5. Water Monitoring Programs

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Lawrence Livermore National Laboratory (LLNL) monitors water systems including 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 2016). 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 2017, the Livermore Site discharged an average of 1.2 million L/d (310,000 gal/d) of wastewater to the City of Livermore sewer system or 5.3% of the total flow into the City's system. This volume includes wastewater generated by Sandia National Laboratories/California (SNL) and a very small quantity from Site 300. In 2017, SNL generated approximately 14% of the total effluent discharged from the Livermore outfall. Wastewater from SNL 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 Wastewater Discharge Permit (Permit #1250) requirements administered by the Water Resources Division (WRD) of the City of Livermore, 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 Environmental Functional Area (EFA) Water Team Staff Wastewater Discharge Authorization Record (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 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 [denoted as DCSs by DOE]) 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 the WRD for LLNL. The WRD limit is smaller by a factor of 30 than the DOE monthly limit, so the limits are similar; 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 2017 combined release of alpha and beta sources was 0.445 GBq (0.012 Ci), which is 1.2% of the corresponding 10 CFR Part 20 limit (37 GBq [1.0 Ci]). The tritium total was 4.5 GBq (0.12 Ci), which is 2.43% of the 10 CFR Part 20 limit (185 GBq [5 Ci]).

Table 5-1. Estimated total radioactivity in LLNL sanitary sewer effluent, 2017.

Radioactivity	Estimate based on effluent activity (GBq)	MDC[(a)] (GBq)
Tritium	4.500	0.734
Gross alpha	0.006	0.092
Gross beta	0.439	0.083

(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 0.360 Bq/mL (9.73 pCi/mL) was far below the permit discharge limit of 12 Bq/mL (333 pCi/mL).

Complete calendar year 2017 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 2018 Report (Jones 2018). Cesium and plutonium results are from monthly composite samples of LLNL and LWRP effluent and from quarterly composites of LWRP sludge. For 2017, the annual total discharges of cesium-137 and plutonium-239 were far below the DOE DCSs. Plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The highest plutonium concentration observed in 2017 sludge is 0.2 mBq/g (0.005 pCi/g), which is many times lower than the National Council on Radiation Protection and Measurements (NCRP) recommended soil 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 2017, a total of 4.50 GBq (0.12 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, 2007–2017.

Year	Tritium (GBq)	Plutonium-239 (GBq)
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}
2015	2.21	1.10×10^{-5}
2016	0.64	$9.38 \text{ x } 10^{-6}$
2017	4.50	1.44×10^{-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 quarterly basis and analyzed for total toxic organic (TTO) compounds. Samples for cyanide and metals are collected quarterly. Results from LLNL's 2017 sanitary sewer effluent monitoring program are provided in **Appendix A**, **Section A.3**.

Table 5-3. Summary of analytical results for permit-specified monthly, 24-hour composite sampling of the LLNL sanitary sewer effluent, 2017.

Parameter (mg/L)	Detection frequency[(a)]	Minimum	Maximum	Median
Biochemical oxygen demand	12 of 12	30	250	76
Total dissolved solids	12 of 12	550	950	735
Total suspended solids	12 of 12	18	300	80

(a) The number of times an analyte was positively identified, followed by the number of samples that were analyzed.

As previously noted, grab samples of LLNL's sanitary sewer effluent are collected monthly for TTO analysis (permit limit = 1.0 mg/L) and quarterly for cyanide and metals analysis. In 2017, LLNL did not exceed any of these discharge limits. Results from the monthly TTO analyses for 2017 show that no priority pollutants, listed by the U.S. Environmental Protection Agency (EPA) as toxic organics, were identified in LLNL effluent above the 10 µg/L permit-specified reporting limit. 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.

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 Permit #1250.

The processes at LLNL that are determined to be regulated under the Categorical Standards may change as programmatic requirements dictate. Categorical processes identified at LLNL (from both the Metal-Finishing Category, 40 CFR 433, and the Electrical and Electronic Components Category, 40 CFR 469) are listed in Permit #1250.

Only processes that discharge to the sanitary sewer require semiannual sampling, inspection, and reporting. During 2017, 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 2017, 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 2017 and January 2018 Semiannual Wastewater Point-Source Monitoring Reports (Rosene, 2017; 2018).

In addition, WRD source control staff performed their required annual inspection and sampling of the two discharging categorical processes in October 2017. 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 and reported in the Semiannual Wastewater Point-Source Monitoring Report. Currently, wastewater from these processes are either recycled onsite or contained for eventual removal and appropriate disposal by Radioactive and Hazardous Waste Management (RHWM).

5.1.3 Discharges of Treated Groundwater

LLNL's groundwater discharge permit (1510G, 2017–2018) allows treated groundwater from the Livermore Site Ground Water Project (GWP) to be discharged in the City of Livermore sanitary sewer system (see **Chapter 7** for more information on the GWP). During 2017, there were no discharges (from on-site-or off-site locations) to the sanitary sewer from the Environmental Restoration Department GWP activities. When such discharges occur, permit compliance is maintained by Treatment Facility Operators through the systematic use of engineering and administrative controls, including WDARs generated for each discharge. This information is reported to the City of Livermore.

5.1.4 Environmental Impact of Sanitary Sewer Effluent

During 2017, 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.

The data demonstrate that LLNL continues to have excellent control of both radiological and nonradiological discharges to the sanitary sewer. Monitoring results for 2017 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 were collected from the influent to the Site 300 sewage evaporation pond at a location internal to the evaporation pond itself, and at the effluent from the evaporation pond prior to flow to the sewage percolation pond. All samples were obtained in accordance with the written, standardized procedures summarized in Gallegos (2016).

5.2.1 Sewage Evaporation and Percolation Ponds

Sanitary effluent (nonhazardous wastewater) generated at buildings in the General Services Area at Site 300 is managed in 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 2017.

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 2017 semi-annual and annual reports shows compliance with all MRP and permit conditions and limits (Blake 2018). 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 2018).

5.3 Storm Water Compliance and Surveillance Monitoring

The State Water Quality Control Board issued a new Storm Water Industrial General Permit (IGP) (2014-0057-DWQ) that took effect July 1, 2015. LLNL modified the storm water monitoring plan for both sites to achieve compliance with this new permit. Storm water monitoring at both sites also follows the requirements in the U.S. DOE handbook *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 2015) 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. See **Figure 5-1** for storm water sampling locations.

For construction projects that disturb one acre of land or more, LLNL also meets storm water compliance monitoring requirements of the California National Pollutant Discharge Elimination System (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.

Under the industrial storm water permit, LLNL is required to collect and analyze samples at specified locations two times during the period from July 1 to December 31 and two times during the period from January 1 to June 30, if specific criteria are met and the sampling window coincides with regular working hours. The State storm water reporting period is offset from the reporting period in this *Environmental Report*. Although runoff samples were collected from all 5 storm water locations at the Livermore Site for only 3 events during 2017, LLNL was successful in collecting the required 4 samples during both the 2016-2017 and the 2017-2018 State IGP reporting periods. Samples were collected at Site 300 from location EWTF on February 9, and both EWTF and 883W on November 16, 2017. All other precipitation events at Site 300 during 2017 were not qualifying and could not be sampled in compliance with the permit. LLNL is required to visually inspect the storm drainage system during up to four qualifying storm events to observe runoff quality and once each month during dry periods to identify any dry weather flows. Annual facility inspections are performed to ensure that the Best Management Practices (BMPs) for controlling storm water pollution are implemented and adequate.

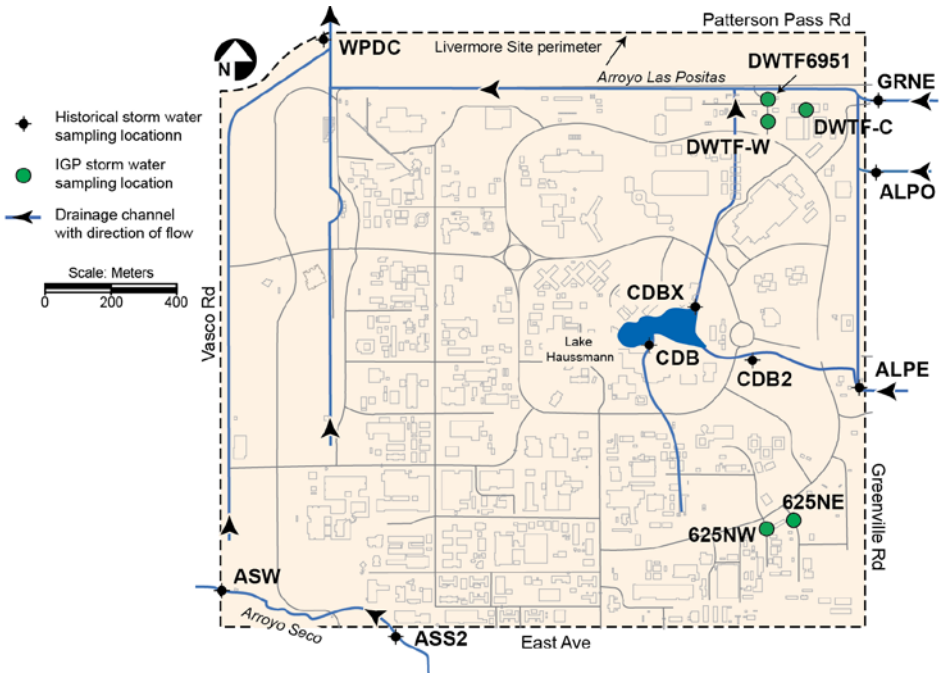

Figure 5-1. Storm water sampling locations, Livermore Site, 2017

5.3.1 Storm Water Inspections

Each principal directorate at LLNL conducts an annual inspection of its facilities to verify implementation of BMPs and to ensure that those measures are adequate. LLNL's principal associate directors identified some minor corrections to the BMPs and certified in 2017 that their facilities complied with the provisions of LLNL's Storm Water Pollution Prevention Plans (SWPPPs). LLNL submits storm water analytical results to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) and to the CVRWQCB through an online database called the Storm Water Multiple Application and Report Tracking System (SMARTS) for each Qualifying Storm Event (QSE).

For each construction project permitted by Order Number 2009-0009-DWQ, LLNL or designated subcontractors conduct visual monitoring of construction sites before, during, and after storms to assess the effectiveness of the BMPs. Annual compliance certifications, if necessary, summarize the inspections.

5.3.2 Storm Water Compliance

LLNL is required to meet the requirements of the new IGP. There are two types of Numeric Action Levels (NALs) in the new permit.

Annual NAL exceedance – occurs when the average of all the analytical results for a parameter from samples taken within a reporting year exceeds an annual NAL value for that parameter.

Instantaneous maximum NAL exceedance – occurs when two or more analytical results for Total Suspended Solids (TSS), Oil and Grease (O&G) or pH from samples taken within a reporting year exceed the instantaneous maximum NAL value (or are outside the NAL pH range).

An NAL exceedance is determined as follows:

a. For annual NALs, an exceedance occurs when the average of all analytical results from all samples taken at a facility during a reporting year for a given parameter exceeds an annual NAL value listed in Table 2 of this General Permit; or,

b. For the instantaneous maximum NALs, an exceedance occurs when two or more analytical results from samples taken for any parameter within a reporting year exceed the instantaneous maximum NAL value (for Total Suspended Solids, and Oil and Grease), or are outside of the instantaneous maximum NAL range (for pH) listed in Table 2 of this General Permit.

During calendar year 2017, LLNL exceeded an Instantaneous NAL for pH at the Livermore Site at 625 NE and 625 NW. Please refer to **Appendix A, Tables A.4.1** to **A.4.4**. Both the Livermore Site and Site 300 remain at Exceedance Response Action Level 2 for magnesium. LLNL has provided data and analysis that show the exceedance of magnesium is due to aerial deposition from natural sources, not industrial activities at LLNL.

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

A full report of storm water runoff samples for the January 1, 2017 to June 30, 2017 is available in the 2017 Annual Storm Water Reports for the Livermore Site and Site 300 in SMARTS. A report of storm water compliance for the Livermore Site and Site 300 from July 1, 2017 to December 31, 2017 will be available in SMARTS after July 15, 2018.

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 Comprehensive Environmental Response, Compensation and Liability Act (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 2016).

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 2-2** 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 Resource Conservation and Recovery Act (RCRA) closure, and their monitoring networks.

During 2017, 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 2016). 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 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 (maximum contaminant levels [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 2017 from 15 of 17 water wells in the Livermore Valley (see **Figure 5-2**) and measured for tritium activity. Wells 16B1 and 17D12 were out of service and could not be sampled.

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 estimated off site was in the groundwater at well 12D2, located about 9.0 km (5.6 mi) west of LLNL (see **Figure 5-2**). The estimated activity there was less than 3.4±2.9 Bq/L (91.9 pCi/L) in 2017, less than 0.5% of the MCL.

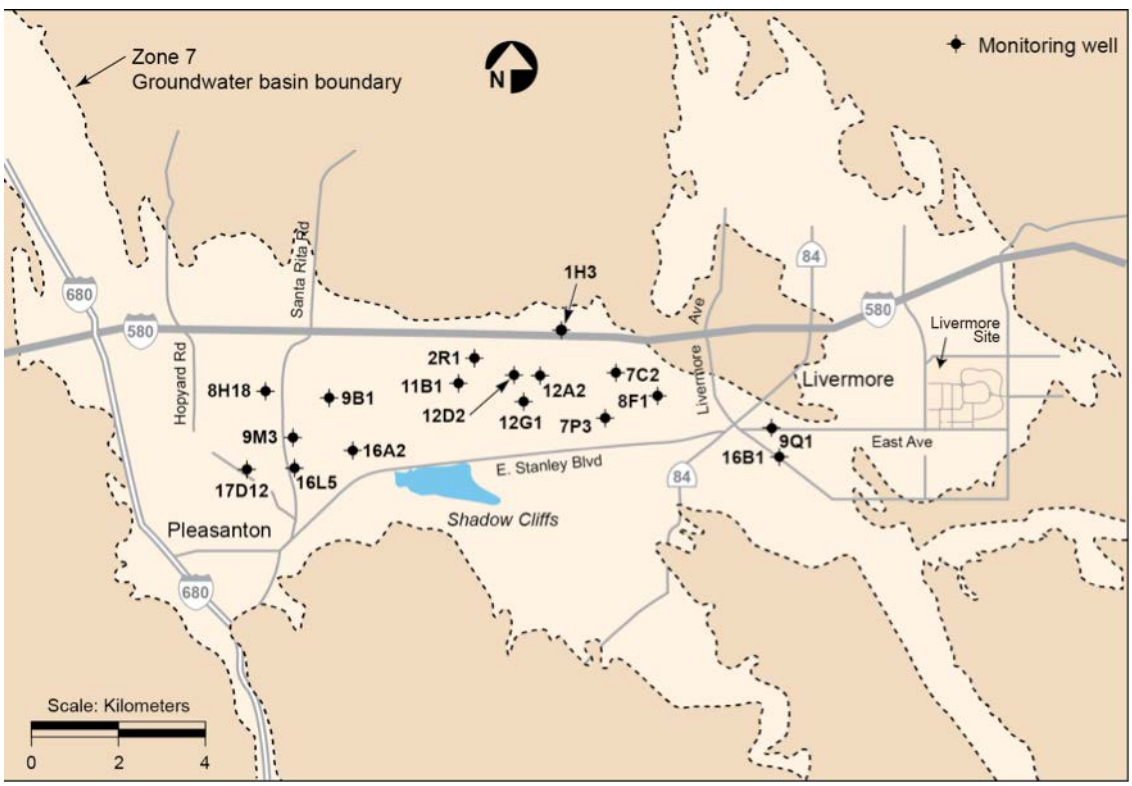

Figure 5-2. Off-site tritium monitoring wells in the Livermore Valley, 2017

5.4.1.2 Livermore Site Perimeter

LLNL's groundwater surveillance monitoring program was designed to complement the Livermore Site 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 5-3**). As discussed in **Chapter 7**, the alluvial sediments have been divided into nine hydrostratigraphic units (HSUs), which are water bearing zones that exhibit similar hydraulic and geochemical properties. The nine HSUs dip 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 2017 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 2017 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 2017 sample from this location showed a concentration of 39 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 2017 from the nearby wells W-556 and W-1012, also along the western perimeter of the LLNL Site, showed chromium (VI) concentrations of 19 µg/L and 10 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 2017 sample from this well (21 mg/L) was again, as in the past 12 years, below the MCL. During 2017, concentration of nitrate in the on-site shallow background well W-221 was 37 mg/L. Detected concentrations of nitrate in western perimeter wells ranged from 12 mg/L (in well W-373) to 47 mg/L (in wells 14B1 and W-151), a range consistent with results reported in previous years.

During 2017, 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.

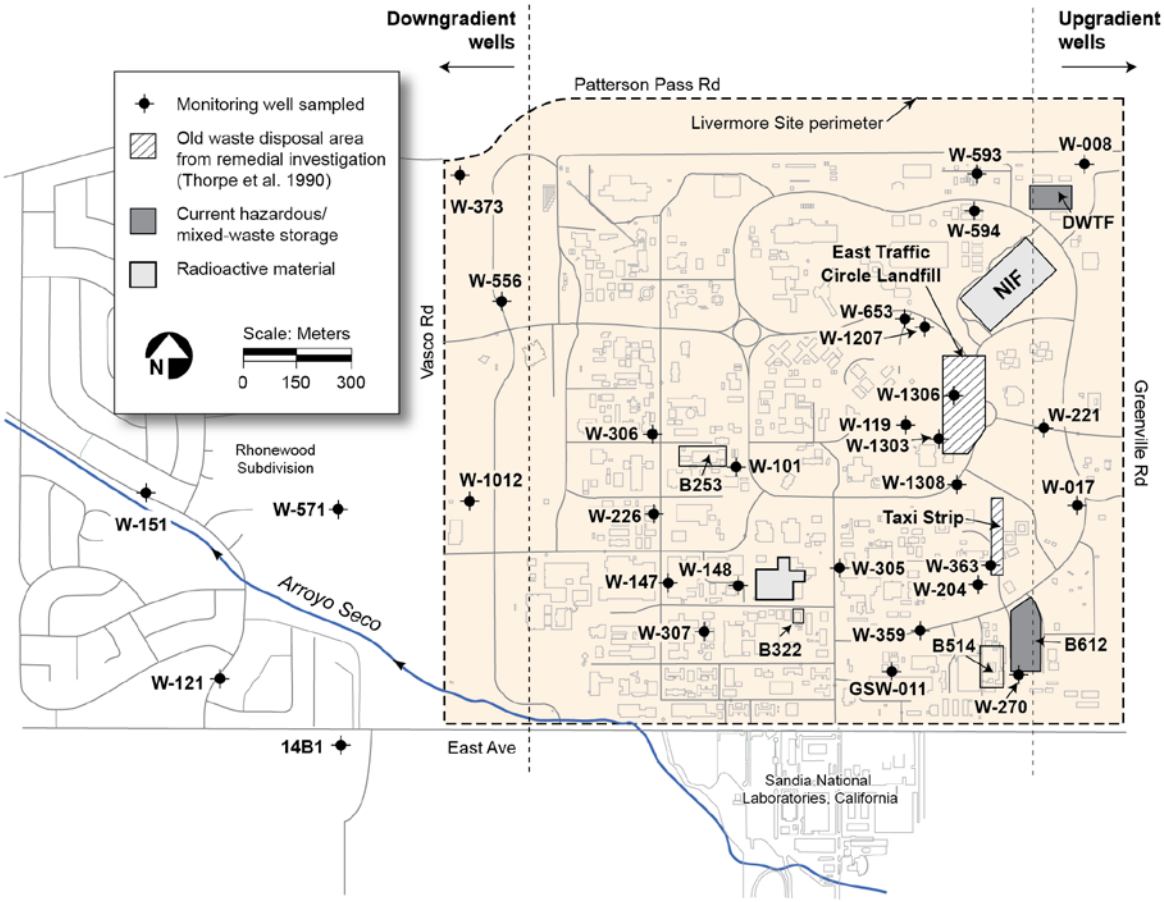

Figure 5-3. Routine surveillance groundwater monitoring wells at the Livermore Site, 2017.

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 5-3**. All analytical results are provided in **Appendix A**, **Section A.5**.

The Taxi Strip and East Traffic Circle Landfill areas (see **Figure 5-3**) 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 2017 for copper, lead, zinc, and tritium. Samples from monitoring wells screened at least partially in HSU-2 (W-119, W-1207, 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 2017.

Near the National Ignition Facility (NIF), LLNL measures pH, conductivity, and tritium concentration of nearby groundwater to establish a baseline. During 2017, 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 Decontamination and Waste Treatment Facility (DWTF) from wells W-593 and W-594 (screened in HSU-3A and HSU-2, respectively) during 2017 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 2017.

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 2017, 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 2017.

Groundwater samples are obtained annually 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 2017, concentration of metals at well W-307 were within typical concentrations reported in recent years. The concentration of manganese in 2017 (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 2017, 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

through 2016, well W-101 was dry and could not be sampled in 2017. 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 2017 have shown significantly lower values—a downward trend ranging from approximately one-quarter to one-half 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 concentrations 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 2017 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 5-4**). 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 connect 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 have 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 **Chapter 7** for a review of groundwater monitoring in this drainage area conducted under CERCLA.)

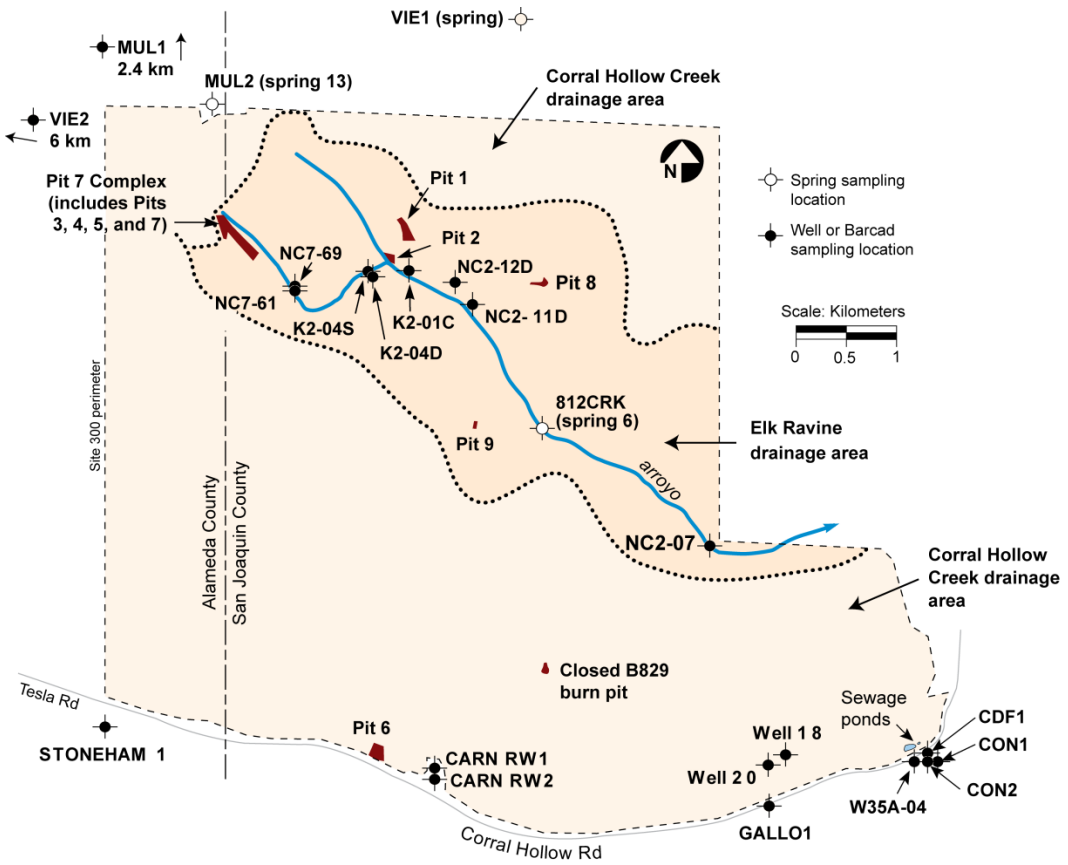

Figure 5-4. Surveillance groundwater wells and springs at Site 300, 2017.

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 Record of Decision (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 2017 LLNL obtained annual or more frequent groundwater samples from the Pit 7 detection monitoring well network. Samples were analyzed for tritium, volatile organic compounds (VOCs), fluoride, high explosive compounds (HMX and RDX), nitrate, perchlorate, uranium (isotopes or total), metals, lithium, and polychlorinated biphenyls

(PCBs). A detailed account of Pit 7 compliance monitoring during 2017, including well locations, maps of the distribution of COCs in groundwater, and analytical data tables is summarized in Dibley et al. (2009).

Elk Ravine. Groundwater samples were obtained on various dates in 2017 from the widespread Elk Ravine surveillance monitoring network shown in **Figure 5-4** (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 2017. 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 580 Bq/L in 2017, compared to the higher value of 680 Bq/L in 2016. 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 2017 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 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 2017 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 2017; a detailed account of Pit 1 compliance monitoring during 2017, including well locations and tables and graphs of groundwater COC analytical data, is in Blake (2018).

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 2017 from specified Pit 6 monitoring wells. Groundwater wells were analyzed for VOCs, tritium, beryllium, mercury, total uranium, gross alpha/beta, perchlorate, and nitrate.

During 2017, no new releases were detected at Pit 6. A detailed account of Pit 6 compliance monitoring during 2017, 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 2018).

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 DTSC (2017). As planned for compliance purposes, LLNL obtained groundwater samples during 2017 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 gross beta).

During 2017, there were no 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-829-1915 (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 is less than one-quarter of 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. Elevated barium concentrations were reported in groundwater samples collected at well W-829-1938; however, the statistical limit was not exceeded. Typically, at well W-829-1938, barium concentrations are between the reporting limit (25 μg/L) and the statistical limit (30 μg/L). LLNL will continue to track these results as additional data become available.

There were no organic or explosive COCs detected above reporting limits in any samples. 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 2017, including well locations and tables and graphs of groundwater COC analytical data, see Diaz (2018).

Water Supply Well. Water supply well 20, located in the southeastern part of Site 300 (**Figure 5-4**), 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 2017 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 2017 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 5-4)**. 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 2017 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 gross 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 was detected at the off-site locations, well VIE1 at a value of 14 ppb, slightly over the MCL of 10 ppb. LLNL will continue to monitor this well for arsenic.

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

Because air moisture containing HTO is rapidly entrained and washed out locally during rain events, rainwater is collected in rain gauges at fixed locations at both the Livermore Site and Site 300 to provide information about storms that are sampled for runoff. The collected rainwater is analyzed for tritium activity by EPA Method 906.0, which is a liquid scintillation counting method. The tritium activity of each sample is measured and the analytical results compared to the EPA drinking water MCL of 740 Bq/L (20,000 pCi/L) for tritium. In calendar year 2017, the rain gauges were placed at the sample locations SALV, MET, DWTF, and SECO at the Livermore Site as shown in **Figure 5-5**. The samples for calendar year 2017 were collected after the January, March, and November storms.

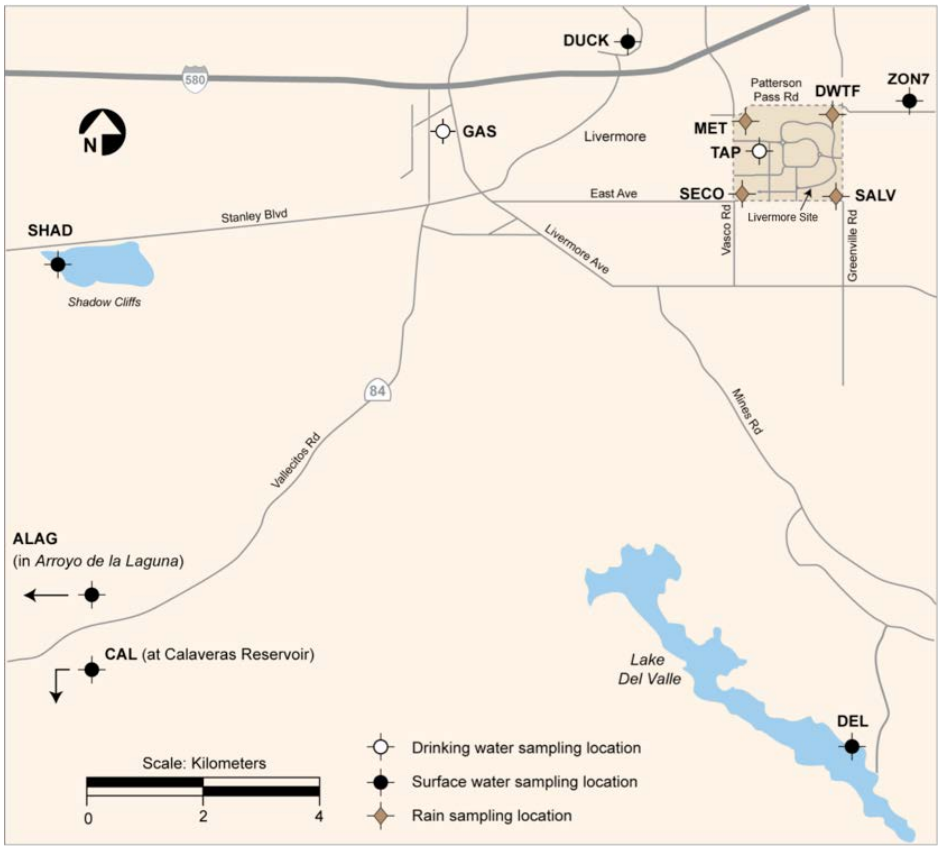

Figure 5-5. Livermore Site and Livermore Valley sampling locations for rain, surface water, and drinking water, 2017.

The highest measured tritium activity, 3.7 Bq/L, was for the March 22 storm and was measured at the SECO location. This activity is less than 1% of the EPA established drinking water standard. All analytical results are provided in **Appendix A, Section A.7**.

In calendar year 2017, LLNL collected samples at three on-site locations at Site 300, ECP, PSTL, and GOLF (see **Figure 5-6**) for both the January and March storms. All of the sample locations for both storms were non-detections for tritium. All analytical results are provided in **Appendix A, Section A.7**.

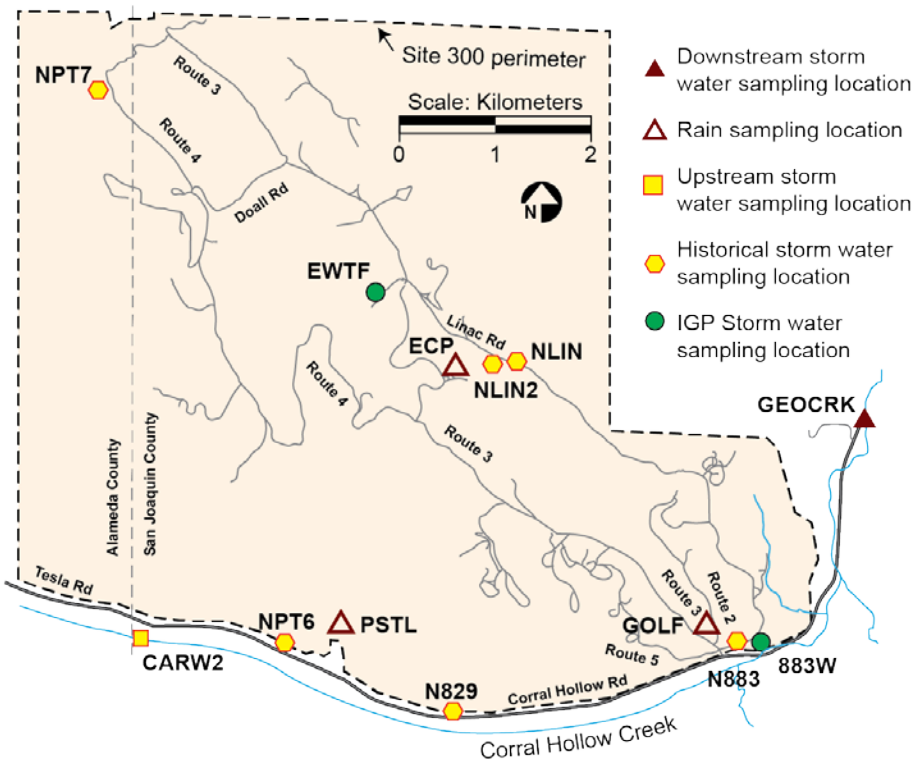

Figure 5-6. Storm water and rainwater sampling locations at Site 300, 2017.

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 5-5** in 2017. Off-site sampling locations DEL, DUCK, ALAG, SHAD, and ZON7 are surface water bodies; of these, 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 (2016). LLNL sampled the two drinking water outlets semiannually and the other locations annually in 2017. 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 2017 was 3.02 Bq/L 81.6 pCi/L), less than 1% of the drinking water MCL. Median activities for gross alpha and gross beta radiation in all water samples were less than 6% of their respective MCLs. 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 activities detected for gross alpha and gross beta occurred in samples collected at DEL (gross alpha at 0.1140 Bq/L [3.08 pCi/L]) and ALAG (gross beta at 0.1430 Bq/L [3.86 pCi/L]). These maximum values were less than 21% and 10% of their respective gross alpha and gross beta drinking water MCLs (see **Table 5-4**).

Table 5-4. Radioactivity in surface and drinking waters in the Livermore Valley, 2017.

Location	Metric	Tritium (Bq/L)[(a)]	Gross alpha (Bq/L)[(a)]	Gross beta (Bq/L)[(a)]
All locations	Median	0.91	0.0268	0.0803
	Minimum	-0.80	-0.0392	0.0388
	Maximum	3.02	0.1140	0.1430
	Interquartile range	1.75	0.0570	0.0440
Drinking water outlet locations	Median	-0.07	0.0068	0.0563
	Minimum	-0.80	-0.0392	0.0388
	Maximum	0.70	0.0881	0.1080
	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, formerly the Drainage Retention Basin, is an artificial water body that has a 45.6 million L (37 acre-feet) capacity. It is in the central portion of the Livermore Site and receives storm-water runoff and treated groundwater discharges. LLNL continues to modify monitoring of Lake Haussmann based on changing regulatory drivers. In 2015, LLNL discontinued sampling at Lake Haussmann as part of LLNL's adjustments to Livermore Site sampling to meet the requirements of the most recent California Industrial General Permit for storm water discharges. Storm Water Compliance and Surveillance Monitoring information is in **Section 5.3**.

5.5.4 Site 300 Drinking Water System Discharges

In 2017, LLNL maintained 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 reach surface water drainage courses. 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 2017 are detailed in the quarterly self-monitoring reports to the CVRWQCB. All 2017 releases from the Site 300 drinking water system quickly percolated into the drainage ditches or dry streambeds and did not reach Corral Hollow Creek, the potential receiving water.