Executive Summary

Jennifer M. Larson
Arthur H. Biermann

Introduction

Lawrence Livermore National Laboratory (LLNL), a U.S. Department of Energy (DOE) facility operated by the University of California (UC), serves as a national resource of scientific, technical, and engineering capabilities. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and assisting Laboratory organizations in ensuring compliance with environmental laws and regulations.

LLNL comprises two sites: the Livermore site and Site 300. The Livermore site occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California. Site 300, LLNL's experimental testing site, is located 24 kilometers to the east in the Altamont Hills and occupies an area of 30.3 square kilometers. Meteorological and environmental monitoring activities are conducted at both sites as well as in surrounding areas.

This summary provides an overview of LLNL's environmental activities in 1999, including radiological and nonradiological surveillance, effluent and compliance monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

Environmental Monitoring Results

During 1999, the Environmental Protection Department sampled air, sewerable water, surface water, ground water, soil and sediment, and vegetation and foodstuff. Samples were analyzed for radioactive and nonradioactive substances using (1) standard methods approved by the U.S. Environmental Protection Agency (EPA), (2) special systems such as the continuous monitoring system for Livermore site sewage, or (3) special analytical techniques designed to measure very low levels of radionuclides. Environmental

radiation was also measured directly using dosimeters. More than 13,000 environmental samples were taken, and more than 250,000 analytical results were obtained.

Air Monitoring

Air was monitored for various airborne radionuclides (including particles and tritiated water vapor) and beryllium at the Livermore site, Site 300, and off-site locations throughout the Livermore Valley and Tracy areas. Concentrations of all monitored radionuclides and beryllium at all of these locations were well below levels that would endanger the environment or public health, according to current regulatory standards. For example, in 1999, the highest median plutonium concentration for samples collected at any air monitoring station was 0.0036% of the federal Derived Concentration Guide (DCG). The DCG specifies the concentration of radionuclides in air or water that could be inhaled or ingested continuously 365 days a year without exceeding the DOE radiation protection standard for the public. Median concentrations of tritiated water vapor collected at Livermore Valley sampling locations showed a highest median value of 0.001% of the DCG, while the highest median values on the Livermore site perimeter and within the site boundaries were, respectively, 0.004% and 0.1% of the DCG. The highest median concentrations of beryllium on the Livermore site and Site 300 were 0.11% and 0.13%, respectively, of the guideline level established by the Bay Area Air Quality Management District and the EPA and are representative of naturally occurring levels.

Stack Air Effluent Monitoring

In 1999, LLNL operated 101 samplers for measuring radioactivity in air effluent at eight facilities at the Livermore site. These samplers extracted a measured volume of air from the exhaust stack of a facility or process and collected particles or vapor in a collection medium. Measured radiological air emissions from Livermore site operations remained well below levels of health and environmental concern. Building 331 emissions accounted for 96% of the estimated total tritium emissions from the site in 1999; emissions from this facility remained at a level far below those of the 1980s and caused public dose impacts far below levels allowed by regulatory standards. Radionuclide emissions from the other monitored facilities were very low.

Nonradioactive air emissions from exempt and permitted sources at LLNL were quite small and typical of values in previous years. For example, total emission of nitrogen oxides from the Livermore site in 1999 was 81 kg per day, which is 0.06% of the quantity of this air pollutant released daily over the entire San Francisco Bay Area; corresponding

numbers for reactive organics were 24 kilograms per day and 0.02%. The total emission of criteria air pollutants (nitrogen oxides, volatile organics, sulfur oxides, particulate matter, carbon monoxide, and lead) was 140 kilograms per day for the Livermore site and about 6 kilograms per day for Site 300.

Sewerable Water Monitoring

Discharges of radioactive and hazardous material to the combined sanitary and industrial sewer at the Livermore site are controlled by use of administrative and engineering controls, including limiting the disposal of those materials and routing some discharged material to retention tanks for later characterization and treatment. Flow-proportional and instantaneous samples of the site's wastewater are regularly collected and analyzed (for metals, radioactivity, toxic chemicals, and water-quality parameters) to ensure that LLNL's sewage effluent meets the requirements of the permit granted by the City of Livermore. In addition, the site effluent is monitored continuously for pH, regulated metals, and radioactivity. If concentrations are detected above warning levels, an alarm sounds and the effluent is automatically contained by LLNL's sewer diversion system. The diversion system captures all but the initial minutes of wastewater flow that causes an alarm, thereby protecting the Livermore Water Reclamation Plant (LWRP) and minimizing any required cleanup. With the 1998 addition of a new monitoring and diversion capability for pH, even the initial minutes of a pH-related release are contained on site.

In 1999, the Livermore site discharged an average of 1.0 million liters per day of wastewater to the City of Livermore sewer system, an amount that constituted 4.4% of the total flow to the system (about 13% of the Livermore site effluent was generated by Sandia National Laboratories/California). The Livermore site's sanitary sewer effluent was monitored continuously and sampled daily, weekly, and monthly to satisfy various permit compliance requirements.

LLNL achieved 100% compliance during 1999 with LWRP wastewater discharge permit limits. Similarly, no sewer releases exceeded discharge limits for radioactive materials during 1999.

Surface Water Monitoring

Surface water sampling and analysis are a large part of the LLNL surveillance and compliance monitoring effort for the Livermore site, Site 300, and their surrounding areas. The waters monitored include storm water runoff, rainfall, water in the

Livermore site Drainage Retention Basin, wastewater discharges from cooling towers at Site 300, and a variety of other water that includes off-site reservoirs and ponds, drinking water taps both on and off site, and the Livermore site swimming pool. Overall, the surface water monitoring data indicate compliance with established regulatory limits and negligible impact on the environment.

Radioactivity detected in the storm water was all at small percentages of the levels allowed in drinking water (referred to as the maximum contaminant level, or MCL). The maximum tritium concentration in storm water effluent at the Livermore site was 17% of the MCL. Plutonium was not detected in the liquid phase of any storm water samples. The sediment phase of one sample contained a low concentration of plutonium, which is consistent with worldwide fallout and naturally occurring concentrations.

Chemical monitoring of Livermore site storm water showed that concentrations of several metals were higher in effluent samples than influent samples. Acute and chronic fish toxicity tests conducted on Livermore site storm water demonstrated no toxicity to the test species. Allowable lead concentration was slightly exceeded in one release from the Drainage Retention Basin. Site 300 storm water contained levels of specific conductance and total suspended solids higher than comparison criteria; however, these effluent levels were lower than the off-site background levels. Sampling results from the Site 300 cooling towers effluent indicated compliance with all limits with the exception of one high flow measurement that was the result of a malfunctioning mechanical valve.

Tritium measurements in rain showed a slight increase in 1999 over the measurements in 1998. The maximum on-site measurement in 1999 was 73% of the MCL. In drinking water sources, the maximum tritium concentration was less than 0.05% of the MCL.

Ground Water Monitoring

Ground water in the Livermore Valley and the Altamont Hills is monitored to assess the progress of remediation efforts in areas of known contamination, to test the impact of LLNL operations on local water sources, and to comply with numerous federal, state, and local permits. Ground water samples are routinely measured for tritium, uranium, and other radioisotopes; gross radioactivity; toxic metals; a wide range of organic chemicals; and other general contaminant indicators. Special consideration is given to monitoring those dissolved elements and organic compounds that are known to be toxic in trace amounts.

The impact of Livermore site and Site 300 operations on off-site ground water continued to be minimal in 1999. In the Livermore Valley, no monitored radioactive or inorganic nonradioactive constituent was found to exceed primary drinking water MCLs in any off-site well. In on-site wells, chromium and nitrates have been detected above the primary MCLs, but these constituents have not migrated off site at levels above the primary MCL. The maximum tritium activity detected in any sample of ground water measured in the Livermore Valley was 1.4% of the MCL, as measured at an on-site location. At Site 300, tritiated water and depleted uranium have been released to ground water from landfills and firing tables, but the boundaries of the slowly moving ground water plumes lie entirely within site boundaries. The shallow ground water beneath Site 300 contains volatile organic compounds (VOCs), tritium, nitrate, Freon, perchlorate, and depleted uranium, but it presents no current health risks because this contaminated water is not used as a potable water supply for domestic, industrial, or agricultural use. LLNL works with the regulatory agencies to contain or clean up ground water contamination where needed.

Soil and Sediment Monitoring

The impact of Laboratory operations on soil and sediment at the Livermore site in 1999 was insignificant and unchanged from previous years. The highest level of plutonium (isotopes 239 and 240) measured at the LWRP represented 1.9% of the EPA preliminary remediation goal for commercial or industrial sites. Other constituents of concern were measured at background or trace concentrations or were below the limit of detection. At Site 300, the concentrations of radionuclides and beryllium in soil samples were generally representative of background or naturally occurring levels, as in previous years. Elevated concentrations of uranium-238 found in Site 300 soils in 1999 were attributed to contamination by debris from firing-table experiments.

Sampling of the vadose zone, carried out as part of the Livermore Ground Water Management Program, showed that ground water on the Livermore site is not being affected by contaminants carried in storm water.

Soil was sampled at Big Trees Park in Livermore during August and September of 1998 to provide information about the vertical and lateral distribution of plutonium in the soil, the pathway by which plutonium got to the park, and the distribution of plutonium in areas of public concern. All sample results indicated that plutonium concentrations were below the risk-based preliminary remediation goal for residential areas. In a January 2000 report, the Agency for Toxic Substances and Disease Registry (ATSDR) stated that the use of plutonium-contaminated sewage sludge as a soil amendment was the most credible pathway by which plutonium reached the park. The EPA, the

California Department of Health Services, and ATSDR all concurred that there was no unacceptable risk to human health or the environment from the levels of plutonium present at Big Trees Park.

Vegetation and Foodstuff Monitoring

LLNL impacts on vegetation and food in the Livermore Valley remained minimal in 1999. Tritium, which is the only measurable radionuclide in the vegetation and foodstuff monitoring program, was estimated to be well below levels of concern, even when organically bound tritium was taken into account. In 1999, tritium concentrations in wines from the Livermore Valley, California, and Europe are within the range of those reported in previous years and remain low in wines from all areas. Even the highest detected tritium value in Livermore Valley wine represented only 1.1% of the amount of tritium that EPA allows in drinking water (no health standards exist for radionuclides in wine).

Radiological Dose Assessment

Radiological dose-assessment modeling—using conservative EPA-mandated computer models, actual LLNL meteorology, population distributions appropriate to the two sites, and 1999 radionuclide usage inventory and monitoring data—was conducted this past year for key facilities. Emissions from more than 200 points were reported in 1999. These sources were of several types: stacks and other exhaust pathways from buildings, diffuse area sources generally external to buildings, and open-air firing tables at Site 300 where explosives experiments were conducted.

LLNL reports public doses resulting from air releases of radionuclides during routine operations and from accidents. The principal exposure pathways taken into account are internal exposures from inhalation of air and ingestion of foodstuff and drinking water contaminated by the air releases. Releases of radioactivity from LLNL via water do not directly contribute to the public dose because this water is not used as a potable water supply for domestic, industrial, or agricultural use.

The most significant radiological effluent for the Livermore site from the standpoint of public dose continues to be tritium, the radioactive isotope of hydrogen. The calculated total potential dose for the sitewide maximally exposed individual (SW-MEI), (i.e., a hypothetical member of the public having the greatest possible exposure from Livermore site operations in 1999) was 1.0 microsievert (0.1 millirem). This result was calculated based on LLNL's standard assumptions regarding potential public dose

caused by tritium releases. In 1998, the EPA mandated that LLNL's compliance evaluations use a more conservative assumption, in which gaseous tritium must be treated as though it were tritiated water vapor. This translates to a higher calculated dose of 1.20 microsievert (0.12 millirem) to the SW-MEI. Trends in this SW-MEI dose for the Livermore site over the last eight years show levels in the range 1.0 to 0.4 microsievert per year (0.1 to 0.04 millirem per year), down from 2.40 microsievert per year (0.24 millirem per year) in 1990. These small radiation quantities exhibit large percentage but small absolute value fluctuations from year to year.

At Site 300, depleted uranium (containing isotopes with atomic weights 238, 235, and 234) remains by far the principal contributor to off-site dose. The calculated total potential dose to the SW-MEI during 1999 was 0.35 microsievert (0.035 millirem). This is well within the range of doses calculated over the past 10 years.

Conservatively calculated radiological doses to the maximally exposed public individuals from Livermore site and Site 300 emissions amounted to about 1.0% (1.2% using EPA assumptions) and 0.35%, respectively, of the EPA National Emission Standards for Hazardous Air Pollutants regulatory standard. These doses are a small fraction (about 1/2500) of the doses received by these populations from natural background radiation. Thus, the potential radiological doses from LLNL operations in 1999 were well within regulatory limits and were very small compared with doses from natural background radiation sources.

Environmental Compliance and Program Activities

LLNL works to ensure that its operations comply with all environmental laws and federal, state, and local regulatory guidelines. Many activities related to water, air, waste, waste reduction, community "right to know," and other environmental issues were addressed in 1999.

Ground Water Remediation

As a Superfund site, LLNL continued to treat ground water at both the Livermore site and Site 300 under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act. LLNL's primary treatment method to remediate contaminated ground water is pump-and-treat technology. In 1999, nearly 270 kilograms of VOCs were removed from 1.1 billion liters of ground water and 20,000 cubic meters of water vapor from soil at the Livermore site. These efforts at control and remediation have reduced VOC concentrations throughout the site and reduced plume sizes.

New treatment facilities were added to the Treatment Facility A (TFA) and TF5475 areas. TFA-East, which began operating in 1999, consists of one extraction well. A portable solar-powered unit treats the extracted ground water. Vapor Treatment Facility (VTF) 5475, which began operation in early 1999, extracts soil vapor from the vadose zone using a vapor extraction system. The soil vapor is processed using granulated activated carbon. Because of elevated tritium concentrations in the vadose zone, VTF5475 was designed as a closed-loop system. Following removal of VOCs from the process air stream, the tritiated vapor is reinjected into the subsurface at a soil vapor inlet well, and no effluent vapor is released to the atmosphere.

Significant progress was also made at Site 300, where 39 kilograms of VOCs were removed from soil and ground water. In addition to the three treatment facilities, which operated throughout the year, three new treatment facilities were constructed and began operation in 1999. In the Eastern General Services Area, the plume of high (>500 parts per billion) trichloroethene (TCE) concentrations has been restricted to the Site 300 property. It had previously extended more than 1600 m beyond the site boundary before the treatment facility started up in 1991. With only a few minor exceptions, treated ground water discharges and VOCs vented to air were within permit limits during 1999.

Waste Minimization and Pollution Prevention

LLNL continues to employ a weighted ranking system to prioritize and evaluate its waste streams. Cost, type of waste, and operational aspects are emphasized rather than simple considerations of total waste volume. Transuranic and transuranic-mixed and low-level wastes continue to be of highest priority for LLNL even though their relative quantities are low.

Comparing 1999 with the 1993 baseline, levels of waste in three of the four categories—radioactive, hazardous, and mixed—have decreased by more than the 50% specified in LLNL's contract with UC. The total waste diverted from landfills in 1999 was more than 47,000 tons, comparable to the 1998 total. Although LLNL has not yet achieved a 33% reduction goal for routine nonhazardous waste, its recycling percentage for nonhazardous waste was 89% in 1999.

The Laboratory has a Chemical Exchange Warehouse (CHEW) that enables employees to locate needed chemicals already on site. By reducing the need to buy new chemicals, production of waste is minimized. Employees can use ChemTrack, LLNL's computerized

chemical inventory system, to search for chemicals in CHEW. In 1999, ChemTrack tracked 176,000 chemicals through the use of bar codes, hand-held bar code laser scanners, and customized software.

Air, Wastewater, and Water Compliance

LLNL continued to perform all activities necessary to comply with clean air and clean water requirements. In 1999, the Bay Area Air Quality Management District issued or renewed 137 operating permits for the Livermore site. The San Joaquin Valley Unified Air Pollution Control District issued or renewed 47 permits for Site 300 operations. LLNL has permits for underground and aboveground storage tanks and for discharge of treated ground water, industrial and sanitary sewage, and storm water. Site 300 has additional permits for inactive landfills, cooling tower discharges, operation of the sewer lagoon, septic tanks, and leach fields. The Laboratory complies with all requirements for self-monitoring and inspections associated with these permits.

Endangered Species

LLNL meets the requirements of both the U.S. Endangered Species Act and the California Endangered Species Act as they pertain to endangered or threatened species and other species of special concern that may exist or are known to exist at the LLNL sites. In 1999, biological assessment surveys were performed for special-status species at 76 LLNL project construction (ground disturbance) areas. Although no active San Joaquin kit fox dens were discovered, 10 occupied American badger dens were found. In addition, 18 active burrowing owl dens were discovered at Site 300; the owls were marked with leg bands to initiate long-term studies, monitoring, and conservation of the species. A population of the federal candidate species California tiger salamander (*Ambystoma tigrinum*) was monitored, and a Livermore site population of the federally threatened red-legged frog (*Rana aurora draytonii*) was monitored and protected. Also at the Livermore site, three separate pairs of white-tailed kites (*Elanus lecurus*), a state-protected raptor, successfully nested and fledged 18 young.

Two of the three known natural populations of the large-flowered fiddleneck (*Amsinckia grandiflora*), a federally listed endangered plant species, occur at Site 300, where a portion of the site has been designated as critical habitat for the plant. In spite of attempts to reduce competing grass in 1998, the number of native plants continued to decline in 1999. Investigations into the use of controlled burns and rodent predation on seed population are currently planned.

Monitoring of the big tarplant (*Blepharazonia plumosa*), a California Native Plant Society "rare" plant, and the Diamond-petaled poppy (*Eschscholzia rhombipetala*), a plant previously thought to be extinct, continued in 1999. The big tarplant continued to be widespread throughout Site 300, although the individual populations were reduced in size. A total of nine Diamond-petaled poppy plants were located; of these, six plants produced seed-bearing pods.

Environmental Occurrences

Notification of environmental occurrences at the Laboratory is required by a number of environmental laws, regulations, and DOE orders. LLNL responded to four incidents that required federal and/or state agency notification during 1999. None of these caused adverse impact to human health or the environment.

Work Smart Standards

In 1997, LLNL and DOE's Oakland Operations Office inaugurated a Work Smart Standard (WSS) process. As part of this process, safety and environmental professionals from both organizations identified environment, safety, and health hazards and established standards of operation to protect the public, workers, and the environment from these hazards. WSSs were implemented in 1999 and include more than 250 requirements directly related to the environment.

Conclusion

The current techniques LLNL uses for environmental monitoring are very sensitive, allowing detection of extremely low levels of constituents. The combination of surveillance and effluent monitoring, source characterization, and computer modeling shows that radiological doses to the public caused by LLNL operations are less than 1% of regulatory standards and are about 2500 times smaller than the doses received from natural background radiation. The analytical results and evaluations generally show continuing low contaminant levels, reflecting the responsiveness of the Laboratory in controlling pollutants.

In 1999, LLNL successfully engaged in environmental compliance activities related to water, air, waste, waste reduction, and other environmental issues. Some key examples include ground water remediation activities that restricted a high TCE plume at Site 300,

waste minimization efforts that reduced the amount of waste generated in LLNL operations, and recycling efforts that diminished the quantity of waste sent to landfills. Actions to protect endangered species at both LLNL sites continued on several fronts.

In summary, the results of the 1999 environmental programs demonstrate that LLNL is committed to protecting the environment and ensuring that its operations are conducted in accordance with applicable federal, state, and local laws and regulations. The environmental impacts of LLNL operations are minimal and pose no threat to the public or the environment.