Lawrence Livermore National Laboratory (LLNL) is a U.S. Department of Energy (DOE) national laboratory operated by the University of California. LLNL has two sites—the Livermore site located in Livermore, California, and the Experimental Test Site (Site 300) located approximately 20 km (12 mi) east of Livermore, near Tracy, California.

When it was founded in September 1952, LLNL's purpose was to support the Nation's nuclear weapons program by providing innovative design and engineering. Since that time, LLNL has grown to become one of the world's premier scientific centers, with additional substantial research efforts directed toward laser fusion energy, computation, non-nuclear energy, biomedicine, and environmental science.

Although LLNL's mission has been fundamentally one of scientific research, as an institution it has been ever mindful of its responsibilities for protecting the environment and the health and safety of its employees. As stated in the *Environment, Safety and Health Manual*, "It is the Laboratory's environment, safety, and health (ES&H) policy to perform work in a manner that protects the health and safety of employees and the public, preserves the quality of the environment, and prevents property damage. The environment, safety, and health are to be priority considerations in the planning and execution of all work activities at the Laboratory. Furthermore, it is the policy of LLNL to comply with applicable ES&H laws, regulations, and requirements."

To meet these requirements, LLNL currently monitors the ambient air, water, soil, vegetation and foodstuff, and air and liquid effluents for numerous radiological and nonradiological materials. LLNL complies with all federal, state, and local environmental permitting requirements, including the requirements imposed by listing as a Superfund site on the National Priorities List.

This summary is a brief overview of environmental compliance and monitoring activities undertaken by LLNL in calendar year 2003.

Radiological Monitoring

The emissions most often associated with LLNL, especially the Livermore site, are the emissions of tritium (which is the radioactive isotope of hydrogen) to the atmosphere. Tritium emissions occur in two chemical forms: tritium gas (HT) and tritiated water (HTO). The HT and HTO emissions from the Tritium Facility are monitored continuously. In addition, samples of ambient air, vegetation, sewer effluent, storm water, rainwater, groundwater, sediment, and wine are collected and analyzed for HTO. **Figure EX-1** shows the HTO emissions from LLNL Livermore site operations, including the emissions from Sandia/California, a neighboring Department of Energy laboratory that used tritium in its operations from 1979 to 1995. The figure also shows the measured quantities of HTO in ambient air at two locations (VIS and ZON7 air) and

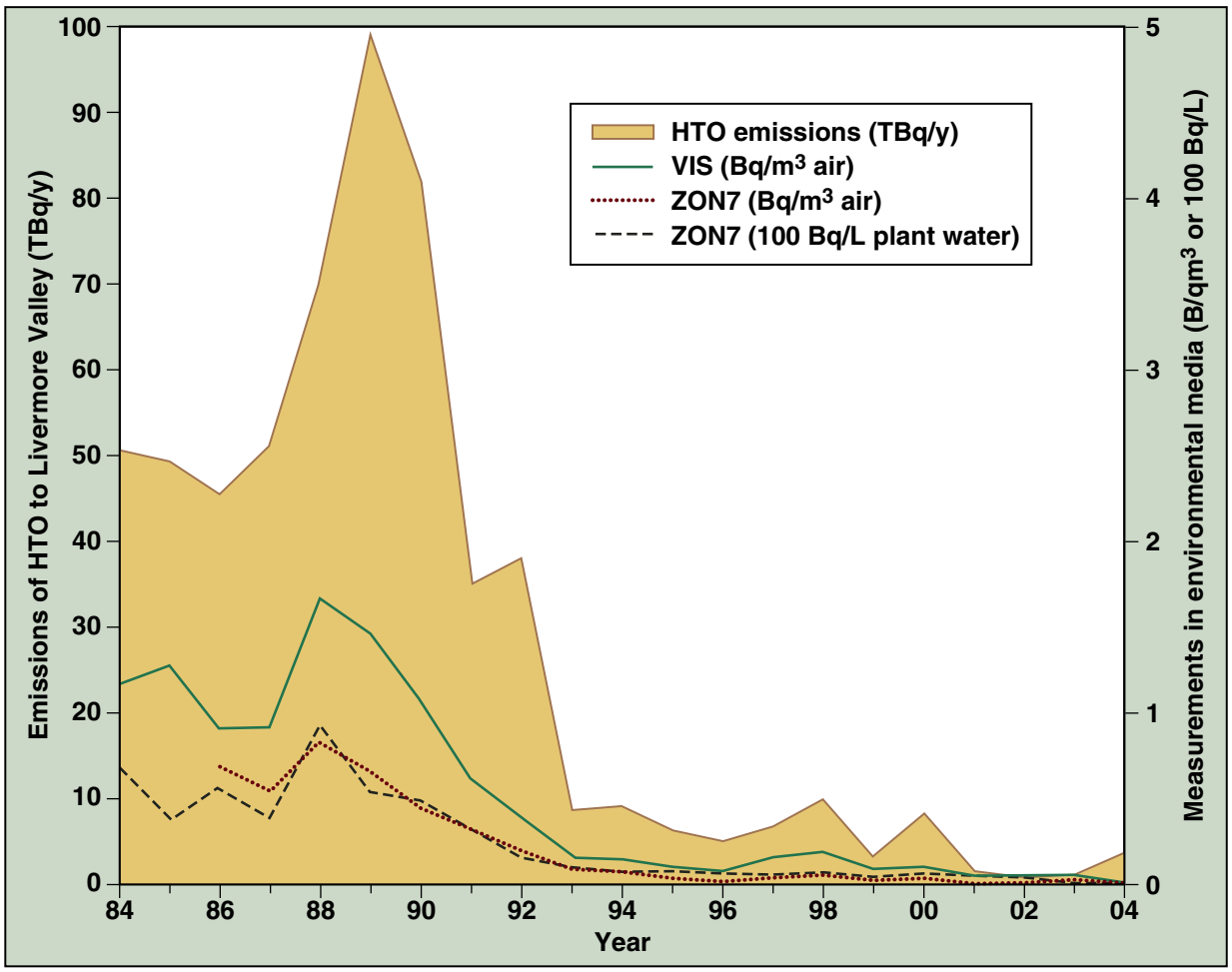


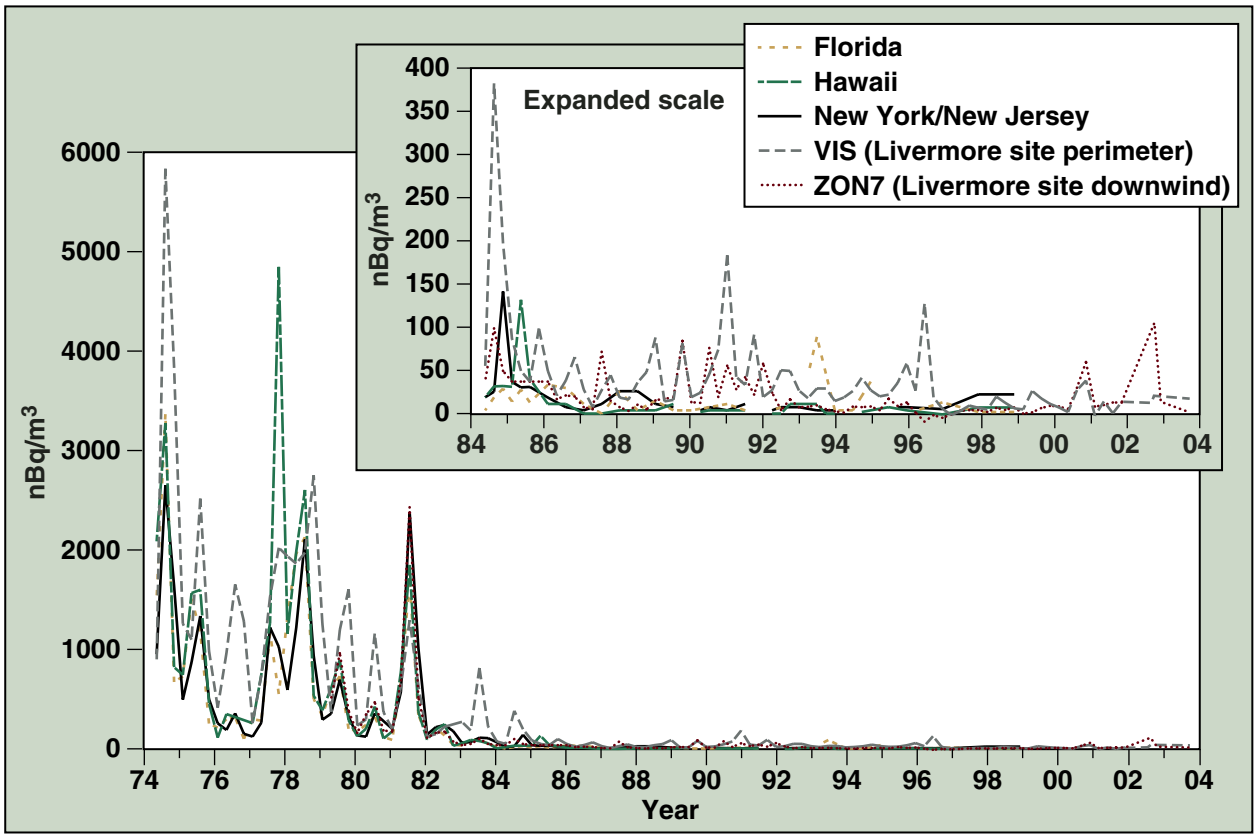
Figure EX-1. Annual median tritium (HTO) concentrations for samples of ambient air and vegetation decline with the declining emissions of HTO

in vegetation from a collocated sampling location (ZON7 plant water). The figure illustrates that ambient environmental measurements decline with the decline in emissions, that the ambient measurement also declines with distance (ZON7 location is farther downwind from the Livermore site than VIS), and that measurements by environmental media are correlated. Although not shown in the figure, measurements of tritium in wine, rainwater, surface water, and sewer effluent show the same trends.

The DOE primary radiation protection standard for protection of the public is 1 mSv/y (100 mrem/y). To enable the determination of whether concentrations of radionuclides in the air or water may cause an exposure greater than the standard, DOE developed Derived Concentration Guides. The Derived Concentration Guides specify the concentrations of radionuclides that an individual could consume, inhale, or be immersed in continuously 365 days a year without receiving a dose greater than 1 mSv/y

(100 mrem/y). The Derived Concentration Guide for HTO in air is 3700 Bq/m^3 (100,000 pCi/m^3). All measurements of HTO in air in 2003 were less than 21 Bq/m^3 (567 pCi/m^3), that is, less than 1% of the Derived Concentration Guide. Although there are no standards for levels of tritium in vegetation or wine, the wine measurements can be compared to the drinking water standard of 740 Bq/L (20,000 pCi/L). The highest measured value for a Livermore Valley wine for the samples collected in calendar year 2003 is 1.7 Bq/L (46 pCi/L), less than 0.2% of the drinking water standard. Tritium concentrations in all wines collected in 2003 are on average approximately 0.1% of the drinking water standard.

Another radioisotope often associated with LLNL operations is plutonium. Current measurements of plutonium at the perimeter of the Livermore site arise from the resuspension of soil contaminated by the operation of solar evaporators of plutonium-containing liquid waste in the early 1970s. **Figure EX-2** shows the measurement of

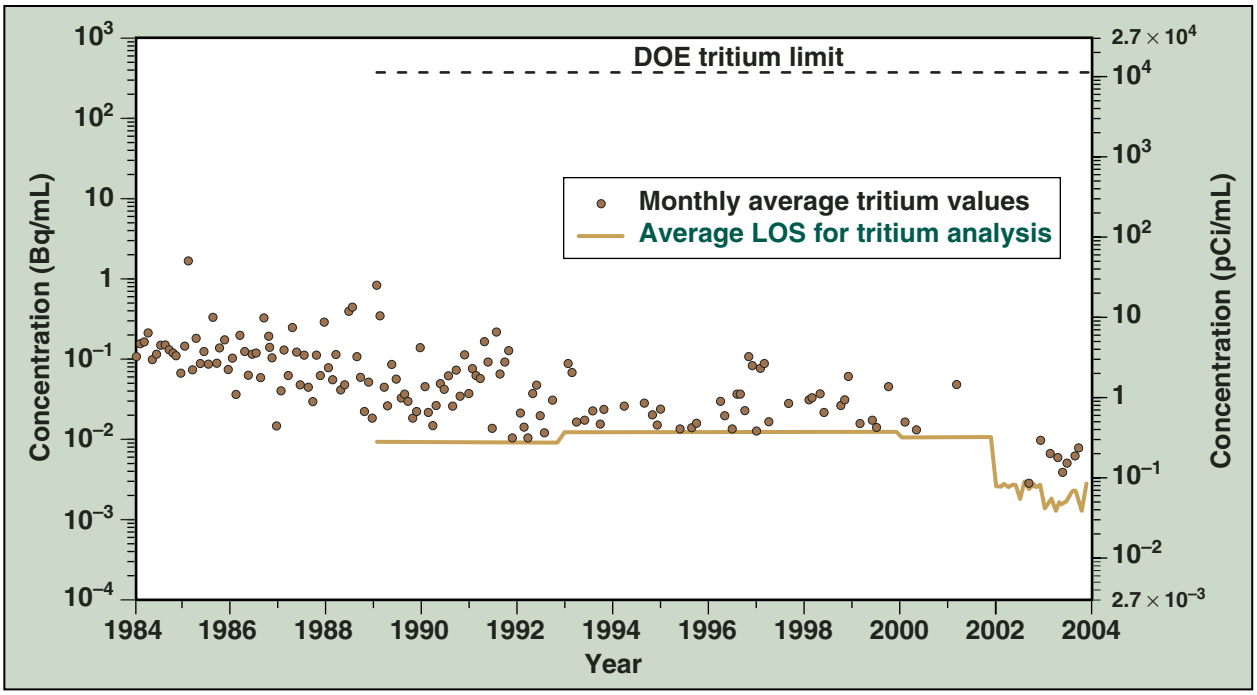


Sources: 1974 to 1985, U.S. Department of Energy Environmental Measurements Laboratory; 1985 to 1999, U.S. Environmental Protection Agency, National Air and Radiation Environmental Laboratory. The samples for Florida were collected in Miami; the samples for Hawaii, in Mauna Loa for 1974 to 1985 and in Honolulu for 1986 to 1999; the samples for New York/New Jersey, in New York City from 1974 to 1990, and in Trenton, New Jersey for 1991 to 1999.

Figure EX-2. Concentrations of plutonium-239+240 in air (nBq/m^3) at three locations throughout the United States, and a perimeter and downwind Livermore site location

plutonium in ambient air from a Livermore site perimeter location (VIS) and a downwind location (ZON7) as well as three other locations from around the United States. The measurements in other parts of the United States result from global fallout from nuclear weapons tests by various nations over the last 50 years. For example, the People's Republic of China conducted eight atmospheric weapons tests of various explosive yields from June 1974 to October 1980. The debris from the tests, including fission products, made a number of passes around the globe before declining to undetectable quantities. The LLNL values at the downwind location (ZON7) are consistent with other measurements of global fallout throughout the United States. The measurements at sampling location VIS show the contributions of resuspension of plutonium-contaminated soil. The Derived Concentration Guide for plutonium in air is 7.4×10^{-4} Bq/m^3 (0.02 pCi/m^3); the highest measured value in 2003 for LLNL sampling locations for plutonium is 6.6×10^{-8} Bq/m^3 (1.8×10^{-6} pCi/m^3), only 0.009% of the Derived Concentration Guide.

Substantial efforts are also undertaken by LLNL to characterize the contribution of operations to the sewer effluent leaving the Livermore site. During 2003, no permitted discharge limit for radioactive materials was exceeded in the sewer effluent. The sewer effluent is monitored continuously for gamma radioactivity, flow rate, pH, and metals. Effluent samples are analyzed daily for gross alpha, gross beta, and tritium radioactivity. Monthly composites of daily sewer samples are analyzed for tritium, plutonium, and cesium radioactivity. **Figure EX-3** shows the monthly average tritium activity in the



Note: Only values above the limit of sensitivity (LOS) of the analytical method used are plotted.

Figure EX-3. Historical tritium concentrations in the Livermore site sanitary sewer effluent

Livermore site sewer effluent since 1984. As can be seen in this figure, the amount of tritium released has declined significantly. During 2003, the monthly tritium activity averages were mostly below the limit of sensitivity of the analytical method used. The maximum monthly tritium release was 0.008 Bq/mL (0.22 pCi/mL), or 0.002% of the Derived Concentration Guide of 370 Bq/mL (10,000 pCi/mL). Similarly, the annual discharges of cesium-137 and plutonium-239 were small percentages, 0.00037% and 0.00004%, respectively, of their Derived Concentrations Guides.

The measurements of radionuclides in soil and the direct measurements of gamma radiation using thermoluminescent dosimeters (TLDs) provide further confirmation of the low level of effects of LLNL's radiological operations on the environment. Most radionuclides in soil were detected at background concentrations. The highest measured value for plutonium-239+240 in soil occurred in a sample from an area of known contamination at the Livermore Water Reclamation Plant. The contamination is the result of an estimated 1.2×10^9 Bq (32 mCi) release of plutonium to the sanitary sewer in 1967 and earlier releases. The maximum measured value for 2003, 14 mBq/dry g (0.38 pCi/dry g), is 3% of the National Council on Radiation Protection (NCRP) recommended screening level of 0.470 Bq/dry g (12.7 pCi) for property used for commercial purposes. The highest measured value for uranium-238 was 110 µg/dry g and was from a sample collected at Site 300, in an area where depleted uranium was used in explosives experiments; the measured value is well below the NCRP screening level of 313 µg/dry g for commercial sites.

TLDs absorb gamma radiation from all sources, including terrestrial sources such as naturally occurring radioactive isotopes of uranium, thorium, radium, and radon present in the soil, cosmic radiation originating from beyond the solar system, as well as any man-made gamma radiation arising from LLNL operations. The TLD measurements for 2003 yielded an annual dose of 0.56 mSv (56 mrem), a value consistent with local measured averages.

Nonradiological Monitoring

Most nonradiological monitoring is performed on samples of groundwater, sanitary sewer water, surface water, and storm water runoff. Although water samples are analyzed for various radioisotopes, their chemical contents are also of concern to regulators, especially where the water is or contributes to a drinking water source or supports aquatic life. Water monitoring at both LLNL sites is conducted to meet general DOE environmental protection requirements, to meet state and federal permit requirements, and to meet Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements. Water monitoring locations include the Livermore site sanitary sewer monitoring station as well as wells, springs, ponds, streams, and drinking water reservoirs. With the exception of a lead and minor pH fluctuations in sanitary sewer effluent, all nonradiological constituents of samples collected in 2003 were within

regulatory or permit limits. Even with the sanitary sewer discharges, no corrective action was required by the regulatory agency and none of the discharges represented a threat to the environment.

Superfund Activities

Two substantial LLNL environmental activities are the investigations and cleanup of groundwater that are being conducted at the Livermore site and at Site 300. The groundwater contaminants at the Livermore site are primarily the volatile organic compounds, trichloroethylene (TCE) and perchloroethylene (PCE). The original source of these contaminants dates from the time that the Livermore site was a Naval Air Station during World War II, when aircraft repair and servicing took place on the site. TCE and PCE were solvents used in cleaning airplane parts.

For the most part, the groundwater contaminants remain within the Livermore site boundary; however, they do extend beyond the boundary to the west and south of the site. Maps showing the extent of PCE contamination in 1988 before cleanup of the PCE plume began, and the current extent of PCE contamination are shown in **Figure EX-4**. These maps show the progress that has been made in the PCE cleanup. Since remediation began in 1989, approximately 8.5 billion liters (2.2 billion gallons) of groundwater and over 1.4 million cubic meters (49 million cubic feet) of vapor have been treated, removing more than 1550 kilograms (3420 pounds) of volatile organic compounds from all remediation sites.

Volatile organic compounds are also the main groundwater contaminants at Site 300. The sites are similar in that the contamination is, for the most part, confined to the site. The sites differ in that Site 300, with an area of 30.3 km^2 (11.8 mi^2), is much larger than the Livermore site, and has been divided into eight operable units based on the nature and extent of contamination, and topographic and hydrologic considerations. The Livermore site at 3.28 km^2 (1.3 mi^2) is effectively one operable unit. Site 300 has additional contaminants, including organosilicate oil, nitrate, high explosives, perchlorate, and depleted uranium. Many of these contaminants are present in the groundwater at Site 300 because of the historic practice of burying debris from high-explosives tests.

LLNL has made substantial progress in cleanup at Site 300. For example, before treatment commenced at the General Services Area (GSA) in 1991, the contaminant plume as shown by monitoring of groundwater wells at the eastern GSA operable unit, extended more than a mile down the Corral Hollow Creek channel. Now, TCE concentrations have been decreased to below drinking water standards in groundwater from all off-site wells. The reduction in this plume is illustrated in **Figure EX-5**. Overall, since remediation efforts began at Site 300 in 1990, more than 977 million liters (258 million gallons) of groundwater and approximately 4.3 million cubic meters (152 million cubic feet) of vapor have been treated, yielding about 234 kilograms (516 pounds) of removed volatile organic compounds.

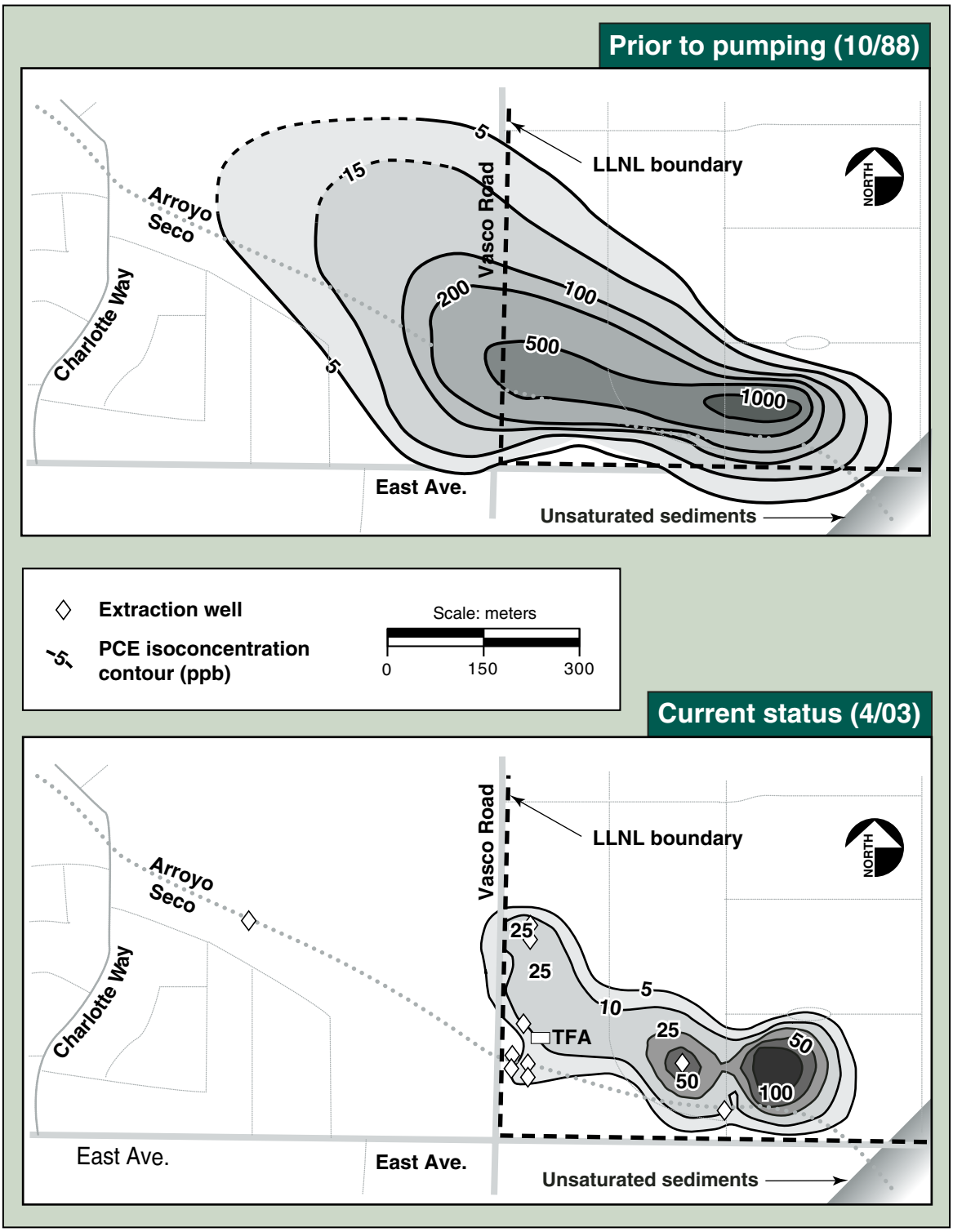


Figure EX-4. Successful reduction of the PCE plume at the western and southern boundaries of the Livermore site

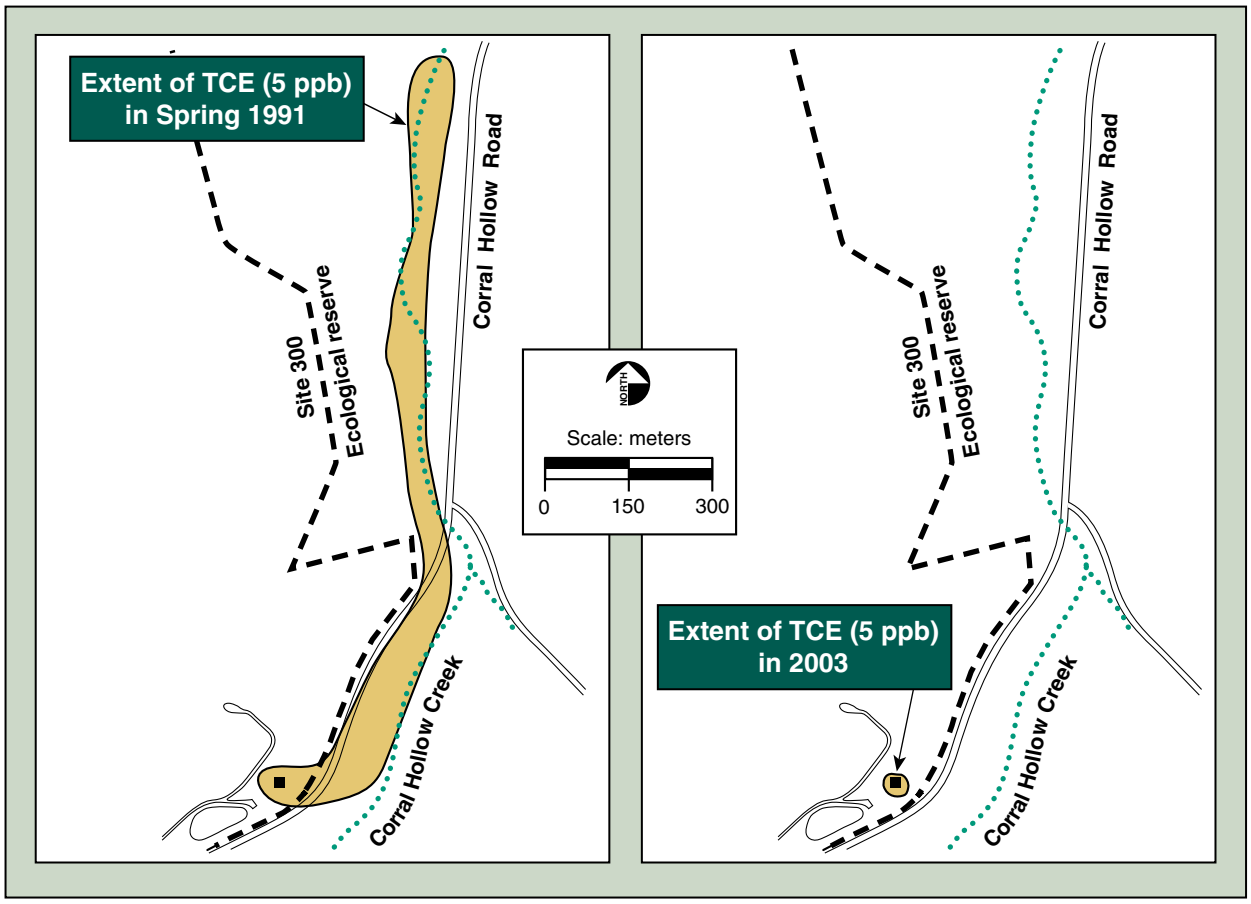


Figure EX-5. Successful reduction of the TCE plume at the southeastern boundary of LLNL's Site 300

Regulatory Permitting and Compliance

LLNL undertakes substantial activities to comply with the 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 Resource Conservation and Recovery Act and state and local hazardous waste regulations; the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA); the Endangered Species Act; the National Historic Preservation Act; the Antiquities Act; and the CERCLA (which is more commonly known as the Superfund Act).

LLNL has numerous environmental permits from a variety of regulatory agencies in all levels of government. Some of these permits cover individual pieces of equipment (for example, air permits for boilers, emergency generators, degreasers, printing presses, or tank permits for product or waste storage). During the years 1990 to 2003, LLNL obtained 150 to 250 air permits each year, depending on operations, while the number of permitted underground tanks steadily declined from 80 to 15 as the tanks were closed or replaced with aboveground tanks. Other permits cover classes of emissions, such as the Regional Water Quality Control Board controls on discharges of industrial or construction-site storm water and treated groundwater to surface water. Similarly, the sewer permits cover all discharges from the Livermore site to the municipal sewage system, setting discharge limits for acidity or alkalinity, metals, organic compounds, and radioactivity. Hazardous waste permits, likewise, cover all operations in which the various physical forms of hazardous, radioactive, mixed, and medical waste are handled or stored.

LLNL had numerous inspections from several local, state, and federal agencies in 2003. All inspections showed LLNL to be in compliance with regulatory requirements except for the following instances. An air inspection at the Livermore site in February 2003 identified a record keeping violation from September 2002 to February 2003, for which LLNL paid a $2650 civil penalty. Hazardous waste facility inspections at the Livermore site in March 2003 identified four potential violations regarding training records; storage time limits of two mixed waste containers; operating record discrepancies; and inadequate aisle spacing between waste containers. For these violations, LLNL provided the regulatory agency with updated training dates; applied to extend the storage time limits on the mixed waste containers; corrected the discrepancies in the operating records; and re-arranged the waste containers to provide adequate aisle spacing, respectively. Another inspection at the Livermore site on waste generator areas in June 2003 identified an unlabeled container in poor condition outside a waste accumulation area; the container, containing sea water which is not a hazardous material, was appropriately disposed. An inspection in October 2003 of hazardous waste facilities at Site 300 identified a training violation; however, LLNL is contesting the violation since LLNL had discussed the training plan with the regulating agency prior to the permit being issued and the agency did not include the training requirement in LLNL's permit. U.S. EPA conducted a multimedia inspection at the Livermore site in November 2003 covering air, water, hazardous waste, tank, and other environmental regulations and permits. A violation regarding incorrect dates on two hazardous waste containers was corrected during the inspection. Two violations regarding LLNL's oil spill prevention program require LLNL to update the Livermore site Spill Prevention Control and Countermeasure Plan and enhances LLNL's current maintenance inspections of aboveground oil containers; these corrections are in process. None of the violations in 2003 resulted in a release or posed a threat to the public or the environment.

Permitting is not the only type of compliance activity. Another significant compliance activity is reporting, and generating data to support the reports. Some reporting can occur as frequently as monthly (such as the sanitary sewer reports), or annually (such as the waste minimization reports); however, reporting may be virtually any period determined by the regulatory agency. Reports cover subjects as varied as hazardous materials

business plans; NEPA and CEQA evaluations of new projects, experiments and construction; waste management reports; storm water pollution prevention plans and reports; antiquities and cultural evaluations; and endangered species surveys.

One report of public interest provides an estimate of the radiological dose to a hypothetical maximally exposed individual member of the public arising from releases of radioactive material to air. This annual report is submitted to the U.S. Environmental Protection Agency (EPA) to demonstrate compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the federal Clean Air Act. NESHAPs limits the annual dose to members of the public caused by DOE facility operations to 100 μSv (10 mrem). The regulations specify the methods by which airborne emissions and their impacts must be evaluated. The total dose is calculated using the inventories of radionuclides from unmonitored sources as required by the U.S. EPA, as well as stack monitoring and ambient air monitoring, where available. The total dose to the maximally exposed public individual for 2003 was 0.44 μSv (0.044 mrem) for the Livermore site and 0.17 μSv (0.017 mrem) for Site 300. These doses are well below the 100 μSv (10 mrem) standard. LLNL also calculates potential doses to aquatic and terrestrial biota from LLNL operations. These potential doses are found to be well below DOE allowable dose limits. All these dose assessments confirm that the impacts of LLNL operations on the public and the environment are very small.

A final important method by which LLNL complies with environmental regulations is to conduct surveys of and undertake measures to protect endangered and threatened species, as required by the U.S. Endangered Species Act and the California Endangered Species Act. Both the Livermore site and Site 300 have populations of rare or endangered species. Livermore site populations of the California red-legged frog (*Rana aurora draytonii*) were monitored as part of the Arroyo Las Positas maintenance project. Biological assessment surveys were also performed for special-status species at Site 300.

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 dose assessment shows that the radiological dose to the public caused by LLNL operations is less than 1% of regulatory standards and is about 0.02% of the dose received from natural background radiation. The analytical results and evaluations generally show continuing low contaminant levels, reflecting the commitment of LLNL to control pollutants.

In addition, LLNL's extensive environmental compliance activities related to water, air, endangered species, waste, wastewater, and waste reduction provided further controls on LLNL's effects on the environment.

In summary, the results of the 2003 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. Environmental monitoring of LLNL operations does not indicate an adverse impact to public health or the environment.