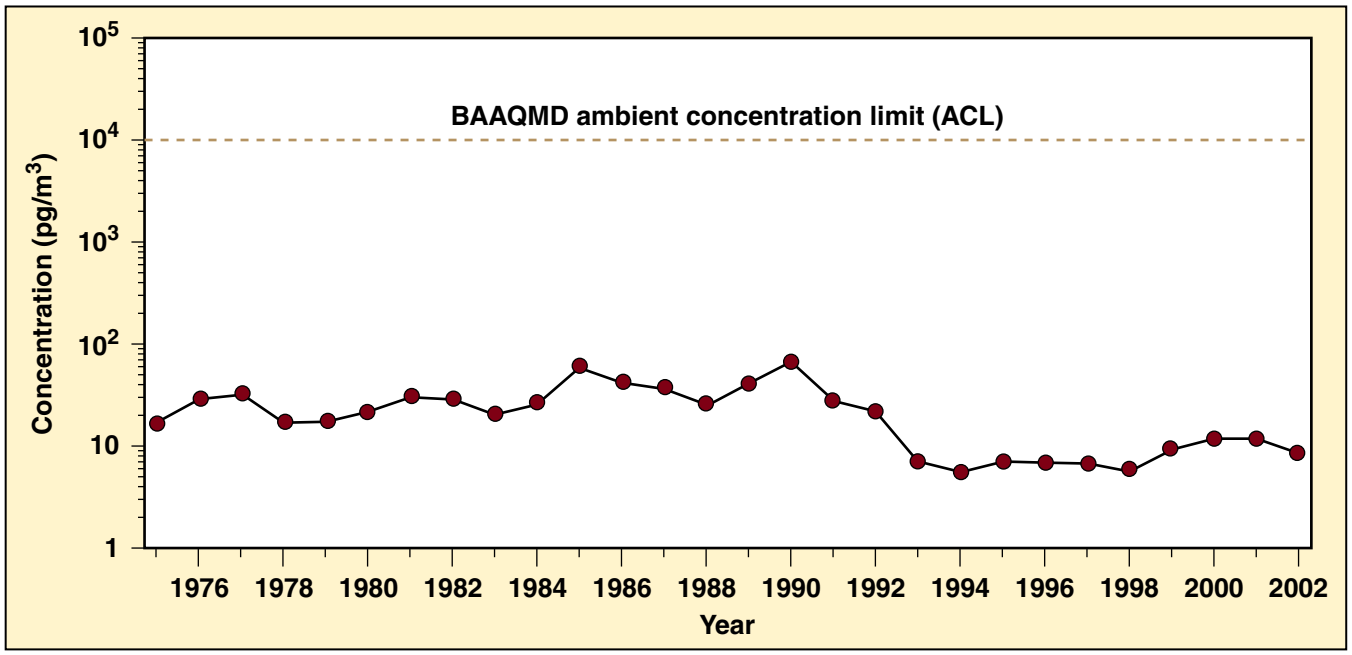


**Figure 5-8. Median concentration of beryllium in air particulate samples taken at the Livermore site perimeter, 1975–2002**

found in the October sample at TFIR. The concentration at this location is typically higher than at all other locations because it is located in a congested part of town and accumulates a greater amount of industrial particulate pollutants. This sample was still far below the ambient concentration limit of 10,000 pg/m$^3$.

## Environmental Impact

### Radioactive Materials

LLNL operations involving radioactive materials had little impact on radionuclide concentrations in ambient air during 2002. 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 according to existing regulatory standards.

The diffuse tritium sources at B292, B331, B514, and B624 had a small, localized effect with minimal impact, if any, on the public. Any potential dose received by a member of the public from the diffuse sources is included in doses calculated for tritium concentrations at the Livermore site perimeter (see Table 5-8, Data Supplement). Tritium concentrations at the Livermore site perimeter were generally slightly greater in 2002 than in 2001, which correlates well with increased stack emissions in the later part of 2002. The increased tritium concentrations observed at the Livermore site perimeter had minimal impact on off-site concentrations.

A maximum dose of 89 nSv/y to a member of the public at the Livermore site perimeter can be estimated based on the extraordinarily conservative assumption that the maximum biweekly concentration (430 mBq/m$^3$) is maintained for an entire year and that a member of the public breathes that

concentration for the entire year. This improbable inhalation dose to the public is just 0.089% of NESHAPs standard of 0.1 mSv/y arising as a result of releases of radionuclides to air from DOE facilities.

## Nonradioactive Materials

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 ppm of beryllium, and the air of the Livermore area and the Central Valley typically contains 10 to 100 μg/$m^3$ of particulates. Using a value of 50 μg/$m^3$ for an average dust load and 1 ppm for beryllium content of dust, a conservative airborne beryllium concentration of 50 pg/$m^3$ can be predicted. The overall average for the Livermore site and Site 300 (including TFIR location in Tracy) are 9.6 pg/$m^3$ and 9.0 pg/$m^3$, respectively. These data are lower than predicted, well below standards, and do not indicate the presence of a threat to the environment or public health.