12. Environmental Radiation Monitoring

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Introduction

A variety of radioisotopes are used at LLNL for biomedical, general, and nuclear weapons research. These include transuranics, tritium, and mixed fission products. In accordance with federal regulations, DOE Orders 5400.1 and 5400.5, and Title 17, California Code of Regulations, Section 30250, LLNL monitors direct gamma radiation to establish background radiation levels in its vicinity and to determine the environmental radiological impact of its operations. Gamma radiation results from natural background sources of terrestrial or cosmic origin and from man-made sources, such as fallout from past nuclear weapons testing and any contribution from LLNL operations.

Because environmental radiological monitoring is used as one measure of the potential direct radiation dose the public receives as the result of LLNL operations, LLNL has developed an extensive radiological monitoring network for its Livermore site perimeter, the Livermore Valley, and the Site 300 perimeter. Direct gamma radiation has been measured at the Livermore site since 1973, and a direct environmental radiation monitoring program was implemented at Site 300 in 1988. Direct gamma radiation is measured using thermoluminescent dosimeters (TLDs), which provide a measure of the total amount of gamma radiation at a particular location. Environmental neutron monitoring, which was also started in 1973, was discontinued at the end of 1994. Currently, environmental exposure to neutrons is not a concern at LLNL. However, should it become necessary for LLNL to start up operations that produce neutrons at significant levels, we are prepared to reinitiate environmental neutron monitoring. As a result of the gamma network assessment, we found that there was a significant amount of spatial correlation throughout the monitoring network. This allowed us to reduce the number of monitoring locations in 1995 while maintaining the integrity of the sampling network, See Chapter 11, *Environmental Monitoring Plan* (Tate et al. 1995).

Monitoring Locations

External doses from direct gamma radiation are monitored at 14 Livermore site perimeter locations (as shown in **Figure 12-1**), and 23 Livermore Valley locations (**Figure 12-2**). These off-site locations are used for background comparison with perimeter locations. Similarly, there are 10 perimeter monitoring locations at Site 300 (**Figure 12-3**) and two locations in the nearby City of Tracy. Six additional locations were added in 1993 in areas near Site 300 (**Figure 12-3**) as a special study. Sampling at locations 84 and 95 was discontinued after the first quarter. In 1995, LLNL discontinued sampling at some locations in the direct radiation network as a result of an assessment of the gamma radiation network.

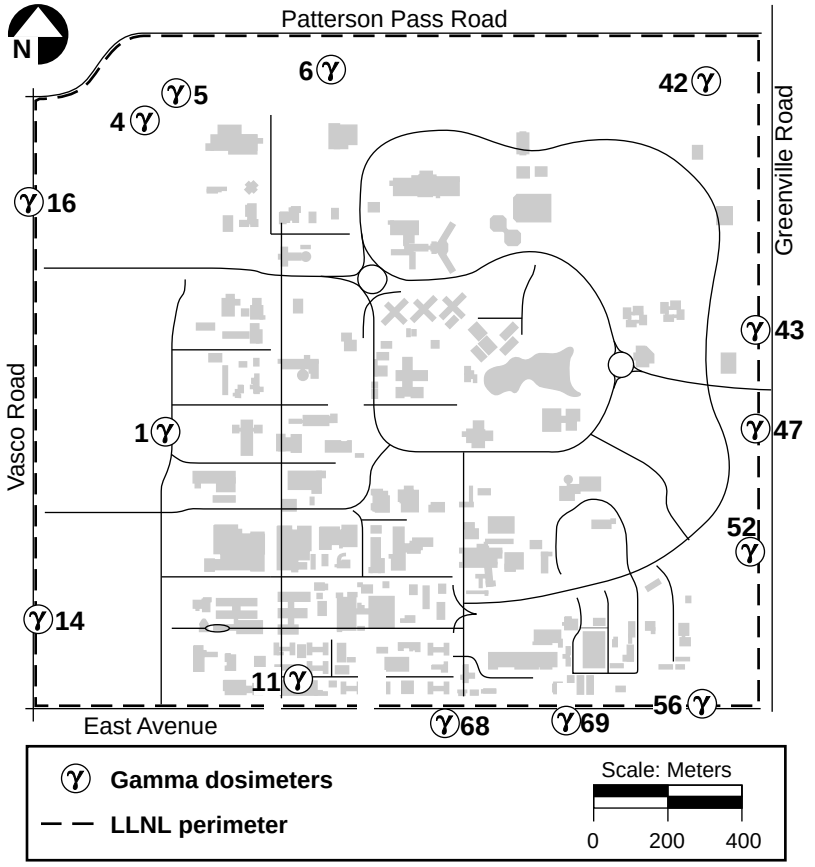

Figure 12-1. Gamma dosimeter locations, Livermore site, 1995.

Sitewide Network Assessment

In an effort to answer questions concerning apparent upward trends from the direct radiation monitoring network, we reassessed our data. We found that variations in read and anneal dates affected our overall results. As a result of this assessment, all of the quarterly data points were normalized to standard 90-day quarters, as is the practice of the Nuclear Regulatory Commission (NRC) (Struckmeyer 1994). By using the same standard-quarter reporting method, data from other DOE and NRC facilities and data from intercomparison studies can be more easily compared. As shown in **Figure 12-4**, when our data are adjusted to standard quarters, the variability in exposures that was previously reported is reduced. The adjusted doses seen at the Livermore site perimeter and the Livermore Valley are comparable and lack significant trend from 1988 to 1995. However, while Site 300 doses are similarly without trend, they continue to measure slightly higher direct gamma doses than the Livermore site and the Livermore Valley, which is expected given the differences in geology between these sites.

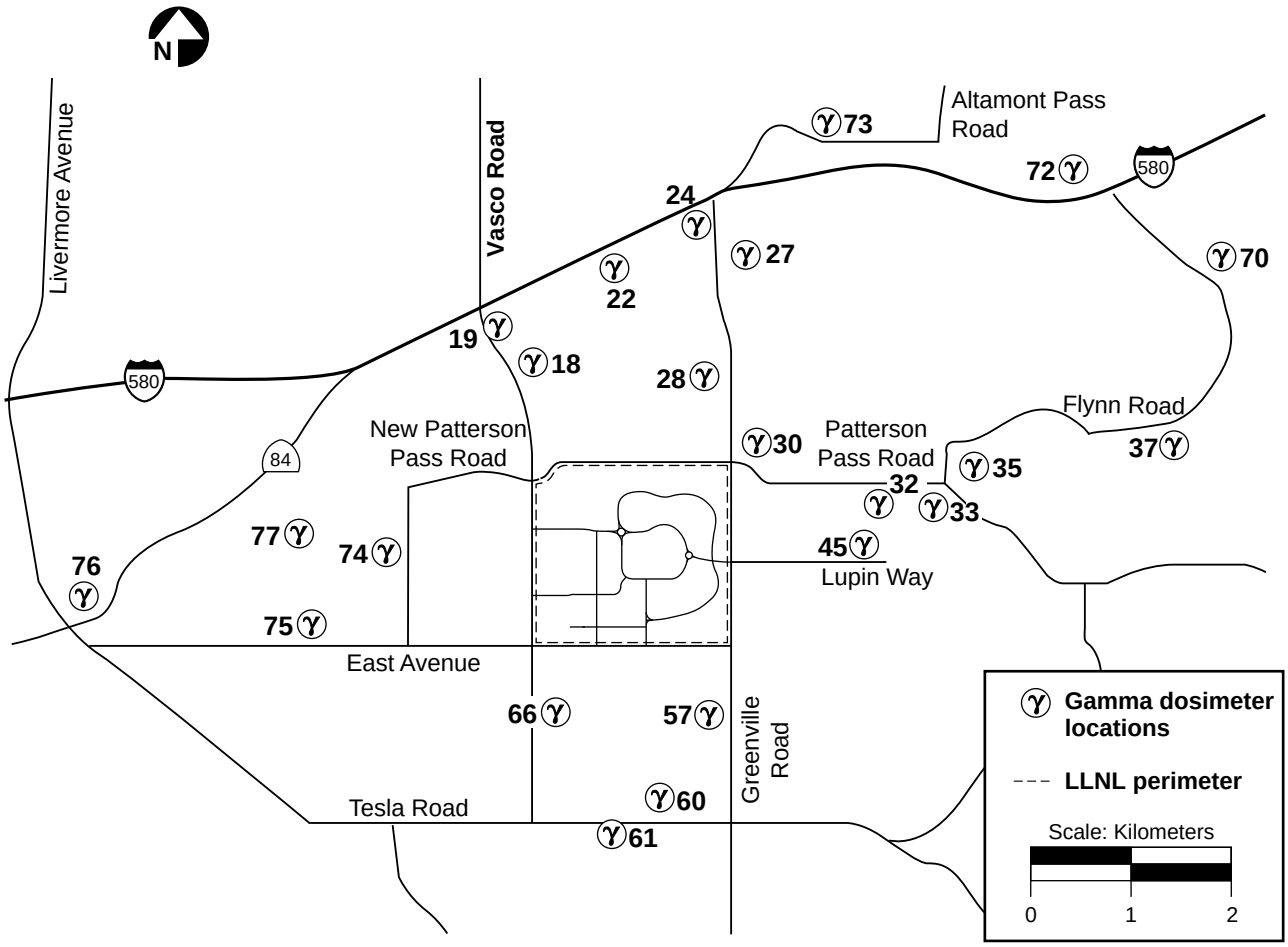

Figure 12-2. Gamma dosimeter locations, Livermore Valley, 1995.

In reviewing the trends of the standard quarter data as shown in **Figure 12-4**, it appears that seasonal variation can occur during the rainy season, most likely because of a decrease in radon emanation from the moist soil. As shown in the figure, the variation was absent during the severe drought years in Northern California (1990 – 1992) but is apparent once again when rainfall returned to normal (1994 – 1995) and above-normal levels (1993).

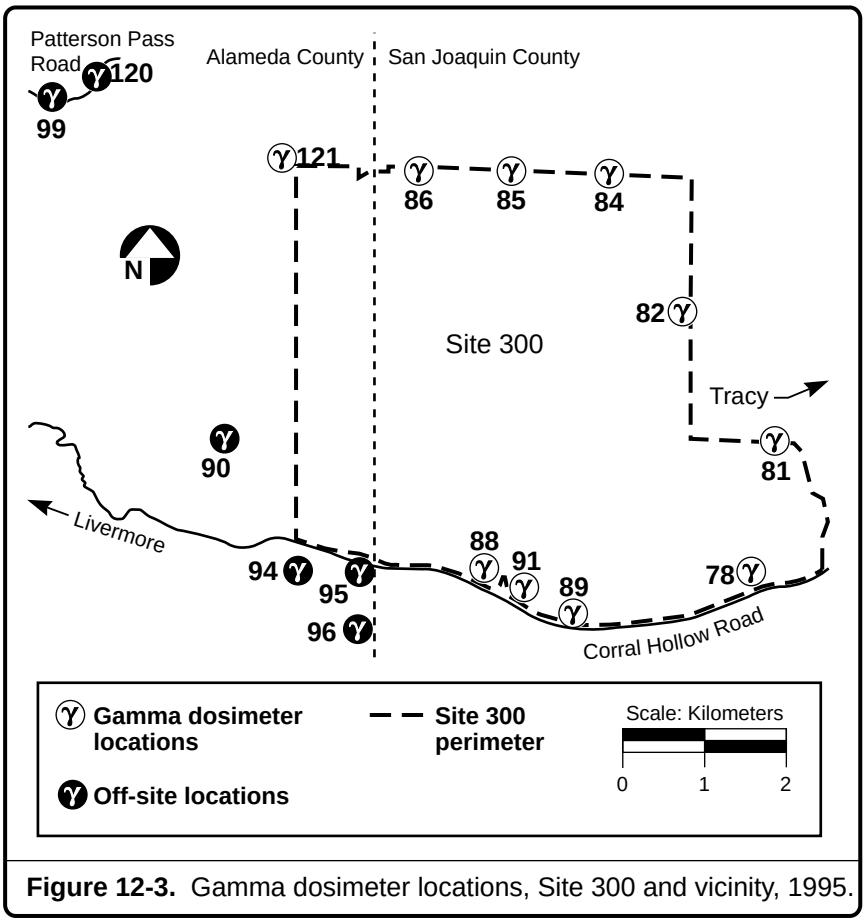

Figure 12-3. Gamma dosimeter locations, Site 300 and vicinity, 1995.

Results of Gamma Monitoring in 1994

Livermore Site

Table 12-1 presents a summary of the quarterly and annual TLD gamma radiation dose equivalents for the Livermore site perimeter locations and Livermore Valley off-site locations. The mean 1995 dose equivalent from external direct radiation exposure at the Livermore site perimeter, 0.56 mSv (56 mrem), is about the same as background external dose measured in the Livermore Valley, 0.55 mSv (55 mrem). **Table 12-2** lists the yearly doses due to direct gamma radiation at the LLNL site perimeter. The data, normalized to 90-day standard quarters, show no significant variation from year to year. **Figure 12-5** presents the frequency distribution for external radiation dose measured at 23 Livermore Valley locations. See Chapter 12, Volume 2, of this report for a discussion of methods and more comprehensive presentation of the data.

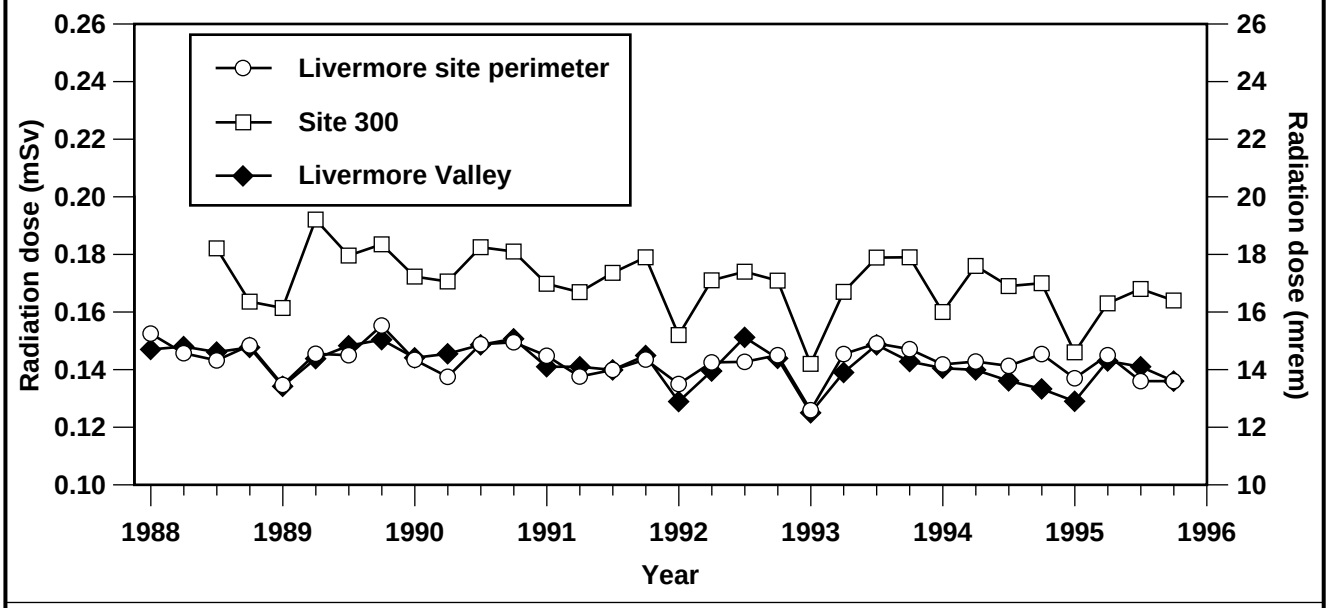

Figure 12-4. Gamma measurements at the Livermore site perimeter, Livermore Valley, and Site 300, 1988 to 1995.

Table 12-1. Summary statistics for all sites in mSv[(a)].

Quarter	Location									
	Livermore site		Livermore Valley		Site 300		Tracy		Off Site	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
First	0.137	0.015	0.129	0.010	0.146	0.012	0.130	0.012	0.158	0.016
Second	0.145	0.011	0.143	0.014	0.162	0.015	0.134	0.006	0.176	0.032
Third	0.142	0.011	0.141	0.016	0.169	0.015	0.137	0.017	0.182	0.025
Fourth	0.136	0.008	0.136	0.011	0.164	0.014	0.135	0.014	0.170	0.027
Total	0.561		0.548		0.639		0.535		0.677	

[a] 1 mSv = 100 mrem.

Table 12-2. Annual dose by year at the Livermore site perimeter due to direct gamma radiation[a].

Year	mSv	mrem
1988	0.59	59
1989	0.58	58
1990	0.58	58
1991	0.56	56
1992	0.56	56
1993	0.57	57
1994	0.56	56
1995	0.56	56

a Data normalized to standard 90-day quarters (360-day years).

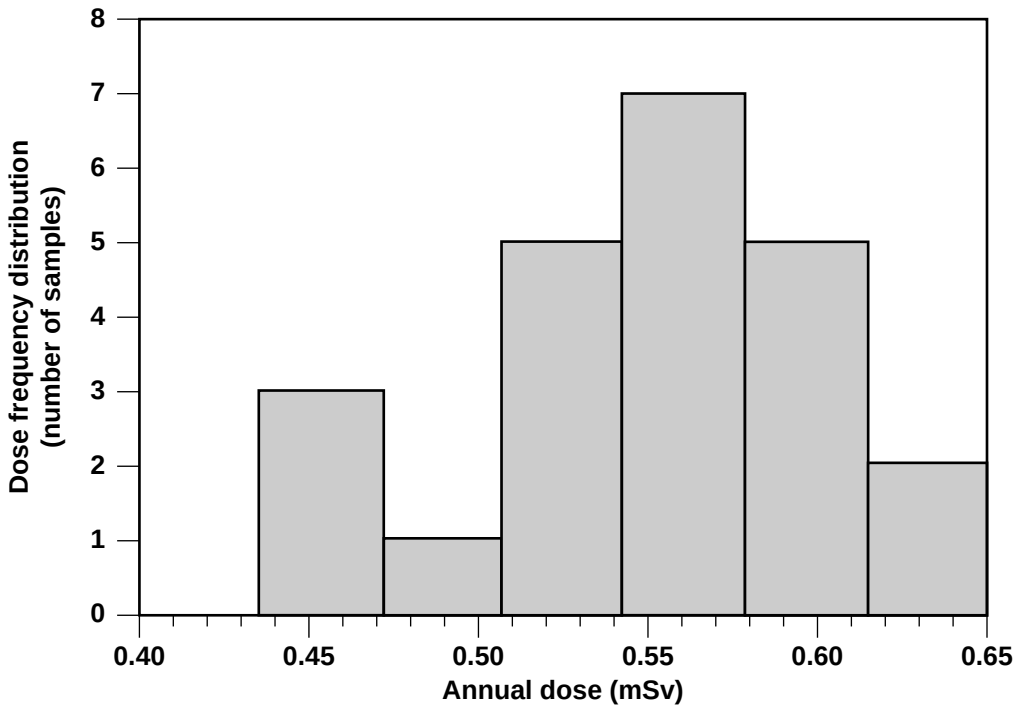

Figure 12-5. Annual direct gamma radiation dose, Livermore Valley, 1995.

Site 300

As seen in **Table 12-1**, the measured Site 300 perimeter average dose in 1995 was 0.64 mSv (64 mrem), the measured dose at the off-site locations near Site 300 was 0.68 mSv (68 mrem), and the measured doses in and near Tracy were 0.54 mSv (54 mrem). All doses are within the predicted range for background radiation, and no LLNL operational impacts are discernible.

At Site 300, the initial TLD network design limited monitoring to the Site 300 perimeter and two locations in and near the city of Tracy, which were chosen to represent background radiation levels. However, the Tracy locations are located on a geological substrate different from that at Site 300. The region around Site 300 has elevated levels of naturally occurring uranium, which is present in the Neroly Formation. The mean dose measured in the off-site locations of the area around Site 300, which is used to represent the high end of background radiation from this formation, was 0.68 mSv (68 mrem) and is greater than the Site 300 perimeter dose of 0.64 mSv (64 mrem). The Tracy area, with a dose of 0.54 mSv (54 mrem), is at a lower elevation, with geological constituents composed of alluvium deposits of clays, sands, and silts overlying the bedrock. The difference in doses can be directly attributed to the difference in geologic substrates.

Environmental Impact

Based on past measurements (Lindeken et al. 1973), environmental terrestrial (geologic) radiation doses in the Livermore Valley vary from 0.25 to 0.60 mSv/y (25 to 60 mrem/y). Cosmic radiation, as calculated for the local elevation and geomagnetic latitude according to the data of Lowder and Beck (1966), is about 0.35 mSv/y (35 mrem/y). This combination results in a typical total direct radiation dose level of 0.60 to 0.70 mSv/y (60 to 70 mrem/y); however, local geological and meteorological factors will impact these dose levels. Direct radiation doses measured at the Livermore site perimeter in 1995 are near these predicted values and are statistically equivalent to the Livermore Valley doses, which are considered natural background levels. This indicates that any dose from LLNL operations is not large enough to be seen within the wide range of natural variation in background levels in different locations.