

Executive Summary

Lawrence Livermore National Laboratory (LLNL) is a premier research laboratory that is part of the National Nuclear Security Administration (NNSA) within the U.S. Department of Energy (DOE). As a national security laboratory, LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. The Laboratory also meets other pressing national security needs, including countering the proliferation of weapons of mass destruction and strengthening homeland security, and conducting major research in atmospheric, earth, and energy sciences; bioscience and biotechnology; and engineering, basic science, and advanced technology. The Laboratory is managed and operated by Lawrence Livermore National Security, LLC (LLNS), and serves as a scientific resource to the U.S. government and a partner to industry and academia.

LLNL operations have the potential to release a variety of constituents into the environment via atmospheric, surface water, and groundwater pathways. Some of the constituents, such as particles from diesel engines, are common at many types of facilities while others, such as radionuclides, are unique to research facilities like LLNL. All releases are highly regulated and carefully monitored.

LLNL strives to maintain a safe, secure and efficient operational environment for its employees and neighboring communities. Experts in environment, safety and health (ES&H) support all Laboratory activities. LLNL's radiological control program ensures that radiological exposures and releases are reduced to as low as reasonably achievable to protect the health and safety of its employees, contractors, the public, and the environment.

LLNL is committed to enhancing its environmental stewardship and managing the impacts its operations may have on the environment through a formal Environmental Management System. The Laboratory encourages the public to participate in matters related to the Laboratory's environmental impact on the community by soliciting citizens' input on matters of significant public interest and through various communications. The Laboratory also provides public access to information on its ES&H activities.

LLNL consists of two sites—an urban site in Livermore, California, referred to as the "Livermore site," which occupies 1.3 square miles; and a rural Experimental Test Site, referred to as "Site 300," near Tracy, California, which occupies 10.9 square miles. In 2011 the Laboratory had a staff of approximately 6800.

Purpose and Scope of the Environmental Report

The purposes of the *Environmental Report 2011* are to record LLNL's compliance with environmental standards and requirements, describe LLNL's environmental protection and remediation programs, and present the results of environmental monitoring. Specifically, the report discusses LLNL's Environmental Management System; describes significant accomplishments in pollution prevention; presents the results of air, water, vegetation, and foodstuff monitoring; reports radiological doses from LLNL operations; summarizes LLNL's activities involving special status wildlife, plants, and habitats; and describes the progress LLNL has made in remediating groundwater contamination.

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Environmental monitoring at LLNL, including analysis of samples and data, is conducted according to documented standard operation procedures. Duplicate samples are collected and analytical results are reviewed and compared to internal acceptance standards.

This report is prepared for DOE by LLNL's Environmental Functional Area (EFA). Submittal of the report satisfies requirements under DOE Order 231.1B, Environmental Safety and Health Reporting, and DOE Order 458.1, Radiation Protection of the Public and Environment. The report is distributed in electronic form and is available to the public at <https://saer.llnl.gov/>, the website for the LLNL annual environmental report. Previous LLNL annual environmental reports beginning in 1994 are also on the website.

Regulatory Permitting and Compliance

LLNL undertakes substantial activities to comply with many federal, state, and local environmental laws. The major permitting and regulatory activities that LLNL conducts are required by the Clean Air Act; the Clean Water Act and related state programs; the Emergency Planning and Community Right-to-Know Act; the Resource Conservation and Recovery Act and state and local hazardous waste regulations; the National Environmental Policy Act; the Endangered Species Act; the National Historic Preservation Act; the Antiquities Act; and the Comprehensive Environmental Response, Compensation and Liability Act.

Integrated Safety Management System and Environmental Management System

LLNL established its Environmental Management System (EMS) to meet the requirements of the International Organization for Standardization (ISO) 14001:1996 in June 2004. In June 2006, LLNL upgraded its EMS to meet the requirements of ISO 14001:2004. During 2006 and 2007, LLNL developed Environmental Management Plans (EMPs) that address lab-wide and programmatic significant aspects. During 2008, more focus was placed on raising lab-wide awareness of EMS and on continued development of EMPs. In October 2009, LLNL became ISO 14001:2004 certified. In 2011, LLNL had 8 active Lab-wide EMPs and initiatives on significant aspects, including eco-friendly purchasing, waste generation and greenhouse gas reductions, energy use, water conservation, fossil fuel consumption, hazardous material use/waste generation and radioactive materials use.

Pollution Prevention

A strong Pollution Prevention/Sustainability Program (P2S) is an essential supporting element of LLNL's EMS. The P2S Program at LLNL strives to systematically reduce all types of waste generated and eliminate or minimize pollutant releases to all environmental media from all aspects of the operations at the Livermore site and Site 300.

Each year, the LLNL submits nominations for the NNSA environmental awards program, which recognizes exemplary performance in integrating environmental stewardship practices to reduce risk, protect natural resources, and enhance site operation.

In 2011, LLNL received three NNSA Environmental Stewardship awards, two DOE EStar awards, a California Department of Resources Recycling and Recovery (CalRecycle) Waste Reduction Award Program (WRAP) award for recycling efforts, and a Federal Electronics Challenge Bronze award for management of electronics.

P2 Program outreach in 2011 included participation in a community Earth Day event, assisting LLNL and Sandia in starting a Farmers Market, publishing articles in the LLNL newspaper, and maintaining of an internal P2S website and a green hotline for all LLNL employees.

Air Monitoring

LLNL operations involving radioactive materials had minimal impact on ambient air during 2011. Estimated nonradioactive emissions are small compared to local air district emission criteria.

Releases of radioactivity to the environment from LLNL operations occur through stacks and from diffuse area sources. In 2011, radioactivity released to the atmosphere was monitored at six facilities on the Livermore site and one at Site 300. In 2011, 6978 GBq (188.6 Ci) of tritium was released from the Tritium Facility, and 0.56 GBq of tritium (0.015 Ci) was released from the Decontamination and Waste Treatment Facility and 45.1 GBq of tritium (1.22 Ci) was released from the National Ignition Facility (NIF). The Contained Firing Facility at Site 300 had 210 Bq (5.6 nCi) of depleted uranium released in particulate form in 2011. The dose to the hypothetical, site-wide maximally exposed individual (SW-MEI) member doses at the Livermore site and Site 300 are less than one percent of the annual NESHAPs standard, which is 100 μ Sv/y (10 mrem/y) total site effective dose equivalent. None of the other facilities monitored for gross alpha and gross beta radioactivity had emissions in 2011.

The magnitude of nonradiological releases (e.g., reactive organic gases/precursor organic compounds, nitrogen oxides, carbon monoxide, particulate matter, sulfur oxides) is estimated based on specifications of equipment and hours of operation. Estimated releases in 2011 for the Livermore site and Site 300 were similar to 2010 levels. Nonradiological releases from LLNL continue to be a very small fraction of releases from all sources in the Bay Area or San Joaquin County.

In addition to air effluent monitoring, LLNL samples ambient air for tritium, radioactive particles, and beryllium. Some samplers are situated specifically to monitor areas of known contamination; some monitor potential exposure to the public; and others, distant from the two LLNL sites, monitor the natural background. In 2011, ambient air monitoring data confirmed estimated releases from monitored stacks and were used to determine source terms for resuspended plutonium-contaminated soil and tritium diffusing from area sources at the Livermore site and

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resuspended uranium-contaminated soil at Site 300. In 2011, radionuclide particulate, tritium, and beryllium 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.

Water Monitoring

Water monitoring is carried out to determine whether any radioactive or nonradioactive constituents released by LLNL might have a negative impact on public health and the environment. Data indicate LLNL has good control of its discharges to the sanitary sewer, and discharges to the surface water and groundwater do not have any apparent environmental impact.

Permits, including one for discharging treated groundwater from the Livermore site Ground Water Project, regulate discharges to the City of Livermore sanitary sewer system. During 2011, monitoring data under the LLNL Wastewater Permit #1250 (2011–2012) demonstrated full compliance with all discharge limits, and most of the measured values were a small fraction of the allowed limits. All discharges to the Site 300 sewage evaporation pond and percolation ponds were within permitted limits, and groundwater monitoring related to this area showed no measurable impacts.

Storm water is sampled for constituents such as radioactivity, metals, oxygen, dioxins, polychlorinated biphenyls (PCBs), and nitrate both upstream and downstream from both the Livermore site and Site 300. In 2011, no issues were identified as a result of acute or chronic toxicity tests in runoff waters, and data showed that the quality of Livermore site storm water effluent was similar to that entering the site (influent). Storm water sampling at Site 300 revealed low concentrations of radioactivity, consistent with the background concentrations of naturally occurring radionuclides and low levels of dioxins continue to be observed. Storm water visual observations and best management practices inspections indicated that LLNL's storm water program continues to protect water quality.

In addition to the CERCLA-driven monitoring (i.e., for volatile organic compounds [VOCs]) conducted by LLNL's Environmental Restoration Department (ERD), extensive monitoring of groundwater occurs at and near the Livermore site and Site 300. Groundwater from wells downgradient from the Livermore site is analyzed for anions, hexavalent chromium, and radioactivity. To detect any off-site contamination quickly, the well water is sampled in the uppermost water-bearing layers. Near Site 300, monitored constituents in off-site groundwater include explosives residue, nitrate, perchlorate, metals, volatile and semivolatile organic compounds, tritium, uranium, and other (gross alpha and beta) radioactivity. With the exception of VOCs in wells monitored for CERCLA compliance, the constituents of all off-site samples collected at both the Livermore site and Site 300 were below allowable limits for drinking water.

Surface waters and drinking water are analyzed for tritium and gross alpha and gross beta radioactivity. In the Livermore Valley, the maximum tritium activity was less than 1% of the drinking water standard, and the maximum gross alpha and gross beta measurements were less than 5% of their respective drinking water standards. For Lake Haussmann (formerly called the

Drainage Retention Basin) on the Livermore site, levels of gross alpha, gross beta, tritium, metals, and pesticides were below discharge limits, and organics and PCBs were below detection limits. Aquatic bioassays for acute and chronic toxicity showed no effects in water discharged from Lake Haussmann. At Site 300, maintenance and the operation of drinking water and cooling systems resulted in permitted discharges without adverse impact on surrounding waters.

Terrestrial Radiological Monitoring

The impact of LLNL operations on surface soil in 2011 was insignificant. Soil is analyzed for plutonium, gamma-emitting radionuclides, tritium, and PCBs as appropriate. Plutonium concentrations at the Livermore Water Reclamation Plant continued to be high relative to other sampled locations, but even this concentration was only 1.8% of the screening level for cleanup recommended by the National Council on Radiation Protection (NCRP). At Site 300, soils are analyzed for gamma-emitting radionuclides and beryllium. In 2011, uranium-238 concentrations in soils at Site 300 were below NCRP-recommended screening levels. Beryllium concentrations were within the ranges reported since sampling began in 1991.

Vegetation and Livermore Valley wine were sampled for tritium. In 2011, the median of concentrations in all off-site vegetation samples was below the lower limit of detection of the analytical method. The highest concentration of tritium in Livermore Valley wines sampled in 2011 was less than 0.49% of the drinking water standard.

LLNL's extensive network of thermoluminescent dosimeters measures the natural terrestrial and cosmogenic background; in 2011, as in recent years, no impact from LLNL operations was detected.

Biota

Through monitoring and compliance activities in 2011, LLNL avoided most impacts to special status species and enhanced some habitats. LLNL studies, preserves, and tries to improve the habitat of five species at Site 300 that are covered by the federal or California Endangered Species Acts—California tiger salamander (*Ambystoma californiense*), California red-legged frog (*Rana draytonii*), Alameda whipsnake (*Masticophis lateralis euryxanthus*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), and the large-flowered fiddleneck (*Amsinckia grandiflora*)—as well as species that are rare and otherwise of special interest. At Site 300, LLNL monitors populations of birds and rare species of plants and also continues restoration activities for the four rare plant species known to occur at Site 300—the large-flowered fiddleneck, the big tarplant (*Blepharizonia plumosa*, also known as *Blepharizonia plumosa* subsp *plumosa*), the diamond-petaled poppy (*Eschscholzia rhombipetala*), and the round-leaved filaree (*Erodium macrophyllum*).

LLNL took several actions to control invasive species in 2011. Measures taken at the Livermore site to control bullfrogs, which are a significant threat to California red-legged frogs, included

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dispatching adults and allowing part of Arroyo Las Positas to dry out in October 2011. As in previous years, Site 300's invasive species control efforts have been focused largely on dispatching feral pigs and animals that threaten red-legged frog habitat.

The 2011 radiological doses calculated for biota at the Livermore site or Site 300 were far below screening limits set by DOE, even though highly conservative assumptions maximized the potential effect of LLNL operations on biota.

Radiological Dose

Annual radiological doses at the Livermore site and Site 300 in 2011 were found to be well below the applicable standards for radiation protection of the public. Dose calculated to the site-wide maximally exposed individual (SW-MEI) for 2011 was $0.17 \mu\text{Sv}$ (0.017 mrem) for the Livermore site and $9 \times 10^{-7} \mu\text{Sv}$ ($9 \times 10^{-8} \text{ mrem}$) at Site 300. These doses are well below the federal National Emissions Standards for Hazardous Air Pollutants of $100 \mu\text{Sv}$ (10 mrem) and are significantly less than the doses from natural background radiation. There were no unplanned releases of radionuclides to the atmosphere at the Livermore site or at Site 300.

Groundwater Remediation

Groundwater at both the Livermore site and Site 300 is contaminated from historical operations; the contamination, for the most part, is confined to each site. Groundwater at both sites is undergoing cleanup under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Remediation activities removed contaminants from groundwater and soil vapor at both sites, and documentation and investigations continue to meet regulatory milestones.

At the Livermore site, contaminants include volatile organic compounds (VOCs), fuel hydrocarbons, metals, and tritium, but only the VOCs in groundwater and saturated and unsaturated soils need remediation. VOCs are the main contaminant found at the nine Site 300 Operable Units (OUs). In addition, nitrate, perchlorate, tritium, high explosives, depleted uranium, organosilicate oil, polychlorinated biphenyls, and dioxins, furans, and metals have been identified for remediation at one or more of the OUs.

In 2011, concentrations continued to decrease in most of the Livermore site VOC plumes due to active remediation and the removal of more than 55 kg of VOCs from both groundwater and soil vapor. Hydraulic containment along most portions of the western and southern boundaries of the site was fully established in 2011 and limited progress was made toward interior plume and source area clean up.

In 2011 at Site 300, perchlorate, nitrate, the high explosive RDX, and organosilicate oil were removed from groundwater in addition to about 11 kg of VOCs. Each Site 300 OU has a different profile of contaminants, but overall, groundwater and soil vapor extraction and natural attenuation

continue to reduce the mass of contaminants in the subsurface. Cleanup remedies have been fully implemented and are operational at eight of the nine OUs at Site 300. The CERCLA pathway for the last OU, Building 812, was negotiated with the regulatory agencies in 2011. All milestones were met (see Chapter 2).

Conclusion

LLNL's Environmental Management System provides a framework that integrates environmental protection into all work planning processes. The success of EMS is evidenced by LLNL's certification to the ISO 14001:2004 standard in 2009, coupled with a consistent record of good environmental stewardship and compliance. The combination of surveillance and effluent monitoring, source characterization, and dose assessment showed that the radiological dose to the hypothetical, maximally-exposed individual member of the public caused by LLNL operations in 2011 was substantially less than the dose from natural background. Potential dose to biota was well below DOE screening limits. LLNL demonstrated good compliance with permit conditions for releases to air and to water. Analytical results and evaluations of air and various waters potentially impacted by LLNL operations showed minimal contributions from LLNL operations. Remediation efforts at both the Livermore site and Site 300 further reduced concentrations of contaminants of concern in groundwater and soil vapor.