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, and engineering and administrative controls are applied to minimize releases.

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 (EMS). 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 with websites and public meetings.

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 2017, the Laboratory had a staff of approximately 7,100.

Purpose and Scope of the Environmental Report

The purposes of the *Environmental Report 2017* 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 EMS; 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.

Environmental monitoring at LLNL, including analysis of samples and data, is conducted according to documented standard operating 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, "Environment, 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 with 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 (CAA); the Clean Water Act (CWA) and related state programs; the Emergency Planning and Community Right-to-Know Act (EPCRA); the Resource Conservation and Recovery Act (RCRA) and state and local hazardous waste regulations; the National Environmental Policy Act (NEPA); the Endangered Species Act (ESA); the National Historic Preservation Act (NHPA); the Antiquities Act; and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

Integrated Safety Management System and Environmental Management System

LLNL established its 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 2017, LLNL had 8 active Lab-wide EMPs and initiatives on significant aspects, including sustainable acquisition, municipal waste reduction, greenhouse gas reductions, hazardous material use/waste generation, ecological resources disturbances, energy conservation, water conservation, and water discharges.

Pollution Prevention

A strong Pollution Prevention/Sustainability Program (P2S) is an essential supporting element of LLNL's EMS. LLNL operations have reduced the quantity and toxicity of waste generated, eliminated or reduced pollutant releases, and recycled common and unique materials.

Each year, 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 2017 LLNL received Best-In-Class awards from NNSA for an onsite solar electrical generation system, and a newly installed three-dimensional printer system that uses significantly less resources and generates less waste than the previous electronics prototyping process.

The P2S Program outreach efforts in 2017 included holding April 2017 Earth Day events; participation, with Sandia National Laboratory, in the 3rd annual Bike to Work Day; publishing articles in the LLNL online newsletter; and maintaining 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 2017. Estimated nonradioactive emissions are low 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 2017, radioactivity released to the atmosphere was monitored at five facilities on the Livermore Site and one at Site 300. In 2017, 1621 GBq (43.8 Ci) of tritium was released from the Tritium Facility, and 42.6 GBq of tritium (1.15 Ci) was released from the National Ignition Facility (NIF). The Contained Firing Facility (CFF) at Site 300 had measured stack emissions in 2017 for depleted uranium. A total of 1.2×10^{-5} GBq (3.3×10^{-7} Ci) of uranium-234, 8.5×10^{-7} GBq (2.3×10^{-8} Ci) of uranium-235, and 8.5×10^{-5} GBq (2.3×10^{-6} Ci) of uranium-238 was released in particulate form. The doses to the hypothetical, site-wide maximally exposed individual (SW-MEI) members at the Livermore Site and Site 300 are less than one percent of the annual National Emissions Standards for Hazardous Pollutants (NESHAPs), which is 100 μSv/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 2017.

The magnitude of nonradiological releases (e.g., reactive organic gases/precursor organic compounds [ROGs/POCs], nitrogen oxides, carbon monoxide, particulate matter, sulfur oxides) is estimated based on specifications of equipment and hours of operation. Livermore Site air pollutant emissions were very low in 2017 compared to the daily releases of air pollutants from all sources in the entire Bay Area. For example, the average daily emission of NOx in the Bay Area was approximately 2.3×10^5 kg/d, compared to the estimated daily release from the Livermore Site of 37.4 kg/d, which is 0.016% of total Bay Area source emissions for NOx. The 2017 Bay Area Air Quality Management District (BAAQMD) estimate for ROGs/POCs daily emissions throughout the Bay Area was approximately 2.2×10^5 kg/d, while the daily emission estimate for 2017 from the Livermore Site was 13.5 kg/d, or 0.0061% of the total Bay Area source emissions for ROGs/POCs. 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 2017, ambient air monitoring data confirmed estimated releases from monitored stacks and was used to determine source terms for resuspended plutonium-contaminated soil and tritium diffusing from area sources at the Livermore Site and resuspended uranium-contaminated soil at Site 300. In 2017, 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 2017, monitoring data under the LLNL Wastewater Discharge Permit #1250 (2016–17, 2017–18) 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.

Under the current storm water Industrial General Storm Water Permit (IGP) (2014-0057-DWQ), the only regulated industrial activities at the LLNL Livermore Site and Site 300 is work related to Treatment, Storage, and Disposal Facilities (TSDF). This includes the Decontamination and Waste Treatment Facility (DWTF) and Area 612 Facilities at Livermore and B-883, Explosive and Waste Treatment Facility (EWTF), and Explosives Waste Storage Facility (EWSF) at Site 300. LLNL has five storm water runoff sampling locations at the Livermore Site and two at Site 300. Storm water runoff samples were collected at the five Livermore Site sample locations for the four required storms during both the 2016-2017 and 2017-2018 seasons. LLNL was able to collect storm water runoff samples at location EWTF on February 9, and both EWTF and 883W on November 16, 2017. Based on annual sample results both the Livermore Site and Site 300 remain at Exceedance Response Action Level 2 for magnesium for 2016-2017 and 2017-2018.

LLNL evaluated both sites for potential industrial sources of aluminum, iron, and magnesium. The evaluation did not identify any significant sources of these three metals as part of TSDF activities. Observations and data collected at both sites overwhelmingly pointed to aerial deposition of naturally occurring soils as the source of the high concentrations of these three constituents in storm water runoff. Historical data of aluminum, iron, and magnesium concentrations at upstream sample locations of the receiving waters show that the metals occur at much higher concentrations than are measured at TSDF discharge locations.

The annual storm water reports for the Livermore Site, National Pollutant Discharge Elimination System (NPDES) General Permit 2014-0057-DWQ (Waste Discharge Identification Number [WDID] 2 01I025682) and Site 300, NPDES General Permit 2014-0057 (WDID 5S39I021179) are available through the Stormwater Multiple Applications and Report Tracking System (SMARTS) managed by the California State Water Resources Control Board.

In addition to the CERCLA-driven monitoring (i.e., for volatile organic compounds [VOCs]) conducted by LLNL's Environmental Restoration Department (ERD), extensive surveillance 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 the 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 6% of their respective drinking water standards. 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 2017 was insignificant. Soil is analyzed for plutonium, gamma-emitting radionuclides, and tritium. Plutonium concentrations in soil at the Livermore Water Reclamation Plant continued to be high relative to other sampled locations, but even this concentration was only 1.3% 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 2017, uranium-235 and uranium-238 concentrations in soils at Site 300 were below NCRP-recommended screening levels.

Vegetation and Livermore Valley wine were sampled for tritium. In 2017, the median of concentrations in all off-site vegetation samples was below the lower limit of detection of the analytical method. For Livermore Valley wines purchased in 2017, the highest concentration of tritium was just 0.19% of the Environmental Protection Agency's (EPA's) standard for maximal permissible level of tritium in drinking water.

LLNL's extensive network of thermoluminescent dosimeters measures the natural terrestrial and cosmogenic background; in 2017, as in recent years, no impact from LLNL operations was detected.

Biota

Through monitoring and compliance activities in 2017, 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 (*Masticophus 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 continues restoration activities for the four rare plant species known to occur at Site 300—the large-flowered fiddleneck, the big tarplant (*Blepharizonia plumosa*), the diamond-petaled California poppy (*Eschscholzia rhombipetala*), and adobe navarretia (*Navarretia nigelliformis* ssp. *radians)*.

LLNL took several actions to control invasive species in 2017. Measures taken at the Livermore Site to control bullfrogs, which are a significant threat to California red-legged frogs, included dispatching adults and removing egg masses in Lake Haussmann and Arroyo Las Positas. To remove bullfrog tadpoles and invasive fish, the LLNL reach of Arroyo Las Positas was allowed to dry out in September of 2017 by temporarily halting groundwater discharges to the arroyo.

The 2017 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 2017 were found to be well below the applicable standards for radiation protection of the public. Dose calculated to the SW-MEI for 2017 was 1.9×10^{-2} µSv (1.9×10^{-3} mrem) for the Livermore Site and 4.8×10^{-4} µSv (4.8×10^{-5} mrem) at Site 300. These doses are well below the federal NESHAPs of 100 µSv (10 mrem) and are significantly less than the doses from natural background radiation.

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 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 VOCs, fuel hydrocarbons, metals, and tritium, but only the VOCs in groundwater and saturated and unsaturated soils need remediation. Combinations of VOCs, nitrate, perchlorate, tritium, high explosives, depleted uranium,

organosilicate oil, polychlorinated biphenyls, dioxins, furans, and metals have been identified for remediation at one or more of the nine Operable Units (OUs) at Site 300.

In 2017, concentrations continued to decrease in most of the Livermore Site VOC plumes due to active remediation and the removal of more than 43 kg of VOCs from both groundwater and soil vapor. Groundwater concentration and hydraulic data indicate subtle but consistent declines in the VOC concentrations and areal extent of the contaminant plumes in 2017.

In 2017 at Site 300, perchlorate, nitrate, the high explosive RDX, and organosilicate oil were removed from groundwater in addition to about 6.5 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 and characterization activities continued. All milestones were met or renegotiated with the regulatory agencies (see **Chapter 2**).

Conclusion

LLNL's EMS 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, 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 2017 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.

This page is intentionally left blank.