5. Water Monitoring Programs

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Lawrence Livermore National Laboratory (LLNL) monitors water systems including wastewater, storm water, and groundwater, as well as rainfall and local surface water. Water systems at the Livermore Site and Site 300 operate differently. For example, the Livermore Site is serviced by a publicly owned treatment works (POTW), but Site 300 is not. Therefore, each site treats and disposes of sanitary wastewater differently. 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 sampling media (LLNL's *Environmental Monitoring Plan*, Brunckhorst 2019). Sampling plans are prepared by the LLNL network analysts who are responsible for developing and implementing monitoring programs or networks. Network analysts determine the sampling analytes and 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 2022, the Livermore Site discharged an average of 886,223 L/d (234,141 gal/d) of wastewater to the City of Livermore sewer system or 4.4% 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 2022, SNL generated approximately 6.4% 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. 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 by 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

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

Department of Energy (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 included in sections of DOE Order 458.1.

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. The Derived Concentration Standards (DCS), which complement DOE Order 458.1, limit the concentration of each radionuclide discharged to publicly owned treatment works. If the measured monthly average concentration of a radioisotope exceeds its limit, LLNL is required to improve discharge control measures until concentrations are below the DOE limits.

The DOE Order 458.1 requirements to control discharges into sanitary sewers include the following annual discharge limits: 185 GBq (5 Ci) tritium, 37 GBq (1 Ci) carbon-14, or 37 GBq (1 Ci) all other radionuclides combined. 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 2022 combined release of alpha and beta sources was 0.193 GBq (0.005 Ci), which is 0.52% of the corresponding DOE Order 458.1 limit (37 GBq [1.0 Ci]). The total tritium activity was 1.867 GBq (0.050 Ci), which is 1.01% of the DOE Order 458.1 limit (185 GBq [5 Ci]).

Table 5-1. Estimated Total Radioactivity in LLNL Sanitary Sewer Effluent, 2022

Radioactivity	Estimate based on effluent activity (GBq)	MDC[(a)] (GBq)
Tritium	1.867	0.713
Gross alpha	0.023	0.052
Gross beta	0.170	0.037

(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 was 0.059 Bq/mL (1.60 pCi/mL).

Calendar year 2022 data for measured concentrations of cesium-137 and plutonium-239 in the sanitary sewer effluent from LLNL and the LWRP, and plutonium-239 in LWRP sludge are reported in the LLNL January and February 2023 Reports (Rosene 2023b; 2023c). Cesium and plutonium results are from monthly composite samples of LLNL and LWRP effluent and from quarterly composites of LWRP sludge. For 2022, the annual total discharges of cesium-137 and plutonium-239 were significantly below the DOE DCSs. Plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The highest plutonium concentration observed in 2022 sludge was 0.133 mBq/g (0.0036 pCi/g), which is many times lower than the American National Standards Institute (ANSI) recommended screening level of 100 mBq/g (3 pCi/g) for volumetric radioactivity (ANSI 2013).

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 2022, a total of 1.867 GBq (0.050 Ci) of tritium was discharged to the sanitary sewer. This amount is similar to historical values, well within regulatory limits, and fully protective of the environment.

Table 5-2. Historical Radioactive Liquid Effluent Releases from the Livermore Site, 2012 – 2022

Year	Tritium (GBq)	Plutonium-239+240 (GBq)
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	9.38×10^{-6}
2017	4.50	1.44×10^{-5}
2018	5.46	8.7×10^{-6}
2019	5.54	2.01×10^{-5}
2020	8.01	7.99×10^{-6}
2021	3.67	2.27×10^{-5}
2022	1.87	4.46×10^{-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. Effluent flow-proportional composite samples are collected on a daily (midnight-to-midnight), weekly (Thursday through Wednesday), monthly (composited from daily), and quarterly (composited from daily) basis; effluent grab samples are also collected each month, once per quarter, and annually. All samples are collected continuously throughout the year. Results from LLNL's 2022 sanitary sewer effluent monitoring program are provided in **Appendix A, Section A.3.** A summary of the analytical results from the permit-specified weekly composite sampling program is presented in **Table 5-3.**

Table 5-3. Summary of Analytical Results for Permit-Specified 24-hour Composite Sampling of the LLNL Sanitary Sewer Effluent, 2022

Parameter (mg/L)	Detection Frequency[(a)]	Minimum	Maximum	Median
Biochemical Oxygen Demand (BOD)	52 of 52[(b)]	19	170	64
Total Suspended Solids (TSS)	52 of 52[(b)]	17	220	34
Total Dissolved Solids (TDS)	12 of 12[(b)]	260	1,100	395

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

(b) BOD and TSS samples are taken weekly. TDS is sampled monthly.

The permit requires monthly grab samples of effluent to be analyzed for total toxic organic (TTO) compounds (permit limit = 1.0 mg/L). In 2022, LLNL did not exceed any of these discharge limits. Results from the monthly TTO analyses for 2022, provided in **Appendix A, Section A.3,** show that one priority pollutant, chloroform, which is listed by the U.S. Environmental Protection Agency (EPA) as a toxic organic, was identified in LLNL effluent above the 10 µg/L permit-specified reporting limit. 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 they have 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 2022, two processes discharged wastewater to the sanitary sewer: semiconductor processes located in the Building 153 microfabrication processing laboratories and the abrasive jet machining located in Building 161. In 2022, LLNL analyzed compliance samples for all regulated parameters from both processes and demonstrated compliance with all federal categorical and local discharge limits. As an additional environmental safeguard, LLNL sampled the wastewater in each Building 153 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 2022 and January 2023 Semiannual Wastewater Point-Source Monitoring Reports (Rosene 2022; 2023a). WRD source control staff performed their required annual inspection and sampling of the Building 153 categorical processes in October 2022. 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 is either recycled on-site, pumped out by a third-party vendor and taken to a centralized waste treatment facility for disposal, or contained for eventual removal and appropriate disposal by LLNL's Radioactive and Hazardous Waste Management (RHWM).

5.1.3 Discharges of Treated Groundwater

LLNL's groundwater discharge permit (1510G, 2021–2025) allows treated groundwater from the Livermore Site Ground Water Project (GWP) to be discharged to the City of Livermore sanitary sewer system (see **Chapter 7** for more information on the GWP). During 2022, there were no discharges (from on-site or off-site locations) to the sanitary sewer from the Environmental Restoration Department's 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 2022, 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 2022 reflect an effective year for LLNL's wastewater discharge control program and indicate no adverse impact to the LWRP or to the environment from LLNL sanitary sewer discharges.

5.2 Site 300 Sewage Ponds and Site 300 Waste Discharge Requirements

Wastewater grab samples were collected for Waste Discharge Requirements (WDR) Order No. R5-2008-0148. This network includes the sewage evaporation and percolation ponds, mechanical equipment discharges to percolation pits, cooling tower discharges to percolation pits, and septic systems as shown in **Figure 5-1.**

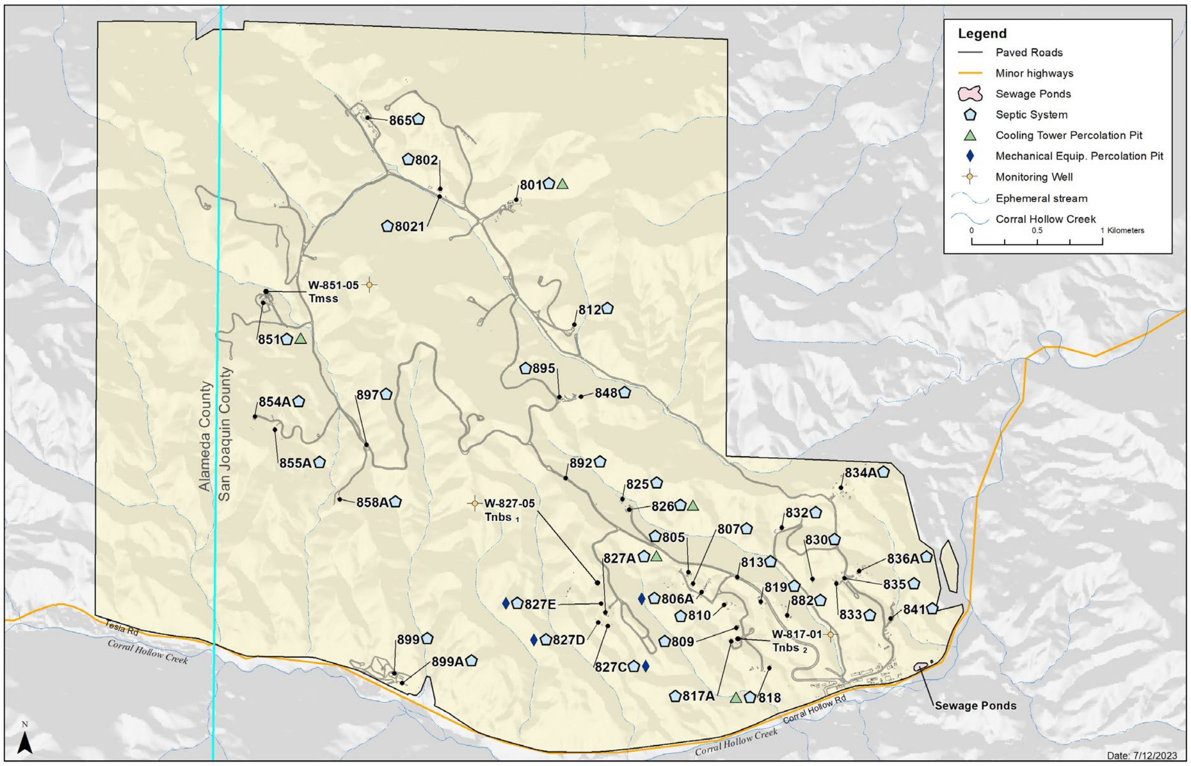

Figure 5-1. WDR-R5-2008-0148 Monitoring Network, 2022

The Site 300 sewage evaporation pond is sampled semiannually at two locations—within the evaporation pond and at the effluent from the evaporation pond prior to flow to the sewage percolation pond. All samples were collected in accordance with the standardized procedures summarized in Brunckhorst (2019).

5.2.1 Sewage Evaporation and Percolation Ponds

Sanitary effluent (nonhazardous wastewater) generated at buildings in the General Services Area (GSA) at Site 300 is managed in an evaporation pond lined with catalytically-blown asphalt. Occasionally, during winter rains when the minimum 12 inches of freeboard depth cannot be maintained, treated wastewater from the sewage evaporation pond may be released into an unlined percolation pond to the east where it enters the ground and the shallow groundwater. Although this potential exists, it did not occur during 2022.

In September 2008, the Central Valley Regional Water Quality Control Board (CVRWQCB) replaced WDR 96-248 with WDR R5-2008-0148. Under the terms of the Monitoring and Reporting Program (MRP) No. R5-2008-0148, LLNL submits semiannual and annual monitoring reports detailing Site 300 discharges of domestic and wastewater effluent to sewage evaporation and percolation ponds in the GSA, mechanical equipment discharges to percolation pits, cooling tower discharges to percolation pits, septic system discharges, and other low-threat discharges to the ground.

The monitoring data collected for the 2022 semiannual and annual reports complied with all MRP conditions and permit requirements (Thomas 2023). 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 (Thomas 2023).

5.3 Storm Water Compliance and Surveillance Monitoring

The current Storm Water Industrial General Permit (IGP) (2014-0057-DWQ) issued by the State Water Resources Control Board (SWRCB) took effect July 1, 2015 (SWRCB 2014). To achieve compliance, LLNL modified the storm water monitoring plan for both sites. 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. See **Figures 5-2** and **5-3** for storm water sampling locations for the Livermore Site and Site 300, respectively.

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 and Land Disturbance Activities (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 IGP, LLNL is required to collect and analyze storm water runoff 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*. Runoff samples were collected for three storm events from all five required storm water locations at the Livermore Site on April 21, November 1, and December 1, 2022. Runoff samples were collected for one storm event at Building 883 at Site 300 on April 19, 2022. All other precipitation events at the Livermore Site and Site 300 during 2022 were not qualifying and/or could not be sampled in compliance with the IGP. LLNL is required to visually inspect the storm drainage system up to four times during 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 adequate Best Management Practices (BMPs) are implemented to control storm water pollution.

The CVRWQCB issued a Water Code Section (WCO) 13267 Order for *Submittal of Technical and Monitoring Reports for The Active Building 851 Firing Table, Lawrence Livermore National Laboratory Site 300, San Joaquin County*, requesting a sediment and storm water runoff monitoring program during the Building 851 Firing Table operational period at Site 300.

Under the WCO, LLNL is required to collect a storm water runoff sample and a sediment sample annually, analyze samples for constituents of concern, and report the sampling results to the CVRWQCB (Abri 2021). Only sediment samples were collected from Building 851 on May 12, and May 25, 2022. No runoff producing storm events occurred during the reporting period. See **Figure 5-3** for storm water and sediment sampling location for the Building 851 sample location.

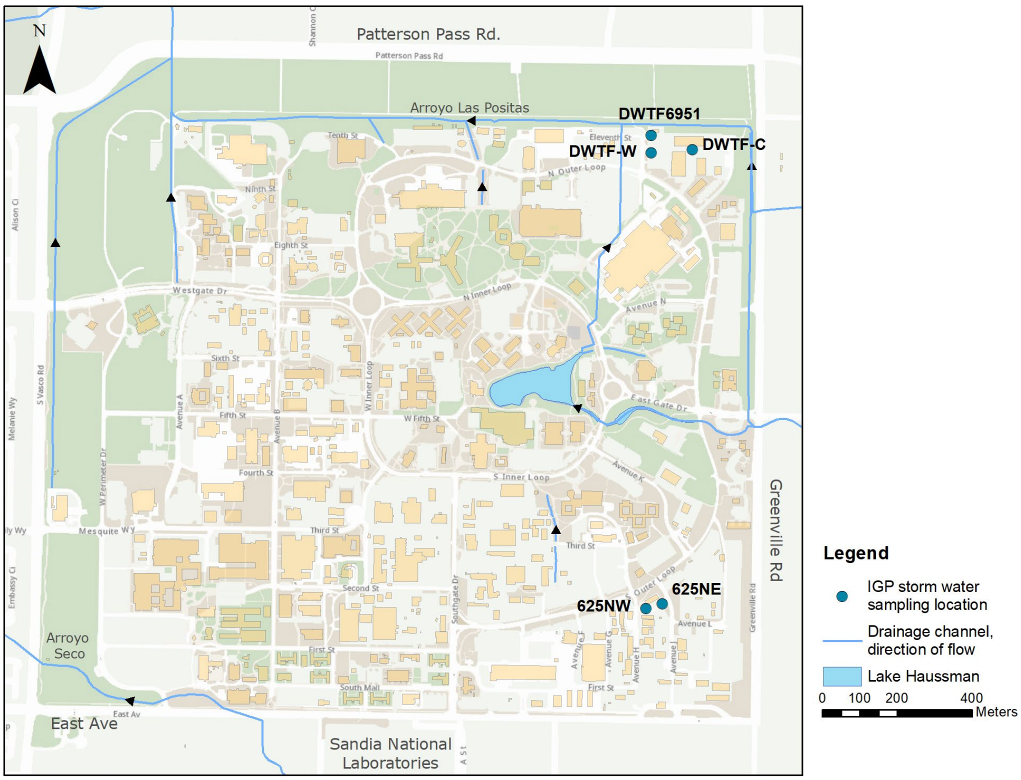

Figure 5-2. Storm Water Sampling Locations at the Livermore Site, 2022

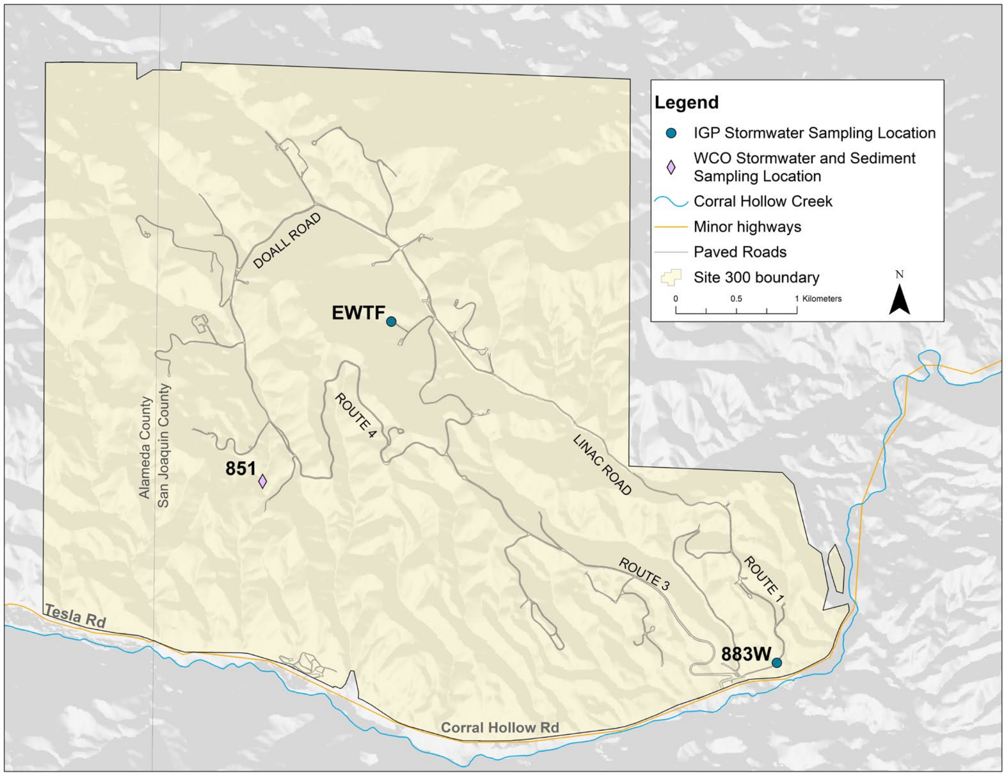

Figure 5-3. Storm Water Sampling Locations at Site 300, 2022

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 corrections to the BMPs and certified that their facilities complied with the provisions of LLNL's Storm Water Pollution Prevention Plans (SWPPPs) in 2022. 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 must meet the requirements of the IGP, which identifies two types of Numeric Action Levels (NALs).

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 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 the General Permit; or

b. For 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 TSS and O&G) or are outside of the instantaneous maximum NAL range (for pH) listed in Table 2 of the General Permit.

Please refer to **Appendix A, Tables A.4.1** to **A.4.5** for storm water sample analytical results. 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. Site 300 remains at Exceedance Response Action Level 1 for TSS due to an Annual NAL exceedance during the 2019-2020 reporting year. BMPs were implemented in 2020 to reduce TSS in storm water runoff at both Site 300 sampling locations. The storm water runoff sample taken at Site 300 on April 19, 2022 is the second sample below the TSS NAL. To return Site 300 to Baseline Status, two more samples below the TSS NAL are required.

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

A full report of storm water runoff samples for January 1, 2022 to June 30, 2022 is included in the 2021-2022 Annual Storm Water Report for the Livermore Site and in SMARTS for Site 300. A report of storm water compliance for the Livermore Site and Site 300 from July 1, 2022 to December 31, 2022 will be available in SMARTS after July 15, 2023.

Please refer to **Appendix A, Tables A.4.1** to **A.4.5** for sediment sample analytical results.

A full report of sediment sampling for 2022 is available in the Building 851 Firing Table Sediment Monitoring Report in GeoTracker.[1] A report of sediment compliance for Building 851 Firing Table will be available in GeoTracker after July 15, 2023.

1 GeoTracker is the SWRCB's data management system for sites that impact, or have the potential to impact, water quality in California, with an emphasis on groundwater. https://geotracker.waterboards.ca.gov/

5.4 Groundwater

LLNL conducts surveillance groundwater monitoring in the Livermore Valley and at Site 300 through networks of wells and springs that include off-site private wells and on-site 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 detect 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* (Brunckhorst 2019).

In 2009, LLNL implemented a CERCLA comprehensive compliance monitoring plan at Site 300 (Dibley et al. 2009) to fulfill DOE and regulatory requirements for on-site groundwater surveillance. LLNL also monitors two surveillance networks to supplement the CERCLA compliance monitoring 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), monitoring frequency, inspection schedule, and reporting requirements. 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 2022, 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 include sampling techniques and information about groundwater monitoring parameters. Different sampling techniques were employed at 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 2022 from 11 of 15 wells in the Livermore Valley (see **Figure 5-4**) and measured for tritium concentration. Wells 11B1 and 12G1 were not sampled in 2022 because they were offline at the time of sampling. Additionally, Well 17D12 was not sampled in 2022 because it was inadvertently removed from the sampling schedule. Well 17D12 has been added back to the sampling schedule and is planned to be sampled in 2023. Although Well 7C2 was sampled, the container broke in transit to the laboratory and no analytical results were able to be processed.

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) drinking water MCL. The maximum tritium concentration estimated off-site was in the groundwater at well 2R1, located approximately 12.9 km (8 mi) west of LLNL (see **Figure 5-4**). The estimated activity at well 2R1 was 0.8 ± 2.6 Bq/L (21.6 pCi/L) in 2022 which is less than 0.15% of the MCL.

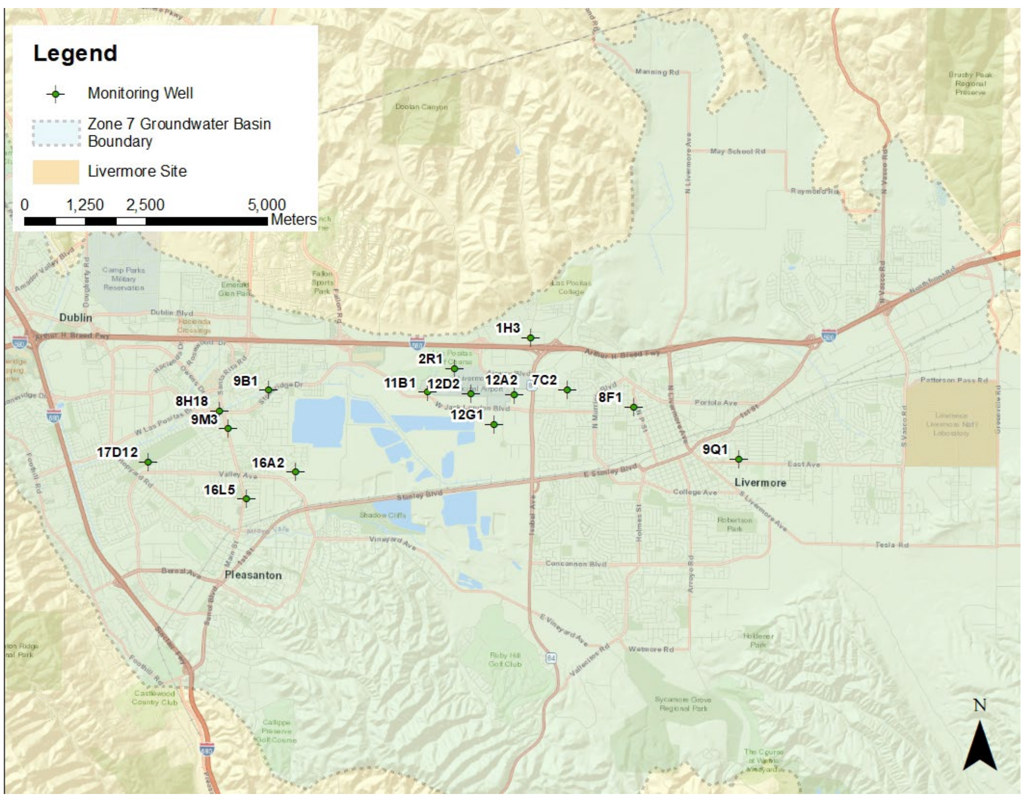

Figure 5-4. Off-Site Tritium Monitoring Wells in the Livermore Valley, 2022

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 consists of 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 5-5**). 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 2022 for general minerals (including nitrate) and for certain radioactive constituents (gross alpha, gross beta, and tritium). In 2022, wells W-556 and W-008 were not sampled due to pump failures. 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 2022 groundwater samples from the upgradient wells represent current background values.

Historically, hexavalent chromium has been detected above the MCL (50 µg/L) in groundwater samples from western perimeter well W-373. However, concentrations of this analyte started dropping below the MCL in 2002. Except for 2006, hexavalent chromium levels at well W-373 have been below the MCL from 2002–2022. The 2022 sample from this location had a concentration of 27 µg/L, which is consistent with the range of hexavalent chromium concentrations (5 µg/L to 52 µg/L) detected at well W-373 since 2002. The groundwater sample collected in 2022 from the nearby well W-1012, also along the western perimeter of the Livermore Site, showed a hexavalent chromium concentration of 8 µg/L. The other well along the western perimeter of the Livermore Site, W-556, was not sampled in 2022 due to a pump failure.

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 2022 sample from this well (21 mg/L) was again, as in the past 17 years, below the MCL. During 2022, the concentration of nitrate in the on-site shallow background well W-221 was 35 mg/L, which is down from levels observed in the past four years. Detected concentrations of nitrate in western perimeter wells ranged from 16 mg/L (in well W-373) to 47 mg/L (in well W-151), which is consistent with results reported in previous years.

During 2022, gross alpha, gross beta, and tritium results for the Livermore Site's perimeter wells were consistent with results from past years. The concentrations continue to remain below drinking water MCLs.

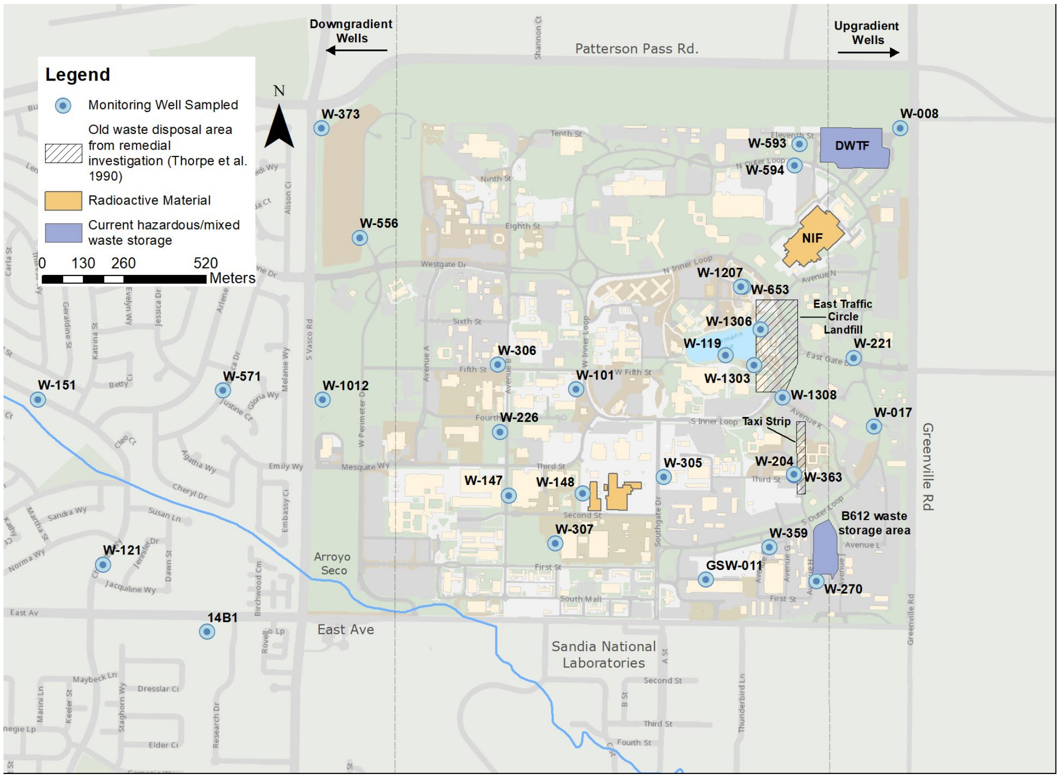

Figure 5-5. Routine Surveillance Groundwater Monitoring Wells at the Livermore Site, 2022

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

The Taxi Strip and East Traffic Circle Landfill areas (see **Figure 5-5**) 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 are analyzed 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 are analyzed for the same elements as the Taxi Strip area wells. All wells were sampled in 2022. Tritium concentrations remained well below the drinking water MCLs at all seven locations that were sampled. In 2019 and 2020, zinc was the only metal detected at these wells. No metals were detected at these monitoring wells in 2021 or 2022.

Near the National Ignition Facility (NIF), LLNL measures pH, conductivity, and tritium concentration of nearby groundwater to establish a baseline. Downgradient of NIF, groundwater samples are collected from wells W-653 and W-1207 (screened in HSU-3A and HSU-2, respectively). Downgradient from the Decontamination and Waste Treatment Facility (DWTF), wells W-593 and W-594 (screened in HSU-3A and HSU-2, respectively) are sampled for tritium annually. Tritium concentrations at the wells near NIF and DWTF were well below the drinking water MCL.

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). These wells were 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 2022.

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 2022, concentration of metals at well W-307 were consistent with concentrations reported in recent years. The concentration of hexavalent chromium at well W-307 decreased from 17 µg/L in 2021 to 14 µg/L in 2022. The concentration of manganese, which had shown some fluctuations in 2012 and 2013, remained below the analytical reporting limit in 2022. LLNL will continue to monitor trends.

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. Wells W-226 and W-306 (screened in HSU-1B and HSU-2, respectively) are sampled annually for metals. In 2022, boron concentrations at W-306 remained consistent with past monitoring results. In 2022, the chromium concentration at well W-226 (21 µg/L) was again above the analytical reporting limit. The concentration of chromium at well W-306 (2 ug/L) remained low and was consistent with 2022 monitoring results. The concentration of hexavalent chromium at well W-226 was above the analytical reporting limit in 2022. However, the concentration remained below drinking water MCLs and was consistent with past monitoring results.

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. As in 2012 through 2020, well W-101 was dry and could not be sampled in 2022. In August 2000, elevated tritium was detected in the groundwater sampled at well W-148 (115 ± 5.0 Bq/L [3,100 ± 135 pCi/L]). This was likely caused by local infiltration of storm water containing elevated tritium. Tritium concentrations 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 2022 have shown significantly lower values – a downward trend ranging from approximately one-tenth to one-half of the August 2000 value due to the natural decay and dispersion of tritium. Well W-147 tritium results for 2022 were also consistent with past years. 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 onsite CERCLA wells and springs and off-site private wells and springs. Representative groundwater samples are obtained at least once per year at every monitoring location; they are routinely measured for various inorganic constituents (primarily metals), a wide range of organic compounds, general radioactivity (gross alpha and gross beta), uranium, and tritium. 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 2022 are included in **Appendix A, Section A.6.**)

5.4.2.1 Elk Ravine Drainage Area

The Elk Ravine drainage area, a tributary to the Corral Hollow Creek drainage system, includes most of northern Site 300 (see **Figure 5-6**). Storm water runoff in the Elk Ravine drainage area collects in arroyos and generally infiltrates quickly 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 water-bearing zones in the area. Elk Ravine and the immediate area contain eight closed landfills, Pits 1 through 5 and 7 through 9, and the firing tables where explosives tests were or 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 conducted under CERCLA in this drainage area.)

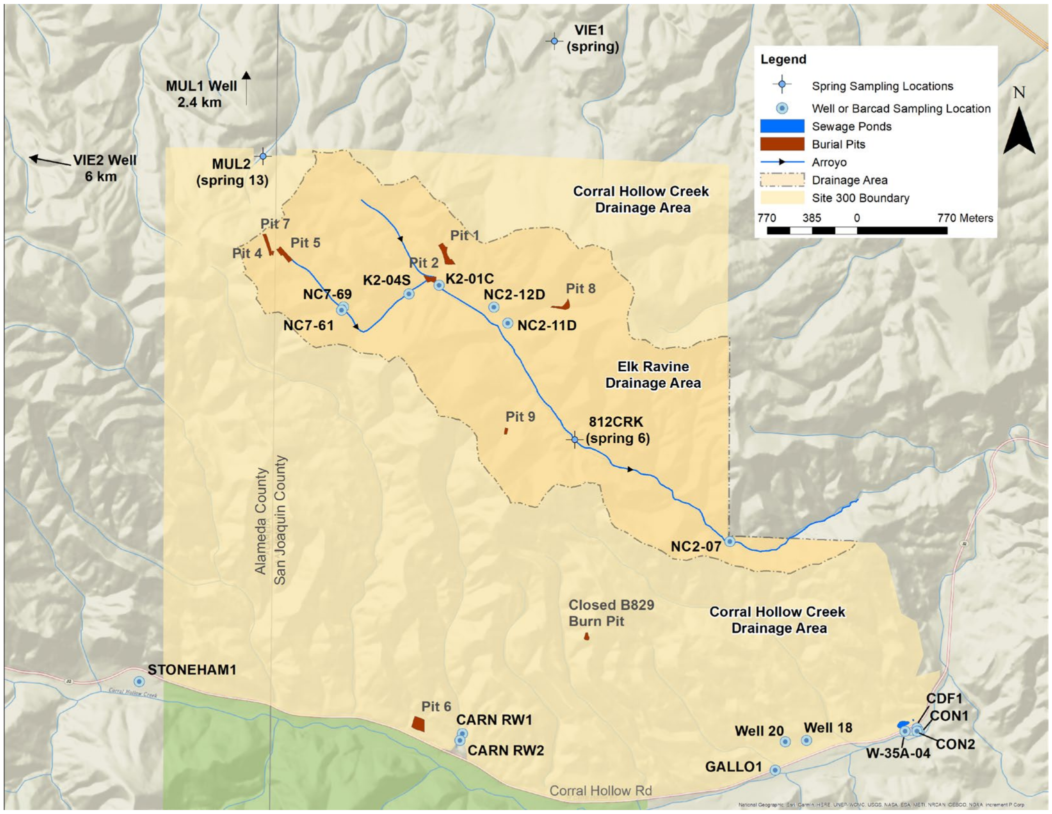

Figure 5-6. Surveillance Groundwater Wells and Springs at Site 300, 2022

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 were transferred to CERCLA. Sampling analytes and frequencies 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 2022 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 conducted during 2022, including a summary of data analysis, well locations, maps of the distribution of COCs in groundwater, and analytical data tables is presented in the CERCLA 2022 Site 300 Annual Compliance Monitoring Report (CMR) that was submitted to the regulatory agencies by the LLNL Environmental Restoration Department (Buscheck et al. 2023).

Elk Ravine. Groundwater samples were obtained on various dates in 2022 from the widespread Elk Ravine surveillance monitoring network shown in **Figure 5-6** (NC2-07, NC2-11D, NC2-12D, NC7-61, NC7-69, 812CRK [SPRING6], K2-04S, K2-01C). Monitoring at well K2-04D ceased in 2014 due to a pump becoming stuck in the well; the well was decommissioned in July 2020. Samples from NC2-07 were analyzed for inorganic constituents (mostly metals), general radioactivity (gross alpha and gross beta), tritium and uranium activity, and explosive compounds (HMX and RDX). Samples from 812CRK were analyzed for inorganic constituents (mostly metals), VOCs (EPA Method 624), general radioactivity (gross alpha and gross beta), and tritium and uranium activity. Wells NC7-61, K2-01C, NC2-12D, NC2-11D, and 812CRK were sampled for nitrate. Wells NC7-61, NC7-69, K2-01C, and NC2-07 were sampled for explosive compounds (HMX and RDX). All wells were analyzed for perchlorate. Additionally, all wells were sampled for general radioactivity (gross alpha and gross beta) and tritium and uranium activity except for well K2-01C, which was not sampled for gross alpha and gross beta.

No new release of COCs from LLNL operations in Elk Ravine to groundwater is indicated by the chemical and radioactivity data obtained during 2022. 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).

The 2022 tritium concentrations for well NC7-61 were 350 ± 69 Bq/L in April and 330 ± 65 Bq/L in October. These concentrations were similar to the tritium concentrations measured in 2021 (370 ± 73 Bq/L, and 400 ± 77 Bq/L). Tritium remains elevated with respect to the background concentration. Tritium, as HTO, has been released in the vicinity of Building 850. Most of the Elk Ravine surveillance network tritium measurements made during 2022 support earlier CERCLA studies showing 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. The 2022 HMX concentrations for NC7-61 were 6.5 ug/L in April and 5.3 ug/L in October, which are consistent with past monitoring results. Detections of the nonradioactive element vanadium at wells NC2-07, 812CRK, and K2-01C were also consistent with past monitoring results.

Groundwater surveillance measurements of gross alpha, gross beta, and uranium activity in Elk Ravine are low and 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, and zinc are all within the ranges of background concentrations for wells and springs at Site 300 presented in the Site-Wide Feasibility Study (Ferry et al. 1999). Background concentrations and activities of metals and radiological substances in ground water were determined through an evaluation of wells and springs identified as being hydrologically isolated from suspected areas of contamination.

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 FFA process. Monitoring requirements are specified in WDR 93-100 (CVRWQCB; 1993, 1998, and 2010) and in Rogers/Pacific Corporation (1990). In 2020, the CVRWQCB issued a letter rescinding the Pit 1 monitoring under WDR 93-100 and transferring the monitoring to CERCLA (CVRWQCB 2020a). The main objective of this detection monitoring is the early identification of any release of constituents from Pit 1 to groundwater. LLNL obtained groundwater samples quarterly during 2022 from the Pit 1 monitoring well network. Samples were analyzed for inorganic constituents (mostly metals), general radioactivity (gross alpha and gross beta), activity of certain radioisotopes (tritium, radium, uranium, and thorium), explosive compounds (HMX and RDX), and VOCs. Compliance monitoring showed no new releases of any constituents from Pit 1 in 2022; a detailed summary of Pit 1 detection monitoring conducted during 2022, including well locations, data analysis, and tables of analytical data, can be found in the 2022 annual CMR (Buscheck et al. 2023).

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 Dibley et al. (2009) and MacQueen et al. (2013). 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 historically released COCs. To comply with monitoring requirements, LLNL collected groundwater samples monthly, quarterly, semiannually, and annually during 2022 from specified Pit 6 monitoring wells. These samples were analyzed for VOCs, tritium, beryllium, mercury, total uranium, gross alpha/beta radioactivity, perchlorate, and nitrate.

During 2022, no new contaminant releases from Pit 6 were detected. A detailed account of Pit 6 compliance monitoring, including well locations, tables of groundwater analytical data, and maps showing the distribution of COCs is summarized in the 2022 Site 300 Annual CMR (Buscheck et al. 2023).

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 the *Hazardous Waste Facility Post-Closure Permit for the B829 Facility* (DTSC 2017). To comply with the permit, LLNL obtained groundwater samples during 2022 from the three wells in the Building 829 monitoring network. Groundwater samples from these wells, screened in the deep regional aquifer, were analyzed for inorganic constituents (mostly metals), turbidity, explosive compounds (HMX, RDX, and TNT), VOCs (EPA Method 624.1), extractable organics (EPA Method 625), and general radioactivity (gross alpha and gross beta).

In 2021, the concentrations for several metal constituents initially exceeded their statistical limits (SLs). However, there were no SL exceedances for any constituents in 2022. In 2019, there was a confirmed manganese SL exceedance at well W-829-15. In 2020 and 2022, manganese was not detected at well W-829-15 above the reporting limit. The 2021 manganese concentration at well W-829-15 initially exceeded the SL, but this result was invalidated after conducting two independent retests. The 2020 – 2022 monitoring results at well W-829-15 support LLNL's claim that the slight exceedance of manganese above the SL in 2019 was likely a result of desorption and dissolution of naturally occurring manganese-bearing minerals in the aquifer. Manganese had not previously been detected at well W-829-15 until 2019 and the manganese concentrations from 2020 – 2022 are consistent with sampling history.

In 2018 and 2019, there were confirmed manganese SL exceedances at well W-829-22. In 2020 and 2022, manganese was not detected at W-829-22 above the reporting limit (RL). The 2021 manganese concentration at well W-829-22 initially exceeded the SL, but this result was invalidated after conducting two independent retests. As LLNL has concluded in the past, the 2018 and 2019 validated manganese detections at W-829-22 were likely the result of local background variability and not an actual manganese release from the B829 burn pit. LLNL will continue to monitor manganese concentrations annually.

In 2019, there was a confirmed barium SL exceedance at well W-829-1938. The 2020 and 2022 barium results at well W-829-1938 were lower than the SL. The 2021 barium concentration at well W-829-1938 initially exceeded the SL, but this result was invalidated after conducting two independent retests. The 2020 – 2022 monitoring results support LLNL's conclusion that the past exceedance did not indicate an actual barium release from the B829 burn pit and that barium concentrations are within the range of local background variability. LLNL will continue to monitor barium annually.

In 2020, LLNL missed an initial chromium SL exceedance at W-829-22 and was not able to resample. The routine second quarter 2020 chromium result was 1.7 µg/L, which slightly exceeded the SL of 1.5 µg/L. LLNL records indicate that chromium has only been detected four times at W-829-22 since monitoring began in 1999. The only other chromium SL exceedance at W-829-22 occurred in 2003 (2.0 µg/L). In 2021 and 2022, chromium at well W-829-22 was <1 µg/L, which supports LLNL's prior claim that the 2020 chromium SL exceedance was likely the result of local background variability and not an actual chromium release from the B829 burn pit.

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 SL values. For a detailed account of compliance monitoring of the closed burn pit during 2022, including well locations and tables and graphs of groundwater COC analytical data, see Will (2023).

Water Supply Well. Well 20 is a drinking water supply well located in the southeastern part of Site 300 (**Figure 5-6**). It is a deep, high production well screened in the Neroly lower sandstone aquifer ($Tnbs_1$) and can produce up to 1,500 L/min (396 gal/min) of potable water. For surveillance purposes, prior to 2019, LLNL obtained groundwater samples quarterly from Well

20 and analyzed samples for inorganic COCs (mostly metals), VOCs, general radioactivity (gross alpha and gross beta), and tritium. In 2019, LLNL determined that surveillance monitoring for Well 20 was no longer necessary because the well is sampled and analyzed for COCs under the monitoring program defined in Domestic Water Supply Permit Amendment No. 01-10-16PA-003.

In March 2020, Site 300's primary water supply changed from Well 20 to Hetch Hetchy surface water purchased from the San Francisco Public Utilities Commission (SFPUC). LLNL still uses Well 20 when Hetch Hetchy water is unavailable. Results for 2022 surveillance measurements of groundwater from Well 20 do not differ significantly from previous years. As in past years, Well 20 showed no evidence of contamination. In addition to the permit-required sampling, Well 20 was sampled for nitrate, HMX, and RDX; all results were non-detect in 2022.

5.4.2.3 Off-site Surveillance Wells and Springs

For surveillance purposes, LLNL obtains groundwater samples from three off-site springs (MUL1, MUL2, and VIE1) and nine off-site wells (VIE2, CARNRW1, CARNRW2, CDF1, CON1, CON2, GALLO1, STONEHAM1, and W-35A-04) (**Figure 5-6**). All off-site surveillance springs and wells were sampled in 2022. All off-site monitoring locations are near Site 300, except for VIE2 which is located at a private residence 6 km west of the site. VIE2 represents a typical potable water supply well in the Altamont Hills.

Samples from CARNRW2 and GALLO1 are typically analyzed at least quarterly for inorganic constituents (metals, nitrate, and perchlorate), general radioactivity (gross alpha and gross beta), and tritium. CARNRW2 is also analyzed for explosive compounds (HMX and RDX) and uranium. CARNRW1 samples are analyzed monthly for VOCs (EPA Method 624), perchlorate, and tritium.

Groundwater samples were obtained at least annually during 2022 from the following off-site surveillance monitoring locations: STONEHAM1, CON1, W-35A-04, and CDF1 (south of Site 300). Samples were analyzed for inorganic constituents, general radioactivity (gross alpha and gross beta), tritium, and explosive compounds (HMX and RDX). Additionally, samples from W-35A-04 and STONEHAM1 were analyzed for uranium.

No constituents attributable to LLNL operations at Site 300 were detected in the off-site groundwater supplies. In 2021, perchlorate was detected at STONEHAM1 for the first time since monitoring began in 2011. However, perchlorate was not detected at STONEHAM1 in 2022. LLNL will continue to track perchlorate concentrations and monitor trends at STONEHAM1. In 2022, nickel was detected at well W-35A-04 after a history of largely non-detect samples since 2010. LLNL will continue to track nickel concentrations and monitor trends at W-35A-04. 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

Air moisture containing HTO is rapidly entrained and washed out locally during rain events. Rain gauge sampling is not required by DOE Order 458.1, or any other federal, state, or local regulation or permit; however, LLNL collects rainwater in rain gauges at fixed locations at both the Livermore Site and Site 300 to supplement information for storm events sampled for runoff. The collected rainwater is analyzed for tritium using EPA Method 906.0, a liquid scintillation counting method, and the analytical results are compared to the EPA drinking water MCL of 740 Bq/L (20,000 pCi/L) for tritium.

In calendar year 2022, the rain gauges were placed at the sample locations SALV, MET, DWTF, and SECO at the Livermore Site as shown in **Figure 5-7.** Site 300 rain gauges were located at ECP, PSTL, and GOLF as shown **Figure 5-8.**

The samples for calendar year 2022 were collected at the Livermore Site after the April 21, November 3, and December 1 qualifying storms. The highest measured tritium concentration,7.5 Bq/L, was for the April 21 storm and was collected at the DWTF sample location This concentration is approximately 1% of the EPA established drinking water MCL. All analytical results are provided in **Appendix A, Section A.7.**

The rainwater sample collected at Site 300 was after the April 20 qualifying storm. All three samples were non-detections for tritium with analytical error applied. All analytical results are provided in **Appendix A, Section A.7.**

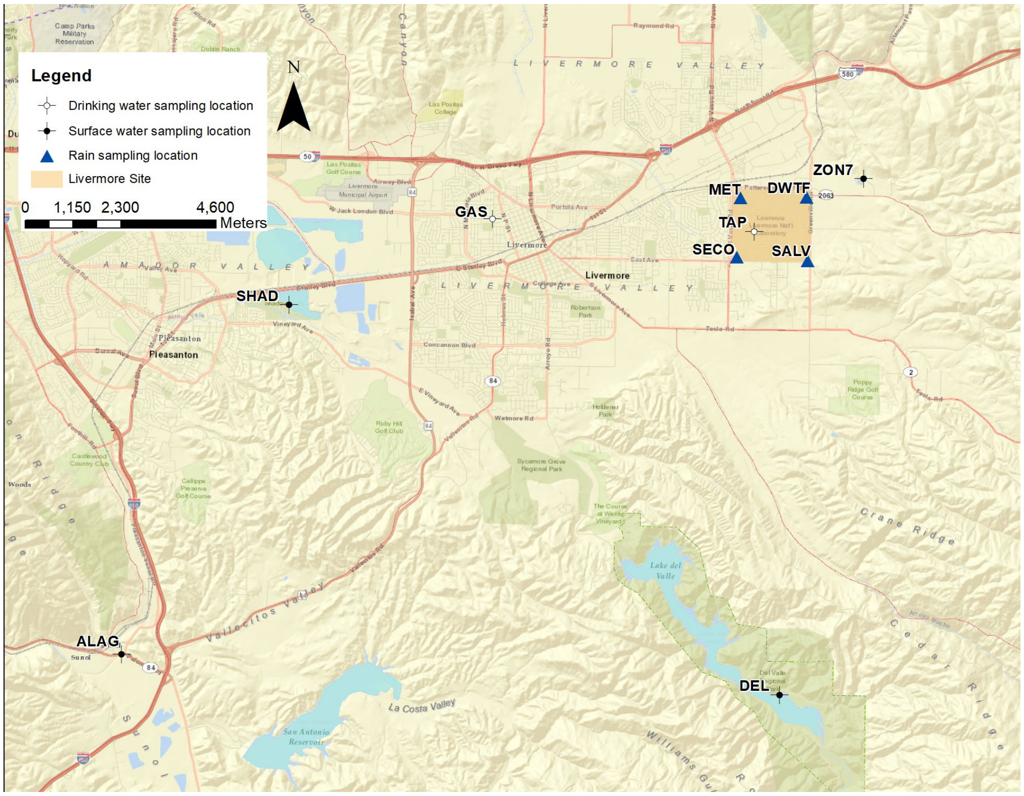

Figure 5-7. Livermore Site and Livermore Valley Sampling Locations for Rain, Surface Water, and Drinking Water, 2022

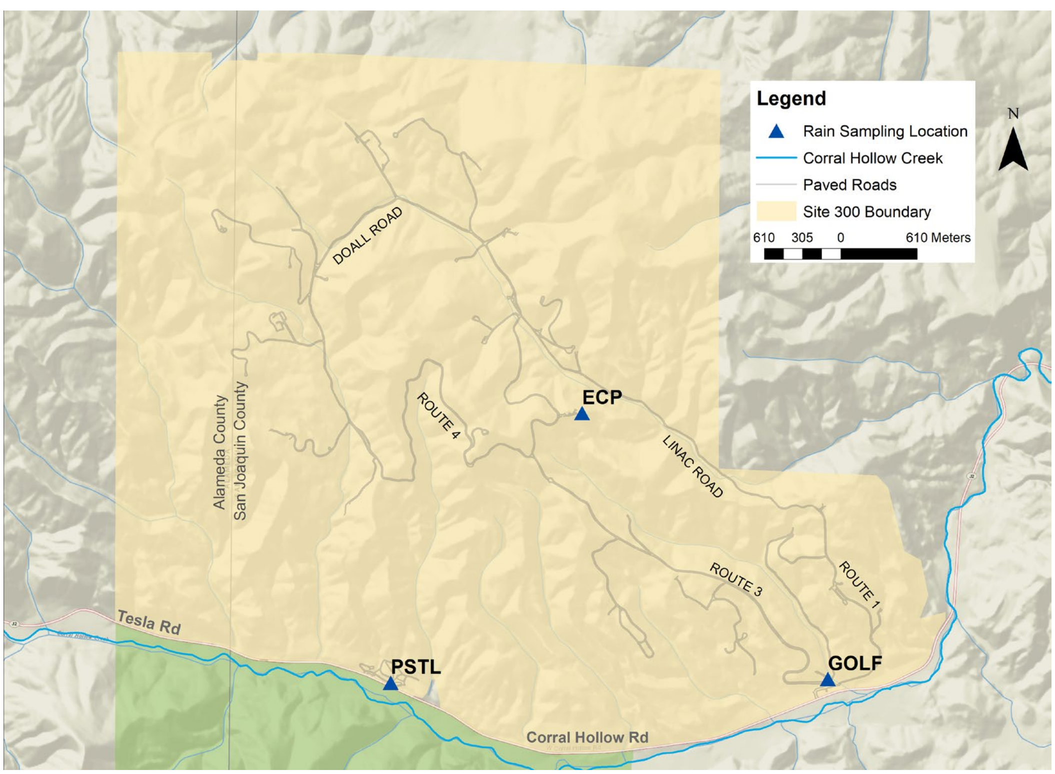

Figure 5-8. Rainwater Sampling Locations at Site 300, 2022

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 5-7** in 2022. Off-site sampling locations DEL, ALAG, SHAD, and ZON7 are surface water bodies; of these, DEL and ZON7 are also drinking water sources. The Springtown Pond (DUCK) is an artificial duck pond that was removed by the City of Livermore in 2018 and therefore the location was removed from the surface water sampling plan. 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 standardized procedures summarized in Brunckhorst (2019). In 2022, LLNL sampled GAS and TAP semiannually and ALAG, DEL, SHAD, and ZON7 annually. All locations were sampled for tritium, gross alpha, and gross beta. All analytical results are provided in **Appendix A, Section A.7.**

The median tritium concentration in all water location samples was estimated to be below the analytical laboratory's minimum detectable activities, or minimum quantifiable activities. The maximum tritium concentration detected in any sample collected in 2022 was 0.39 Bq/L (10.5 pCi/L), which is less than 1% of the drinking water MCL. All gross alpha results were less than the drinking water MCL. Historically, concentrations of gross alpha and gross beta radiation in drinking water sources have fluctuated around the analytical laboratory's minimum detectable activities. At such low levels, the counting error associated with the measurement 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 GAS (gross alpha at 0.0892 Bq/L [2.41 pCi/L] and gross beta at 0.1420 Bq/L [3.84 pCi/L]). These maximum values were less than 17% and 8% 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, 2022

Location	Metric	Tritium (Bq/L)(a)	Gross alpha (Bq/L)(a)	Gross beta (Bq/L)(a)
All locations	Median	-1.295	0.0362	0.093
	Minimum	-2.82	-0.0253	0.0031
	Maximum	0.39	0.0892	0.142
	Interquartile range	0.73	0.0385	0.0790
Drinking water outlet locations	Median	-0.835	0.0183	0.0814
	Minimum	-1.74	-0.0253	0.0031
	Maximum	0.39	0.0892	0.142
	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 Site 300 Drinking Water System Discharges

In 2022, LLNL maintained coverage under General Order R5-2022-0006, NPDES Permit No. CAG995002 for occasional large volume discharges from the Site 300 drinking water system that may reach surface water drainage courses. 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

More information is included in the quarterly self-monitoring reports to the CVRWQCB. All 2022 releases from the Site 300 drinking water system percolated into the drainage ditches or dry streambeds and did not reach Corral Hollow Creek, the potential receiving water.

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