5. Water Monitoring Programs

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Lawrence Livermore National Laboratory monitors a multifaceted system of waters that includes wastewaters, storm water, and groundwater, as well as rainfall and local surface water. Water systems at the two LLNL sites (the Livermore Site and Site 300) operate differently. For example, the Livermore Site is serviced by publicly owned treatment works but Site 300 is not, resulting in different methods of treating and disposing of sanitary wastewater at the two sites. Many drivers determine the appropriate methods and locations of the various water monitoring programs, as described below.

In general, water samples are collected according to written, standardized procedures appropriate for the medium (Gallegos 2012). Sampling plans are prepared by the LLNL network analysts who are responsible for developing and implementing monitoring programs or networks. Network analysts decide which analytes are sampled (see **Appendix B**) and at what frequency, incorporating any permit-specified requirements. Except for analyses of certain sanitary sewer and retention tank analytes, analyses are usually performed by off-site, California-certified contract analytical laboratories.

5.1 Sanitary Sewer Effluent Monitoring

In 2014, the Livermore Site discharged an average of 0.87 million L/d (230,000 gal/d) of wastewater to the City of Livermore sewer system or 5.2% of the total flow into the City's system. This volume includes wastewater generated by Sandia/California and a very small quantity from Site 300. In 2014, Sandia/California generated approximately 6.7% of the total effluent discharged from the Livermore outfall. Wastewater from Sandia/California and Site 300 is discharged to the LLNL collection system and combined with LLNL sewage before it is released at a single point to the municipal collection system.

LLNL's effluent contains both domestic waste and process wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below. Most of the process wastewater generated at the Livermore Site is collected in retention tanks and discharged to LLNL's collection system following characterization and approval from LLNL's EFA Water Team staff Wastewater Discharge Authorization Requirement (WDAR) approval process.

5.1.1 Livermore Site Sanitary Sewer Monitoring Complex

LLNL's sanitary sewer discharge permit (Permit 1250) requires continuous monitoring of the effluent flow rate and pH. Samplers at the Sewer Monitoring Station (SMS) collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, total toxic organics, and other water-quality parameters.

5.1.1.1 Radiological Monitoring Results

DOE orders and federal regulations establish the standards of operation at LLNL (see **Chapter 2**), including the standards for sanitary sewer discharges. Primarily the standards for radioactive material releases are contained in sections of the DOE Order 458.1 and 10 CFR Part 20.

For sanitary sewer discharges, DOE Order 458.1 provides the criteria DOE has established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (the Derived Concentration Technical Standards [DCTSs]) limit the concentration of each radionuclide discharged to publicly owned treatment works. If the measured monthly average concentration of a radioisotope exceeds its concentration limit, LLNL is required to improve discharge control measures until concentrations are again below the DOE limits.

The 10 CFR Part 20 sanitary sewer discharge numerical limits include the following annual discharge limits for radioactivity: tritium, 185 GBq (5 Ci); carbon-14, 37 GBq (1 Ci); and all other radionuclides combined, 37 GBq (1 Ci). The 10 CFR Part 20 limit on total tritium activity dischargeable during a single year (185 GBq [5 Ci]) takes precedence over the DOE Order 458.1 concentration-based limit for tritium for facilities that generate wastewater in large volumes, such as LLNL. In addition to complying with the 10 CFR Part 20 annual mass-based discharge limit for tritium and the DOE monthly concentration-based discharge limit for tritium, LLNL also complies with the daily effluent concentration-based discharge limit for tritium established by WRD for LLNL. The WRD limit is smaller by a factor of 30 than the DOE monthly limit, so the limits are therefore essentially equivalent; however, the WRD limit is more stringent in that it prevents large single event discharges.

The radioisotopes with the potential to be found in sanitary sewer effluent at LLNL and their discharge limits are discussed below. All analytical results are provided in **Appendix A**, **Section A.3**.

LLNL determines the total radioactivity contributed by tritium, gross alpha emitters, and gross beta emitters from the measured radioactivity in the monthly effluent samples. As shown in **Table 5-1**, the 2014 combined release of alpha and beta sources was 0.19 GBq (0.005 Ci), which is 0.5% of the corresponding 10 CFR Part 20 limit (37 GBq [1.0 Ci]). The tritium total was 1.54 GBq (0.04 Ci), which is 0.8 % of the 10 CFR Part 20 limit (185 GBq [5 Ci]).

Table 5-1. Estimated total radioactivity in LLNL sanitary sewer effluent, 2014.

Radioactivity	Estimate based on effluent activity (GBq)	MDC[(a)]
Tritium	1.54	0.75
Gross alpha	0.01	0.02
Gross beta	0.18	0.05

(a) Minimum detectable concentration

Discharge limits and a summary of the measurements of tritium in the sanitary sewer effluent from LLNL and the Livermore Water Reclamation Plant (LWRP) are reported in LLNL monthly reports. The maximum daily concentration for tritium of 0.099 Bq/mL (2.67 pCi/mL) was far below the permit discharge limit of 12 Bq/mL (333 pCi/mL).

Complete calendar year 2014 data for measured concentrations of cesium-137 and plutonium-239 in the sanitary sewer effluent from LLNL, the LWRP, and in LWRP sludge are reported in the LLNL February 2015 Report (Jones 2015). Cesium and plutonium results are from monthly composite samples of LLNL and LWRP effluent and from quarterly composites of LWRP sludge. For 2014, the annual total discharges of cesium-137 and plutonium-239 were far below the DOE DCTSs. Plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The highest plutonium concentration observed in 2014 sludge is 0.6 mBq/g (0.016 pCi/g), which is many times lower than the National Council on Radiation Protection and Measurements (NCRP) recommended screening limit of 470 mBq/g (12.7 pCi/g) for commercial or industrial property.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 5-2** summarizes the radioactivity in sanitary sewer effluent over the past 10 years. During 2014, a total of 1.54 GBq (0.04 Ci) of tritium was discharged to the sanitary sewer, an amount that is well within environmental protection standards and is comparable to the lowest amounts discharged during the past 10 years.

Table 5-2. Historical radioactive liquid effluent releases from the Livermore Site, 2004–2014.

Year	Tritium (GBq)	Plutonium-239 (GBq)
2004	1.34	1.16×10^{-5}
2005	3.12	9.64×10^{-6}
2006	19.9	7.56×10^{-6}
2007	2.83	6.24×10^{-6}
2008	0.83	5.52×10^{-6}
2009	1.01	5.93×10^{-6}
2010	1.47	5.25×10^{-6}
2011	1.37	2.00×10^{-6}
2012	1.57	7.00×10^{-6}
2013	1.94	5.91×10^{-5}
2014	1.54	3.21×10^{-5}

5.1.1.2 Nonradiological Monitoring Results

LLNL monitors sanitary sewer effluent for chemical and physical parameters at different frequencies depending on the intended use of the result. For example, LLNL's wastewater discharge permit requires LLNL to collect monthly grab samples and 24-hour composites, weekly composites, and daily composites. Once a month, a 24-hour, flow-proportional composite is collected and analyzed; this is referred to as the monthly 24-hour composite in the discussion below. The weekly composite refers to the flow-proportional samples collected over a 7-day period continuously throughout the year. The daily composite refers to the flow-proportional sample collected over a 24-hour period, also collected continuously throughout the year.

A summary of the analytical results from the permit-specified monthly composite sampling program is presented in **Table 5-3**. The permit also requires that grab samples of effluent be collected on a monthly and semiannual basis and analyzed for total toxic organic (TTO) compounds and cyanide, respectively. (Results from LLNL's 2014 sanitary sewer effluent monitoring program are provided in **Appendix A**, **Section A.3**.)

During July 2014, the permit changed how metals are sampled. Metals are no longer measured weekly. Metals are now measured with a 24-hour composite sample collected twice annually in April and October. All of the metals samples in 2014 were in compliance with LLNL's wastewater discharge permit limits.

Table 5-3. Summary of analytical results for permit-specified composite sampling of the LLNL sanitary sewer effluent, 2014.

Sample	Parameter	Detection frequency[(a)]	PQL[(b)]	Minimum	Maximum	Median
Monthly 24-hour Composite	Biochemical oxygen demand (mg/L)	12 of 12	2	43	130	66
	Solids (mg/L)					
	Total dissolved solids	12 of 12	1	280	600	400
	Total suspended solids	12 of 12	1	16	120	31

(a) The number of times an analyte was positively identified, followed by the number of samples that were analyzed.
(b) PQL = Practical quantitation limit (these limits are typical values for sanitary sewer effluent samples).

As previously noted, grab samples of LLNL's sanitary sewer effluent are collected monthly for TTO analysis (permit limit = 1.0 mg/L) and semiannually for cyanide analysis (permit limit = 0.04 mg/L). In 2014, LLNL did not exceed either of these discharge limits. Results from the monthly TTO analyses for 2014 show that no priority pollutants, listed by the EPA as toxic organics, were identified in LLNL effluent above the 10 µg/L permit-specified

reporting limit with the exception of methylene chloride which was measured at 40 µg/L and reported in the December LWRP report. This value is well below the regulatory reporting limit of 1 mg/l. As shown in **Appendix A**, **Section A.3**, one non-regulated organic compound, acetone, was identified in monthly grab samples at concentrations above the 10 µg/L permit-specified reporting limit. Cyanide was below the analytical detection limit for semi-annual samples in April (<0.02 mg/L) and October (<0.02 mg/L).

5.1.2 Categorical Processes

The EPA has established pretreatment standards for categories of industrial processes that EPA has determined are major contributors to point-source water pollution. These federal standards include prescribed sampling, self-monitoring, reporting, and numerical limits for the discharge of category-specific pollutants. At LLNL, the categorical pretreatment standards are incorporated into the wastewater discharge permit (Permit 1250), which is administered by the WRD.

The processes at LLNL that are determined to be regulated under the Categorical Standards may change as programmatic requirements dictate. During 2014, the WRD identified wastewater-generating processes at eight LLNL locations that are defined under either 40 CFR Part 469 or 40 CFR Part 433.

Only processes that discharge to the sanitary sewer require semiannual sampling, inspection, and reporting. During 2014, two processes discharged wastewater to the sanitary sewer: semiconductor processes located in the Building 153 (microfabrication facility), and the abrasive jet machining located in Building 321C. In 2014, LLNL analyzed compliance samples for all regulated parameters from both processes and demonstrated compliance with all federal categorical and local discharge limits. As a further environmental safeguard, LLNL sampled the wastewater in each wastewater tank designated as receiving regulated waste, prior to each discharge to the sanitary sewer. These monitoring data were reported to the WRD in July 2014 and January 2015 Semiannual Wastewater Point-Source Monitoring Reports (Rosene, 2014, 2015).

In addition, WRD source control staff performed their required annual inspection and sampling of the two discharging categorical processes in October 2014. The compliance samples were analyzed for all regulated parameters, and the results demonstrated compliance with all federal and local pretreatment limits.

If any of the non-discharging regulated processes were to discharge process wastewater to the sanitary sewer, they would be regulated under 40 CFR Part 433. Currently wastewater from these processes are either recycled onsite or contained for eventual removal and appropriate disposal by RHWM.

5.1.3 Discharges of Treated Groundwater

LLNL’s groundwater discharge permit (1510G, 2014–2015) allows treated groundwater from the Livermore Site GWP to be discharged in the City of Livermore sanitary sewer system (see Chapter 8 for more information on the GWP). During 2014, there were no discharges (from on-

site or off-site locations) to the sanitary sewer from Environmental Restoration Department (ERD) GWP activities. When such discharges occur, permit compliance is maintained by Treatment Facility Operators through the systematic use of engineering and administrative controls, including Wastewater Discharge Authorization Records (WDARs) generated for each discharge. This information was reported to the City of Livermore (Revelli 2015a).

5.1.4 Environmental Impact of Sanitary Sewer Effluent

During 2014, no discharges exceeded any discharge limits for either radioactive or nonradioactive materials to the sanitary sewer. The data are comparable to the lowest historical LLNL values. All the values reported for radiological releases are a fraction of their corresponding limits.

On August 15, 2014, LLNL received a Notice of Violation (NOV) from the City of Livermore. The NOV was issued based on LLNL's August 6, 2014, self-reporting of the missed July 2014 monthly collection of sewer monitoring samples for Biological Oxygen Demand/ Suspended Solids (BOD/SS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and Total Toxic Organics (TTO).

The data demonstrate that LLNL continues to have excellent control of both radiological and nonradiological discharges to the sanitary sewer. Monitoring results for 2014 reflect an effective year for LLNL’s wastewater discharge control program and indicate no adverse impact to the LWRP or the environment from LLNL sanitary sewer discharges.

5.2 Site 300 Sewage Ponds and Site 300 Waste Discharge Requirements

Wastewater samples collected at Site 300 from the influent to the sewage evaporation pond, within the sewage evaporation pond, and flow to the sewage percolation pond were obtained in accordance with the written, standardized procedures summarized in Gallegos (2012).

5.2.1 Sewage Evaporation and Percolation Ponds

Sanitary effluent (nonhazardous wastewater) generated at buildings in the General Services Area at Site 300 is disposed of through a lined evaporation pond. Occasionally, during winter rains, treated wastewater may discharge into an unlined percolation pond where it enters the ground and the shallow groundwater. Although this potential exists, it did not occur during 2014.

In September 2008, Waste Discharge Requirement (WDR) 96-248 was replaced by WDR R5-2008-0148, a new permit issued by the Central Valley Regional Water Quality Control Board (CVRWQCB) for discharges to ground at Site 300.

Under the terms of this Monitoring and Reporting Program (MRP), LLNL submits semiannual and annual monitoring reports detailing its Site 300 discharges of domestic and wastewater effluent to sewage evaporation and percolation ponds in the General Services Area, and cooling tower blow down to percolation pits and septic systems, and mechanical equipment discharges to percolation pits located throughout the site.

The monitoring data collected for the 2014 semi-annual and annual reports shows compliance with all MRP and permit conditions and limits. All networks were in compliance with the permit requirements. Compliance certification accompanied this report, as required by federal and state regulations.

5.2.2 Environmental Impact of Sewage Ponds

There were no discharges from the Site 300 sewage evaporation pond to the percolation pond. Groundwater monitoring related to this area indicated there were no measurable impacts to the groundwater from the sewage pond operations (Blake 2014).

5.3 Storm Water Compliance and Surveillance Monitoring

LLNL monitors storm water at the Livermore Site in accordance with Permit WDR 95-174 (SFBRWQCB 1995) and at Site 300 in accordance with the California NPDES General Permit for Storm Water Discharges Associated with Industrial Activities (WDR 97-03-DWQ) (SWRCB 1997). Site 300 storm water observations also meet the requirements of the *Post-Closure Plan for the Pit 6 Landfill Operable Unit* [Ferry et al. 1998]. For construction projects that disturb one acre of land or more, LLNL also meets storm water compliance monitoring requirements of the California NPDES General Permit for Storm Water Discharges Associated with Construction Activity (Order Number 2009-0009-DWQ) (SWRCB, 2009). The Energy Independence and Security Act, Section 438 specifically calls for federal development that has a footprint that exceeds 5,000 square feet to maintain or restore predevelopment hydrology. Storm water monitoring at both sites also follows the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) and meets the applicable requirements of DOE Order 458.1. **Appendix B** includes the current list of analyses conducted on storm water, including analytical methods and typical reporting limits.

LLNL permits require sample collection and analysis at the sample locations specified in the permits two times per rainy season if specific criteria are met and the sampling window coincides with regular working hours. Influent (upstream) sampling is also required at the Livermore Site. In addition, LLNL is required to visually inspect the storm drainage system during one storm event per month in the wet season (defined as October through April for the Livermore Site and October through May for Site 300) to observe runoff quality and twice during the dry season to identify any dry weather flows. Annual facility inspections are also required to ensure that the best management practices for controlling storm water pollution are implemented and adequate.

5.3.1 Storm Water Inspections

Each principal directorate at LLNL conducts an annual inspection of its facilities to verify implementation of the Storm Water Pollution Prevention Plans (SWPPPs) and to ensure that measures to reduce pollutant discharges to storm water runoff are adequate. LLNL's principal associate directors certified in 2014 that their facilities complied with the provisions of LLNL's SWPPPs. LLNL submits annual storm water monitoring reports to the SFBRWQCB (Fish 2015a) and to the CVRWQCB (Fish 2015b) with the results of sampling, observations, and inspections.

For each construction project permitted by Order Number 2009-0009-DWQ, LLNL conducts visual monitoring of construction sites before, during, and after storms to assess the effectiveness of the best management practices. Annual compliance certifications, if necessary, summarize the inspections.

In the calendar year 2014, there were two storms at the Livermore Site that met the criteria for a qualifying event (in February and December) as defined in Permit WDR 95-174 (SFBRWQCB 1995). Because of lack of rainfall due to the ongoing drought in California, only one storm at Site 300 met the criteria for a qualifying event (in December) as defined in the General Industrial Storm Water Permit (97-03-DWQ) for Site 300. In July 2015, LLNL implemented the requirements of the new California Industrial General Permit for storm water (Permit 2014-0057-DWQ) at both the Livermore Site and Site 300.

5.3.2 Storm Water Compliance

There are no numeric concentration limits for storm water effluent; moreover, the EPA's benchmark concentration values for storm water are not intended to be interpreted as limits (U.S. EPA 2000). To evaluate the program, LLNL has established site-specific thresholds for selected parameters (Campbell and Mathews 2006). A value exceeds a parameter's threshold when it is greater than the 95% confidence limit for the historical mean value for that parameter. The thresholds are used to identify out-of-the-ordinary data that merit further investigation to determine whether concentrations of that parameter are increasing in the storm water runoff.

With two exceptions, discussed below, the data for both Livermore Site storm events, i.e., February and December 2014, were within acceptable levels as defined in our permit WDR 95-174. A nitrate concentration, above the site-specific threshold value, was found at one Livermore Site effluent location in samples from the February 2014 storm. This value, however, is consistent with nitrate concentrations in groundwater from extraction wells that are discharged under a CERCLA permit to that same location in the Arroyo Seco. Similarly, a gross beta activity above the site-specific threshold value was detected at one Livermore Site effluent location in samples from the December 2014 storm. However, within the uncertainty limits associated with the reported gross beta activity, this value is essentially equal to the site-specific threshold value.

Data for the December 2014 storm event at Site 300 demonstrate that LLNL remained within acceptable effluent runoff levels, as defined in our permit 97-03-DWQ.

Storm water visual observations and best management practices inspections indicated that LLNL's storm water program continues to protect water quality.

Full reports of storm water runoff samples for the July 2013 to June 2014 and the July 2014 to June 2015 water years are available in the Annual Storm Water Reports for the Livermore Site and Site 300 (**Appendix D**).

5.4 Groundwater

LLNL conducts surveillance monitoring of groundwater in the Livermore Valley and at Site 300 through networks of wells and springs that include off-site private wells and on-site DOE CERCLA wells. To meet the goal of maintaining a comprehensive, cost-effective monitoring program, LLNL determines the number and locations of surveillance wells, the analytes to be monitored, the frequency of sampling, and the analytical methods to be used. A wide range of analytes is monitored to assess the impact, if any, of current LLNL operations on local groundwater resources. Because surveillance monitoring is geared to detecting substances at very low concentrations in groundwater, contamination can be detected before it significantly impacts groundwater resources. Groundwater monitoring wells at the Livermore Site, in the Livermore Valley, and at Site 300 are included in LLNL's *Environmental Monitoring Plan* (Gallegos 2012).

Beginning in January 2003, LLNL implemented a new CERCLA comprehensive compliance monitoring plan at Site 300 (Ferry et al. 2002) that adequately covers the DOE requirements for on-site groundwater surveillance. In addition, LLNL continues two additional surveillance networks to supplement the CERCLA compliance monitoring plan and provide additional data to characterize potential impacts of LLNL operations. LLNL monitoring related to CERCLA activities is described in **Chapter 7**. Additional monitoring programs at Site 300 comply with numerous federal and state controls such as state-issued permits associated with closed landfills containing solid wastes and with continuing discharges of liquid waste to sewage ponds and percolation pits; the latter are discussed in **Section 5.2.1**. Compliance monitoring is specified in WDRs issued by the CVRWQCB and in landfill closure and post-closure monitoring plans. (See **Chapter 2**, **Table 2-1** for a summary of LLNL permits.)

The WDRs and post-closure plans specify wells and discharges to be monitored, constituents of concern (COCs) and parameters, frequency of measurement, inspections, and the frequency and form of required reports. These monitoring programs include quarterly, semiannual, and annual monitoring of groundwater, monitoring of various influent waste streams, and visual inspections. LLNL performs the maintenance necessary to ensure the physical integrity of closed facilities, such as those that have undergone CERCLA or RCRA closure, and their monitoring networks.

During 2014, representative samples of groundwater were obtained from monitoring wells in accordance with the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures* (Goodrich and Lorega 2012). The procedures cover sampling techniques and information concerning the parameters monitored in groundwater. Different sampling techniques were applied to different wells depending on whether they were fitted with submersible pumps or had to be bailed. All of the chemical and radioactivity analyses of groundwater samples were performed by California-certified analytical laboratories. For comparison purposes only, some of the results were compared with drinking water limits (MCLs).

5.4.1 Livermore Site and Environs

5.4.1.1 Livermore Valley

LLNL has monitored tritium in water hydrologically downgradient of the Livermore Site since 1988. HTO (tritiated water) is potentially the most mobile groundwater contaminant from LLNL operations. Groundwater samples were obtained during 2014 from 16 of 17 water wells in the Livermore Valley (see **Figure 5-1**) and measured for tritium activity. One well (11B1) was out of service and could not be sampled in 2014.

Tritium measurements of Livermore Valley groundwater are provided in **Appendix A**, **Section A.5**. The measurements continue to show very low activities compared with the 740 Bq/L (20,000 pCi/L) MCL established for drinking water in California. The maximum tritium activity measured off site was in the groundwater at well 8F1, located about 6.0 km (3.7 mi) west of LLNL (see **Figure 5-1**). The measured activity there was 2.6 Bq/L (70.3 pCi/L) in 2014, less than 0.40% of the MCL.

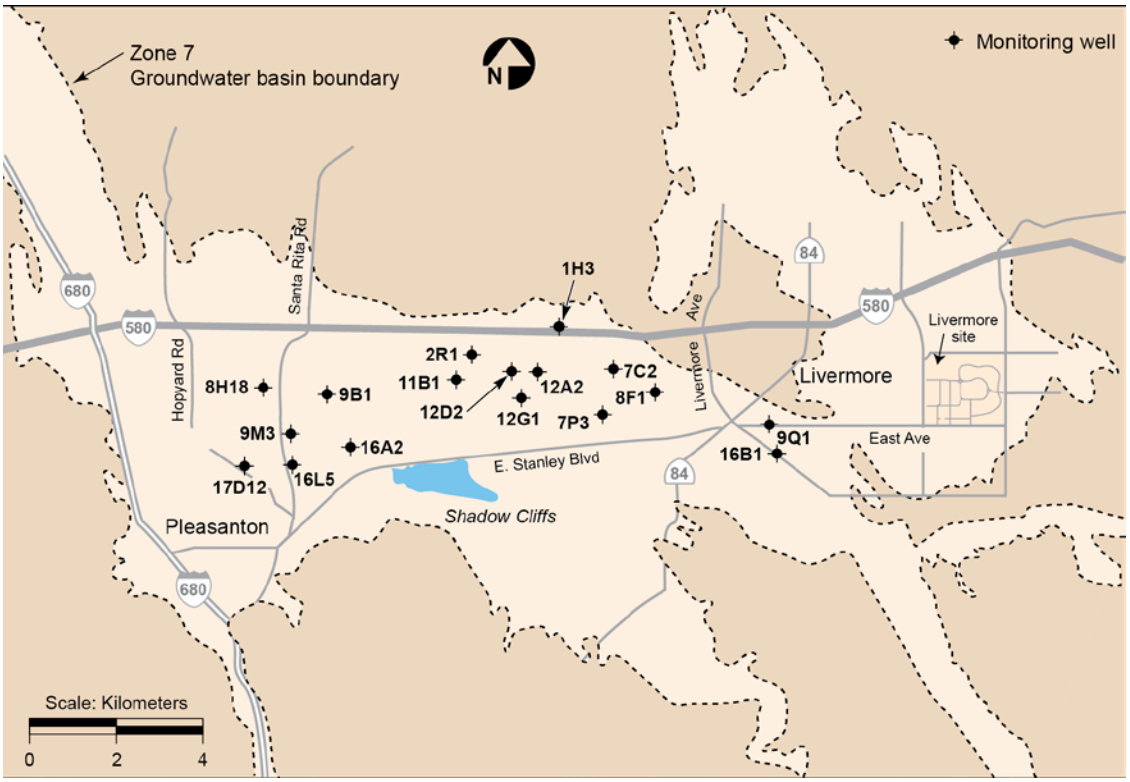

Figure 5-1. Off-site tritium monitoring wells in the Livermore Valley, 2014.

5.4.1.2 Livermore Site Perimeter

LLNL's groundwater surveillance monitoring program was designed to complement the Livermore Site Ground Water Project (GWP) (see **Chapter 7**). The intent of the program is to monitor for potential groundwater contamination from LLNL operations. The perimeter portion of the surveillance groundwater monitoring network uses three upgradient (background)

monitoring wells (wells W-008, W-221, and W-017) near the eastern boundary of the site and seven downgradient monitoring wells located near the western boundary (wells 14B1, W-121, W-151, W-1012, W-571, W-556, and W-373) (see **Figure 5-2**). As discussed in **Chapter 7**, the alluvial sediments have been divided into nine hydrostratigraphic units (HSUs—water bearing zones that exhibit similar hydraulic and geochemical properties) dipping gently westward. Screened intervals (depth range from which groundwater is drawn) for these monitoring wells range from the shallow HSU-1B to the deeper HSU-5. Two of the background wells, W-008 and W-221, are screened partially in HSU-3A; well W-017 is considered a background well for the deeper HSU-5. To detect contaminants as quickly as possible, the seven western downgradient wells (except well 14B1, screened over a depth range that includes HSU-2, HSU-3A, and HSU-3B) were screened in shallower HSU-1B and HSU-2, the uppermost water-bearing HSUs at the western perimeter. These perimeter wells were sampled and analyzed at least once during 2014 for general minerals (including nitrate) and for certain radioactive constituents. Analytical results for the Livermore Site perimeter wells are provided in **Appendix A**, **Section A.5**. Although there have been variations in these concentrations since regular surveillance monitoring began in 1996, the concentrations detected in the 2014 groundwater samples from the upgradient wells represent current background values.

Historically, chromium (VI) had been detected above the MCL (50 µg/L) in groundwater samples from western perimeter well W-373; however, concentrations of this analyte first dropped below the MCL in 2002. The 2014 sample from this location showed a concentration of 36 µg/L; a value consistent with the range of chromium (VI) concentrations (5 µg/L to 52 µg/L) detected at well W-373 since 2002. Groundwater samples collected in 2014 from the nearby wells W-556 and W-1012, also along the western perimeter of the LLNL site, showed chromium (VI) concentrations of 16 µg/L and 11 µg/L, respectively.

From 1996 through 2004, concentrations of nitrate detected in groundwater samples from downgradient well W-1012 were greater than the MCL of 45 mg/L. The nitrate concentration detected in the 2014 sample from this well (25 mg/L) was again, as in the past nine years, below the MCL. During 2014, concentration of nitrate in the on-site shallow background well W-221 was reported to be 28 mg/L. Detected concentrations of nitrate in western perimeter wells ranged from 12 mg/L (in well W-373) to 46 mg/L (in well W-151).

During 2014, gross alpha, gross beta, and tritium were detected occasionally in LLNL's site perimeter wells, at levels consistent with the results from recent years; however, the concentrations again remain below drinking water MCLs.

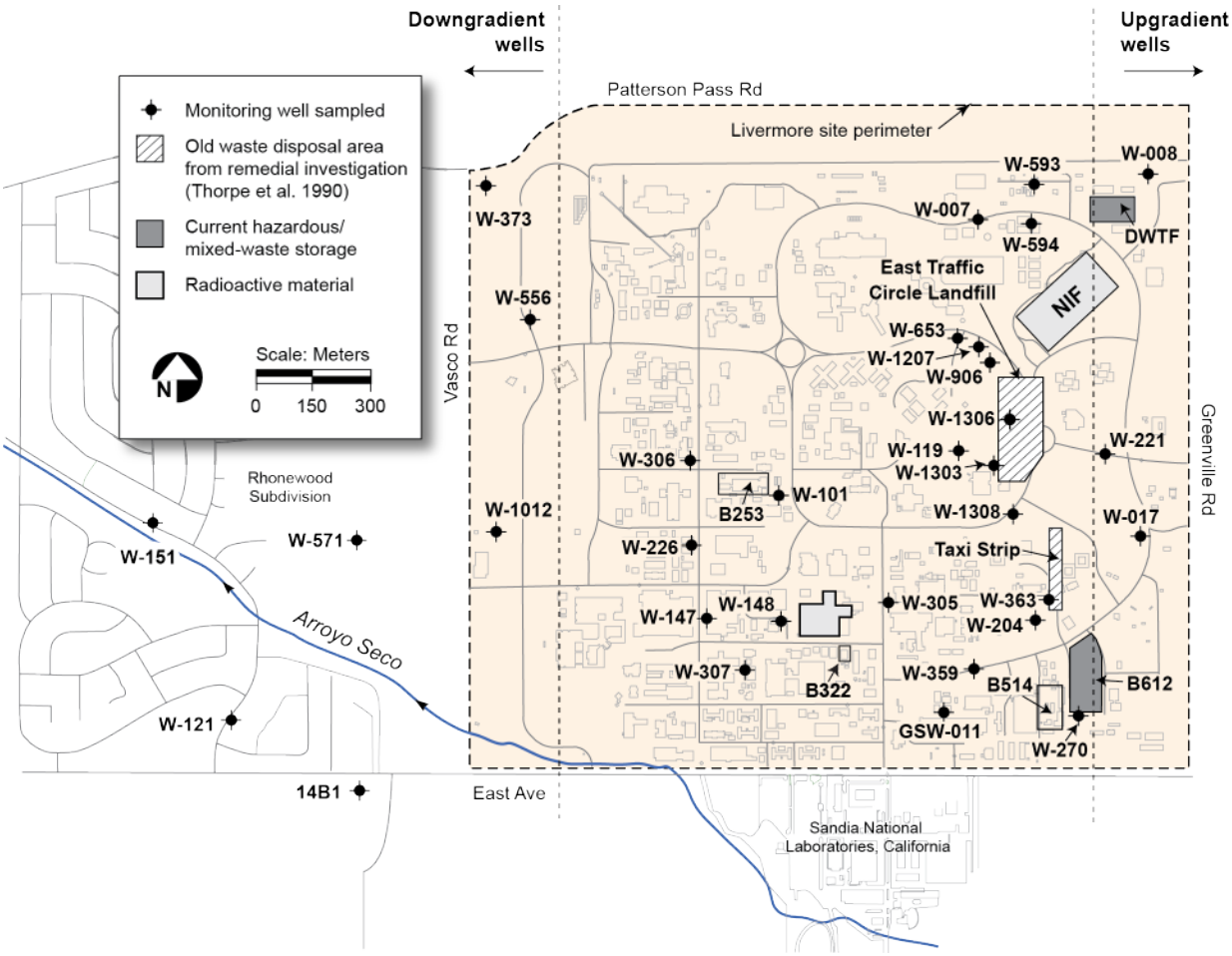

Figure 5-2. Routine surveillance groundwater monitoring wells at the Livermore Site, 2014.

5.4.1.3 Livermore Site

Groundwater sampling locations within the Livermore Site include areas where releases to the ground may have occurred in the recent past, where previously detected COCs have low concentrations that do not require CERCLA remedial action, and where baseline information needs to be gathered for the area near a new facility or operation. Wells selected for monitoring are screened in the uppermost aquifers and are downgradient from and as near as possible to the potential release locations. Well locations are shown in **Figure 5-2**. All analytical results are provided in **Appendix A**, **Section A.5**.

The Taxi Strip and East Traffic Circle Landfill areas (see **Figure 5-2**) are two potential sources of historical groundwater contamination. Samples from monitoring wells screened in HSU-2 (W-204) and HSU-3A (W-363) downgradient from the Taxi Strip area were analyzed in 2014 for copper, lead, zinc, and tritium. Samples from monitoring wells screened at least partially in HSU-2 (W-119, W-906, W-1303, W-1306, and W-1308) within and downgradient from the East Traffic Circle Landfill were analyzed for the same elements as the Taxi Strip area. Concentrations of tritium remained well below the drinking water MCLs at all seven locations, and none of the

trace metals (copper, lead, zinc) were detected in any of these seven monitoring wells during 2014.

Near the National Ignition Facility (NIF), LLNL measures pH, conductivity, and tritium concentration of nearby groundwater to establish a baseline. During 2014, tritium analyses were conducted on groundwater samples collected from wells W-653 and W-1207 (screened in HSU-3A and HSU-2, respectively) downgradient of NIF. Samples were also obtained downgradient from the DWTF from wells W-007, W-593, and W-594 (screened in HSU-2/3A, HSU-3A, and HSU-2, respectively) during 2014 and were analyzed for tritium. Monitoring results from the wells near NIF and DWTF showed no detectable concentrations of tritium, above the limit of sensitivity of the analytical method, in the groundwater samples collected during 2014. Monitoring will continue near these facilities to determine baseline conditions.

The former storage area around Building 514 and the hazardous waste/mixed waste storage facilities around Building 612 are also potential sources of contamination. The area and facilities are monitored by wells W-270 and W-359 (both screened in HSU-5), and well GSW-011 (screened in HSU-3A). During 2014, groundwater from these wells was sampled and analyzed for gross alpha, gross beta, and tritium. No significant contamination was detected in the groundwater samples collected downgradient from these areas in 2014.

Groundwater samples were obtained from monitoring well W-307 (screened in HSU-1B), downgradient from Building 322. Soil samples previously obtained from this area showed concentrations elevated above the Livermore Site's background levels for total chromium, copper, lead, nickel, zinc, and occasionally other metals. LLNL removed contaminated soils near Building 322 in 1999 and replaced them with clean fill. The area was then paved over, making it less likely that metals would migrate from the site. In 2014, the monitoring results for well W-307 showed only slight variations from the typical concentrations reported in recent years. In particular, the concentration of manganese (which had shown some questionable fluctuations in 2012 and 2013) returned to a value below the analytical reporting limit. LLNL will continue to track these results as additional data become available.

Groundwater samples were obtained downgradient from a location where sediments containing metals (including cadmium, chromium, copper, lead, mercury, and zinc) had accumulated in a storm water catch basin near Building 253. In 2014, the samples obtained from monitoring wells W-226 and W-306 (screened in HSU-1B and HSU-2, respectively) again contained dissolved chromium at concentrations above the analytical reporting limit, but these concentrations remained low and essentially unchanged from recent years.

Additional surveillance groundwater sampling locations, established in 1999, are in areas surrounding the Plutonium Facility and Tritium Facility. Potential contaminants include plutonium and tritium from these facilities, respectively. Plutonium is much more likely to bind to the soil than migrate into the groundwater. Tritium, as HTO, can migrate into groundwater if spilled in sufficient quantities. Upgradient of these facilities, well W-305 is screened in HSU-2. Downgradient wells W-101, W-147, and W-148 are screened in HSU-1B; however, as in 2012

and 2013, well W-101 was dry and could not be sampled in 2014. In August 2000, elevated tritium activity was detected in the groundwater sampled at well W-148 (115 ± 5.0 Bq/L [3100 ± 135 pCi/L]). The activity was most likely related to local infiltration of storm water containing elevated tritium activity. Tritium activities in groundwater in this area had remained at or near the same level through 2005, but samples collected from well W-148 in 2006 through 2014 have shown significantly lower values—a downward trend ranging from approximately one-half to one-quarter of the August 2000 value due to the natural decay and dispersion of tritium. LLNL continues to collect groundwater samples from these wells periodically for surveillance purposes, primarily to demonstrate that tritium contents remain below MCLs.

5.4.2 Site 300 and Environs

For surveillance and compliance groundwater monitoring at Site 300, LLNL uses DOE CERCLA wells and springs on site and private wells and springs off site. Representative groundwater samples are obtained at least once per year at every monitoring location; they are routinely measured for various elements (primarily metals), a wide range of organic compounds, general radioactivity (gross alpha and gross beta), uranium activity, and tritium activity. Groundwater from the shallowest water-bearing zone is the target of most of the monitoring because it would be the first to show contamination from LLNL operations at Site 300.

Brief descriptions of the Site 300 groundwater monitoring networks that are reported in this chapter are given below. (All analytical data from 2014 are included in **Appendix A**, **Section A.6**.)

5.4.2.1 Elk Ravine Drainage Area

The Elk Ravine drainage area, a branch of the Corral Hollow Creek drainage system, includes most of northern Site 300 (see **Figure 5-3**). Storm water runoff in the Elk Ravine drainage area collects in arroyos and quickly infiltrates into the ground. Groundwater from wells in the Elk Ravine drainage area is monitored for COCs to determine the impact of current LLNL operations on the system of underground flows that connects the entire Elk Ravine drainage area. The area contains eight closed landfills, known as Pits 1 through 5 and 7 through 9, and firing tables where explosives tests are conducted. None of these closed landfills has a liner, which is consistent with the disposal practices when the landfills were constructed. The following descriptions of monitoring networks within Elk Ravine begin with the headwaters area and proceed downstream. (See **Chapter7** for a review of groundwater monitoring in this drainage area conducted under CERCLA.)

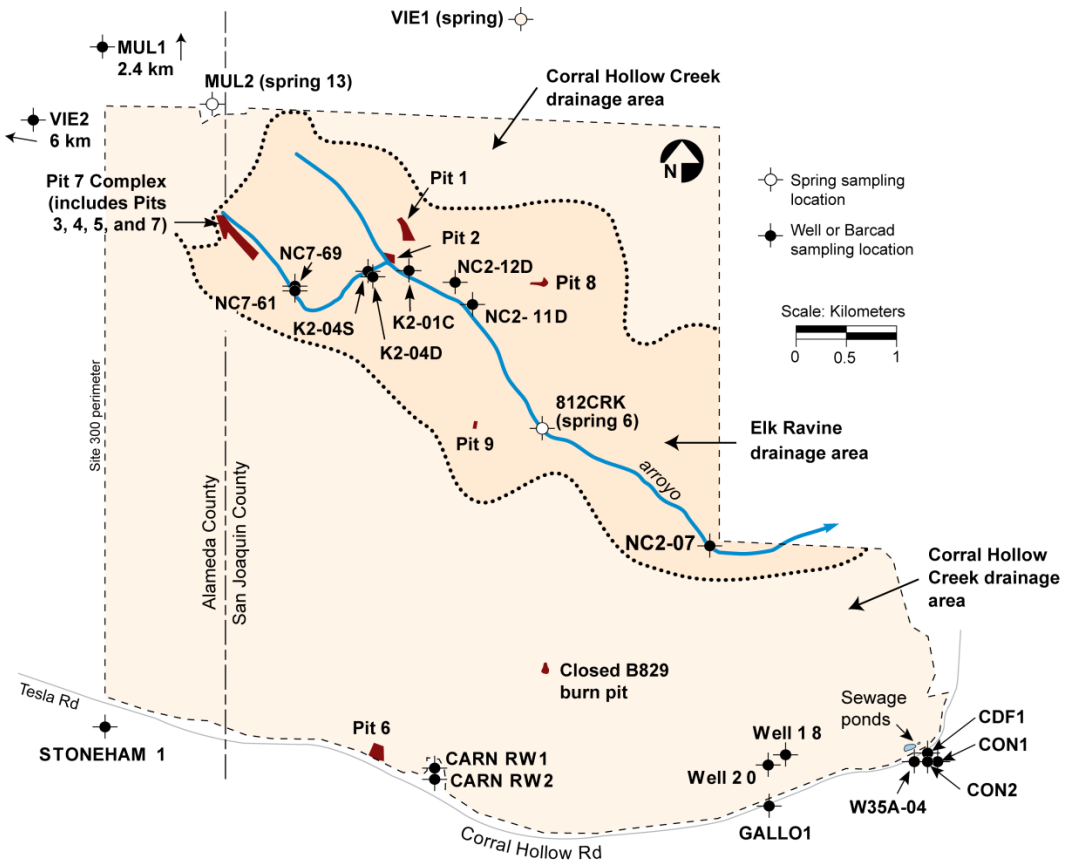

Figure 5-3. Surveillance groundwater wells and springs at Site 300, 2014.

Pit 7 Complex. The Pit 7 landfill was closed in 1992 in accordance with U.S. EPA and California Department of Health Services (now Department of Toxic Substances Control, or DTSC)-approved RCRA Closure and Post-Closure Plans using the LLNL CERCLA Federal Facility Agreement (FFA) process. From 1993 until 2009, monitoring requirements were specified in WDR 93-100, administered by the CVRWQCB (1993, 1998), and in *LLNL Site 300 RCRA Closure and Post-Closure Plans—Landfill Pits 1 and 7* (Rogers/Pacific Corporation 1990). An Amendment to the Interim ROD for the Pit 7 Complex (Site 300 U.S. DOE, 2007) was signed in 2007 under CERCLA. The remedial actions specified in the Interim ROD, including a hydraulic drainage diversion system, extraction and treatment of groundwater, and Monitored Natural Attenuation for tritium in groundwater) were implemented in 2008. In 2010, detection monitoring and reporting for the Pit 7 complex was transferred to CERCLA. Analytes and frequencies of sampling are documented in the CERCLA Compliance Monitoring Plan and Contingency Plan for Site 300 (Dibley et al., 2009). The objective of this monitoring continues to be the early detection of any new release of COCs from Pit 7 to groundwater.

For compliance purposes, during 2014 LLNL obtained annual or more frequent groundwater samples from the Pit 7 detection monitoring well network. Samples were analyzed for tritium, VOCs, fluoride, high explosive compounds (HMX and RDX), nitrate, perchlorate, uranium (isotopes or total), metals, lithium, and PCBs. For a detailed account of Pit 7 compliance

monitoring during 2014, including well locations, maps of the distribution of COCs in groundwater, and analytical data tables, see Dibley et al, 2014.

Elk Ravine. Groundwater samples were obtained on various dates in 2014 from the widespread Elk Ravine surveillance monitoring network shown in **Figure 5-3** (NC2-07, NC2-11D, NC2-12D, NC7-61, NC7-69, 812CRK [SPRING6], K2-04D, K2-04S, K2-01C). Samples from NC2-07 were analyzed for inorganic constituents (mostly metallic elements), general radioactivity (gross alpha and beta), tritium and uranium activity, and explosive compounds (HMX and RDX). Samples from the remaining wells were analyzed only for general radioactivity.

No new release of COCs from LLNL operations in Elk Ravine to groundwater is indicated by the chemical and radioactivity data obtained during 2014. The major source of contaminated groundwater beneath Elk Ravine is from historical operations in the Building 850 firing table area (Webster-Scholten 1994; Taffet et al. 1996). Constituents that are measured as part of the Elk Ravine drainage area surveillance monitoring network are listed in **Appendix B**.

The highest result of tritium analysis for well NC7-61 was 690 Bq/L in 2014, down from 720 Bq/L in 2013. This tritium activity remains elevated with respect to the background concentrations. Tritium, as HTO, has been released in the past in the vicinity of Building 850. The majority of the Elk Ravine surveillance-network tritium measurements made during 2014 support earlier CERCLA studies that show that the tritium in the plume is diminishing over time because of natural decay and dispersion (Ziagos and Reber-Cox 1998). CERCLA modeling studies indicate that the tritium will decay to background levels before it can reach a site boundary.

Groundwater surveillance measurements of gross alpha, gross beta and uranium radioactivity in Elk Ravine are low and are indistinguishable from background levels. (Note that gross beta measurements do not detect the low-energy beta emission from tritium decay.) Additional detections of nonradioactive elements including arsenic, barium, chromium, selenium, vanadium, and zinc are all within the natural ranges of concentrations typical of groundwater elsewhere in the Altamont Hills.

Pit 1. The Pit 1 landfill was closed in 1993 in accordance with a California Department of Health Services (now Department of Toxic Substances Control, or DTSC) approved RCRA Closure and Post-Closure Plan using the LLNL CERCLA Federal Facility Agreement (FFA) process. Monitoring requirements are specified in WDR 93-100, which is administered by the CVRWQCB (1993, 1998, and 2010), and in Rogers/Pacific Corporation (1990). The main objective of this monitoring is the early detection of any release of COCs from Pit 1 to groundwater. LLNL obtained groundwater samples quarterly during 2014 from the Pit 1 monitoring well network. Samples were analyzed for inorganic COCs (mostly metallic elements), general radioactivity (gross alpha and beta), activity of certain radioisotopes (tritium, radium, uranium, and thorium), explosive compounds (HMX and RDX), and VOCs (EPA Methods 601 and 8260). Additional annual analyses were conducted on groundwater samples for extractable organics (EPA Method 625), as well as pesticides and PCBs (EPA Method 608). Compliance

monitoring showed no new releases at Pit 1 in 2014; a detailed account of Pit 1 compliance monitoring during 2014, including well locations and tables and graphs of groundwater COC analytical data, is in Blake (2015).

5.4.2.2 Corral Hollow Creek Drainage Area

Pit 6. Compliance monitoring requirements for the closed Pit 6 landfill in the Corral Hollow Creek drainage area are specified in Ferry et al. (1998, 2002). Two Pit 6 groundwater monitoring programs, which operate under CERCLA, ensure compliance with all regulations. They are (1) the Detection Monitoring Plan (DMP), designed to detect any new release of COCs to groundwater from wastes buried in the Pit 6 landfill, and (2) the Corrective Action Monitoring Plan (CAMP), which monitors the movement and fate of historical releases. To comply with monitoring requirements, LLNL collected groundwater samples monthly, quarterly, semiannually, and annually during 2014 from specified Pit 6 monitoring wells. Groundwater wells were analyzed for VOCs, tritium, beryllium, mercury, total uranium, gross alpha/beta, perchlorate, and nitrate.

During 2014, no new releases were detected at Pit 6. A detailed account of Pit 6 compliance monitoring during 2014, including well locations, tables of groundwater analytical data, and maps showing the distribution of COC plumes, is displayed in the CERCLA Annual Compliance Report that was submitted by the LLNL Environmental Restoration Department (Buscheck 2015).

Building 829 Closed High Explosives Burn Facility. Compliance monitoring requirements for the closed burn pits in the Corral Hollow Creek drainage area are specified in Mathews and Taffet (1997), and in LLNL (2001), as modified by DTSC (2003). As planned for compliance purposes, LLNL obtained groundwater samples during 2014 from the three wells in the Building 829 monitoring network. Groundwater samples from these wells, screened in the deep regional aquifer, were analyzed for inorganics (mostly metals), turbidity, explosive compounds (HMX, RDX, and TNT), VOCs (EPA Method 624), extractable organics (EPA Method 625), and general radioactivity (gross alpha and beta).

During 2014, there were no confirmed COC detections above their respective statistical limits in groundwater samples from any of the Building 829 network monitoring wells. Among the inorganic constituents, perchlorate was not detected above its reporting limit in any sample. With the exception of barium in well W-892-15 (which remains below its statistical limit, but at a level approximately twice the originally calculated background concentration) and manganese in well W-829-1938 (which exhibits a low of approximately one-third the originally calculated background concentration), the metal COCs that were detected showed concentrations that are not significantly different from background concentrations for the deep aquifer beneath the High Explosives Process Area.

There were no organic or explosive COCs detected above reporting limits in any samples. Similarly, all results for the radioactive COCs (gross alpha and gross beta) were below their statistical limit values. For a detailed account of compliance monitoring of the closed burn pit

during 2014, including well locations and tables and graphs of groundwater COC analytical data, see Revelli (2015b).

Water Supply Well. Water supply well 20, located in the southeastern part of Site 300 (**Figure 5-3**), is a deep, high-production well. The well is screened in the Neroly lower sandstone aquifer ($Tnbs_1$) and can produce up to 1,500 L/min (396 gal/min) of potable water. As planned for surveillance purposes, LLNL obtained groundwater samples quarterly during 2014 from well 20. Groundwater samples were analyzed for inorganic COCs (mostly metals), VOCs, general radioactivity (gross alpha and gross beta), and tritium activity. Quarterly measurements of groundwater from well 20 do not differ significantly from previous years. As in past years, the primary potable water supply well at Site 300 showed no evidence of contamination. Gross alpha, gross beta and tritium activities were very low and are indistinguishable from background level activities.

5.4.2.3 Off-site Surveillance Wells and Springs

As planned for surveillance purposes, during 2014 LLNL obtained groundwater samples from two off-site springs (MUL2 and VIE1) and ten off-site wells (MUL1, VIE2, CARNRW1, CARNRW2, CDF1, CON1, CON2, GALLO1, STONEHAM1, and W35A-04) **(Figure 5-3)**. With the exception of one well, all off-site monitoring locations are near Site 300. The exception, well VIE2, is located at a private residence 6 km west of the site. It represents a typical potable water supply well in the Altamont Hills.

Samples from CARNRW2 and GALLO1 were analyzed at least quarterly for inorganic constituents (mostly metals), general radioactivity (gross alpha and beta), tritium activity, explosive compounds (HMX and RDX), and VOCs (EPA method 502.2). Additional annual analyses were conducted for uranium activity and extractable organic compounds (EPA Method 625) for samples collected from CARNRW2 only. In addition, CARNRW1 and CON2 samples were analyzed for VOCs; samples from well CARNRW1 were also sampled for perchlorate and tritium.

Groundwater samples were obtained once (annually) during 2014 from the remaining off-site surveillance monitoring locations: MUL1, MUL2, and VIE1 (north of Site 300); VIE2 (west of Site 300); and STONEHAM1, CON1, CDF1, and W-35A-04 (south of Site 300). Samples were analyzed for inorganic constituents (metals, nitrate, and perchlorate), general radioactivity (gross alpha and beta), tritium and uranium activity, explosive compounds (HMX and RDX), VOCs, and extractable organic compounds (EPA Method 625).

Generally, no constituents attributable to LLNL operations at Site 300 were detected in the off-site groundwater samples. Arsenic and barium were detected at the off-site locations, but their concentrations were below MCLs and are consistent with naturally occurring concentrations. Radioactivity measurements in samples collected from off-site groundwater wells are generally indistinguishable from naturally occurring activities.

5.5 Other Monitoring Programs

5.5.1 Rainwater

Rainwater is sampled and analyzed for tritium activity by EPA 906.0 modified method in support of DOE Order 458.1. Rainwater is collected in rain gauges at fixed locations from both Livermore Site and Site 300. The tritium activity of each sample is measured and the analytical results compared to the MCL of 740 Bq/L (20,000 pCi/L) established by the EPA for drinking water. In calendar year 2014, the rain gauges were placed at the sample locations SALV, MET, DWTF, and SECO as shown in **Figure 5-4**. The sample collection for calendar year 2014 ranged from February to December.

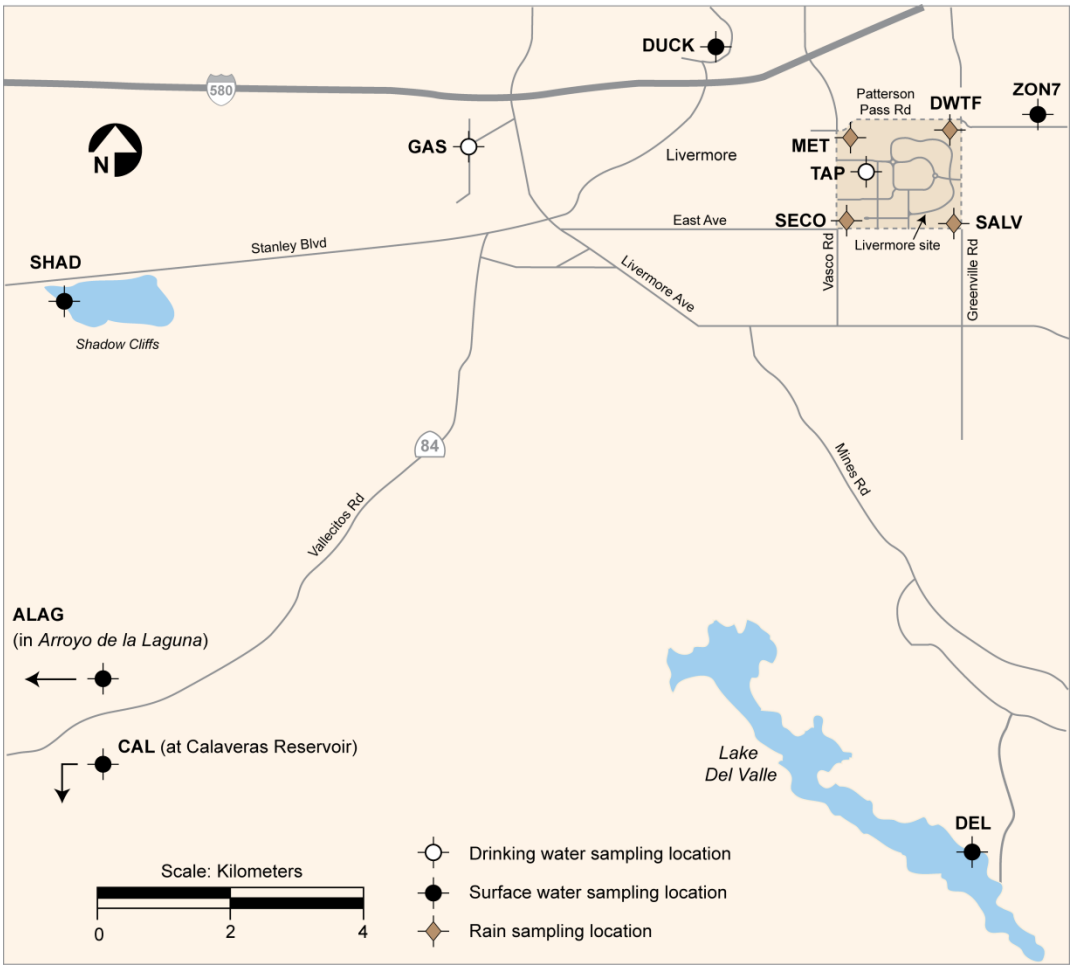

Figure 5-4. Livermore Site and Livermore Valley sampling locations for rain, surface water, and drinking water, 2014.

The highest tritium activity reported was for the February 6th storm was 2.2 Bq/L at the SECO location and 1.2 Bq/L was measured at the MET location. The December 11th storm produced the highest tritium activity reported of 18.0 Bq/L at the SECO location. These reported activities are

significantly less that the MCL of the EPA established drinking water standard stated above. All analytical results are provided in **Appendix A, Section A.7**.

5.5.1.2 Site 300 and Environs

During 2010, LLNL positioned two rain gauges at on-site locations ECP and PSTL (see **Figure 5-5**) to collect rainfall to measure tritium activity at Site 300. Only the 2014 storm on December 11th produced a detectable amount of tritium resulting in 1.3 Bq/L at PSTL. Rainfall samples are usually collected at the same time storm water samples are collected.

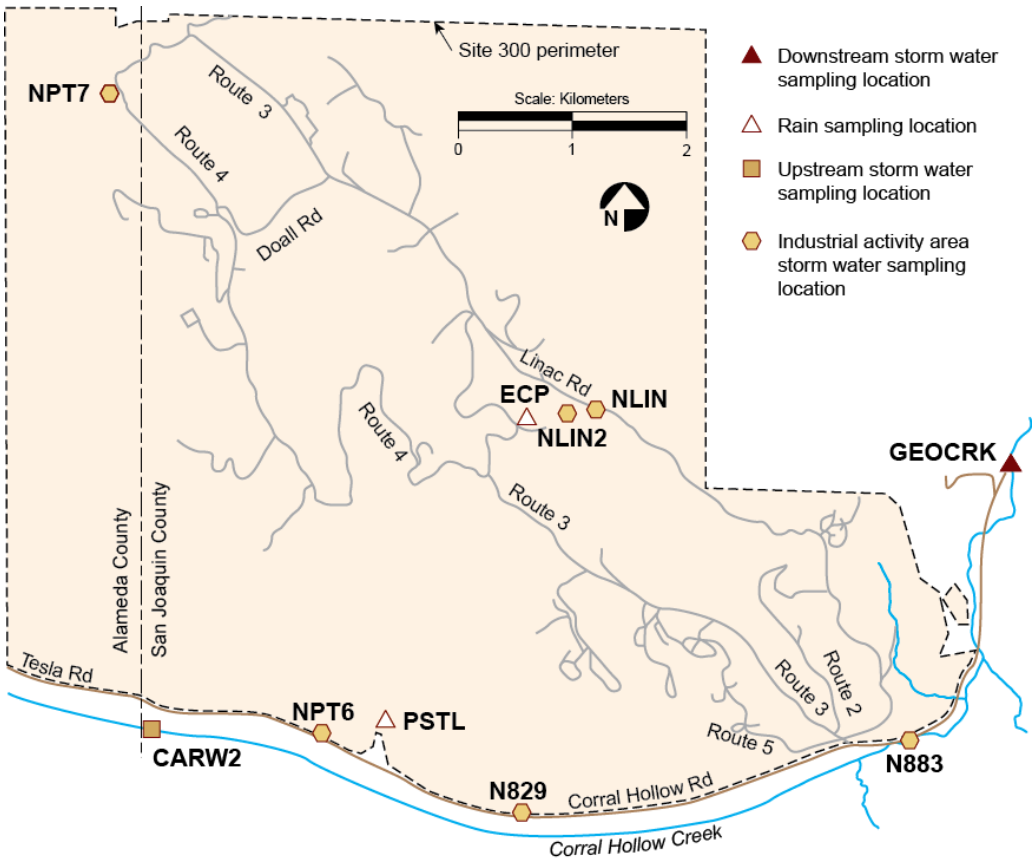

Figure 5-5. Storm water and rainwater sampling locations at Site 300, 2014.

5.5.2 Livermore Valley Surface Waters

LLNL conducts additional surface water surveillance monitoring in support of DOE Order 458.1. Surface and drinking water near the Livermore Site and in the Livermore Valley were sampled at the locations shown in **Figure 5-4** in 2014. Off-site sampling locations CAL, DEL, DUCK, ALAG, SHAD, and ZON7 are surface water bodies; of these, CAL, DEL, and ZON7 are also drinking water sources. GAS and TAP are drinking water outlets; radioactivity data from these two sources are used to calculate drinking water statistics (see **Table 5-4**).

Samples are analyzed according to written, standardized procedures summarized in Gallegos (2012). LLNL sampled the two drinking water outlets semiannually and the other

locations annually in 2014. All locations were sampled for tritium, gross alpha, and gross beta. All analytical results are provided in **Appendix A**, **Section A.7**.

The median activity for tritium in all water location samples was estimated from calculated values to be below the analytical laboratory's minimum detectable activities, or minimum quantifiable activities. The maximum tritium activity detected in any sample collected in 2014 was 2.62 Bq/L 70.8 pCi/L), less than 1% of the drinking water MCL. The median activity for gross alpha radiation in all water samples was less than zero (-0.051 Bq/L), and the median activity for gross beta radiation in all water samples was approximately 5% of the gross beta MCL. Historically, concentrations of gross alpha and gross beta radiation in drinking water sources have fluctuated around the laboratory's minimum detectable activities. At these very low levels, the counting error associated with the measurements is nearly equal to, or in many cases greater than, the calculated values so that no trends are apparent in the data. The maximum activity detected for gross alpha occurred in a sample collected at DEL, and the maximum gross beta radioactivity occurred in a sample collected at DUCK. These maximum values (gross alpha at 0.034 Bq/L [0.92 pCi/L] and gross beta at 0.271 Bq/L [7.32 pCi/L]) were still less than 7% and 15% of their respective drinking water MCLs (see **Table 5-4**).

Table 5-4. Radioactivity in surface and drinking waters in the Livermore Valley, 2014.

Location	Metric	Tritium (Bq/L)[(a)]	Gross alpha (Bq/L)[(a)]	Gross beta (Bq/L)[(a)]
All locations	Median	1.76	-0.0051	0.1018
	Minimum	-1.21	-0.2110	-0.0167
	Maximum	2.62	0.0340	0.2710
	Interquartile range	0.80	0.0675	0.0950
Drinking water outlet locations	Median	1.39	-0.0401	0.0371
	Minimum	-0.79	-0.2110	-0.0167
	Maximum	2.62	0.0179	0.0503
	Drinking water MCL	740	0.555	1.85

(a) A negative number means the sample radioactivity was less than the background radioactivity

5.5.3 Lake Haussmann Monitoring

Lake Haussmann, which was formerly called the Drainage Retention Basin, is an artificial water body that has a 45.6 million L (37 acre-feet) capacity. It is located in the central portion of the Livermore Site and receives storm-water runoff and treated groundwater discharges. LLNL initiated monitoring changes during the 2012 calendar year based on monitoring redundancy, regulatory drivers, and consistent historical data confirming water quality. LLNL revised the two wet and four dry season release samples per year to collect two wet season samples at CDBX, CDB, and CDB2 as currently performed under LLNL's Industrial Storm Water Program. Storm Water Compliance and Surveillance Monitoring information is in Section 5.3 of this report.

5.5.4 Site 300 Drinking Water System Discharges

LLNL currently maintains coverage under General Order R5-2013-0074-025, NPDES Permit No. CAG995001 for occasional large volume discharges from the Site 300 drinking water system that reaches surface water drainage courses. (Prior to 2013, this coverage was provided by the now superseded WDR R5-2008-0081.) The monitoring and reporting program that LLNL developed for these discharges was approved by the CVRWQCB. Discharges, with the potential to reach surface waters that are subject to these sampling and monitoring requirements are:

- Drinking water storage tank discharges
- System-flush and line-dewatering discharges
- Dead-end flush discharges
- Supply well W-18 intermittent operational discharges

Complete monitoring results from 2014 are detailed in the quarterly self-monitoring reports to the CVRWQCB. During the third quarter of 2014, LLNL conducted routine annual flushing of the drinking water system for water quality purposes. In accordance with the CVRWQCB requirements and the LLNL *Pollution Prevention and Monitoring and Reporting Program* (PPMRP), LLNL monitored one flush per pressure zone of drinking water discharged. All 2014 releases from the Site 300 drinking water system quickly percolated into the drainage ditches or streambed and did not reach Corral Hollow Creek, the potential receiving water.