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Permits and Regulatory Affairs Division

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Lawrence Livermore National Laboratory Experimental Test Site 300

Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill

Fourth Quarter/Annual Report 2009

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Summary

This monitoring report is required by the *Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory Site 300* (Ferry *et al.*, 1998). It summarizes post-closure compliance activities performed at the closed Pit 6 landfill during the fourth quarter of 2009. Results from quantitative analyses by state-certified analytical laboratories of chemical constituents of concern in ground water samples are summarized in the report and listed in the appendices.

Constituents of concern measurements made during the fourth quarter 2009 do not differ significantly from past quarters. Tritium exceeded its statistical limits (SL) in two down gradient wells and all other constituents of concern were below the SL. Statistical limits for tritium were previously exceeded in samples collected from some ground water wells near the Pit 6 Landfill. These elevated tritium activities have been previously reported to the Central Valley Regional Water Quality Control Board (CVRWQCB). Wells K6-36 and EP6-08 were dry this quarter and not sampled. As stated in previous reports, it is likely that the elevated concentrations seen for the tritium that are detected in ground water samples at Pit 6 are related to past releases from the landfill prior to its closure in 1998.

This quarter, the required post-closure visual inspection of the Pit 6 cap was performed by LLNL staff. This inspection demonstrated the continued functional and structural integrity of the cap, vegetation cover, and drainage. No deficiencies were noted in the condition of the pit cap during this inspection and the pit cap and drainage structures continue to function adequately at Pit 6.

Introduction

Site 300 is the Lawrence Livermore National Laboratory (LLNL) Experimental Test Facility located in the Altamont Hills approximately 10.5 kilometers (km) (6.5 miles [mi]) southwest of downtown Tracy, California (**Figure 1**). Site 300 is owned by the United States Department of Energy (DOE) and is a 30.3 km^2 (11.8 mi^2) area site operated by Lawrence Livermore National Security, LLC. The closed Pit 6 landfill is located within Site 300 near its southern boundary (**Figure 2**). A post-closure plan requiring quarterly and annual reports of compliance monitoring activities at the Pit 6 landfill (Ferry *et al.*, 1998) was implemented during the second quarter of 1998.

Figure 1. Location of LLNL Site 300.

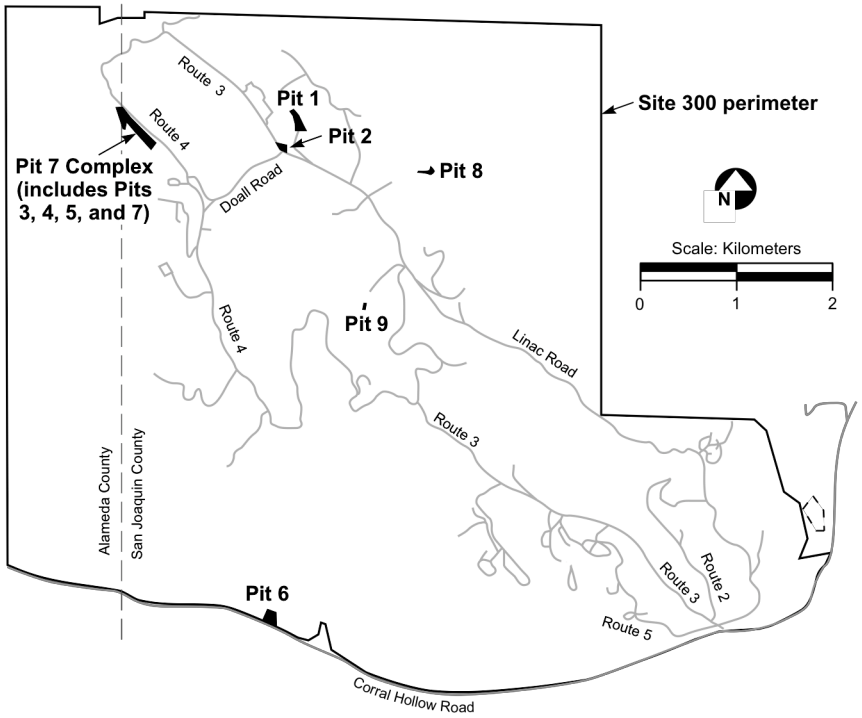

Figure 2. Location of Pit 6 at LLNL Site 300.

Figure 3 shows the locations of the wells that are used to monitor the ground water in the vicinity of the Pit 6 Landfill, including upgradient wells, detection monitoring wells, and corrective action monitoring wells (Ferry *et al.*, 1998). The northern limit of the Carnegie-Corral Hollow Fault zone extends beneath Pit 6 as shown in **Figure 3**. Ground water flows southeastward, following the inclination (dip) of the underlying sedimentary rocks. Depth to the water table ranges from 10 to 20 meters (m) or 32.8 to 65.6 feet (ft) in terrace deposit gravels and bedrock beneath Pit 6. Ground water flows within these gravels to the east-southeast parallel to the Site 300 boundary fence line (Webster-Scholten, 1994).

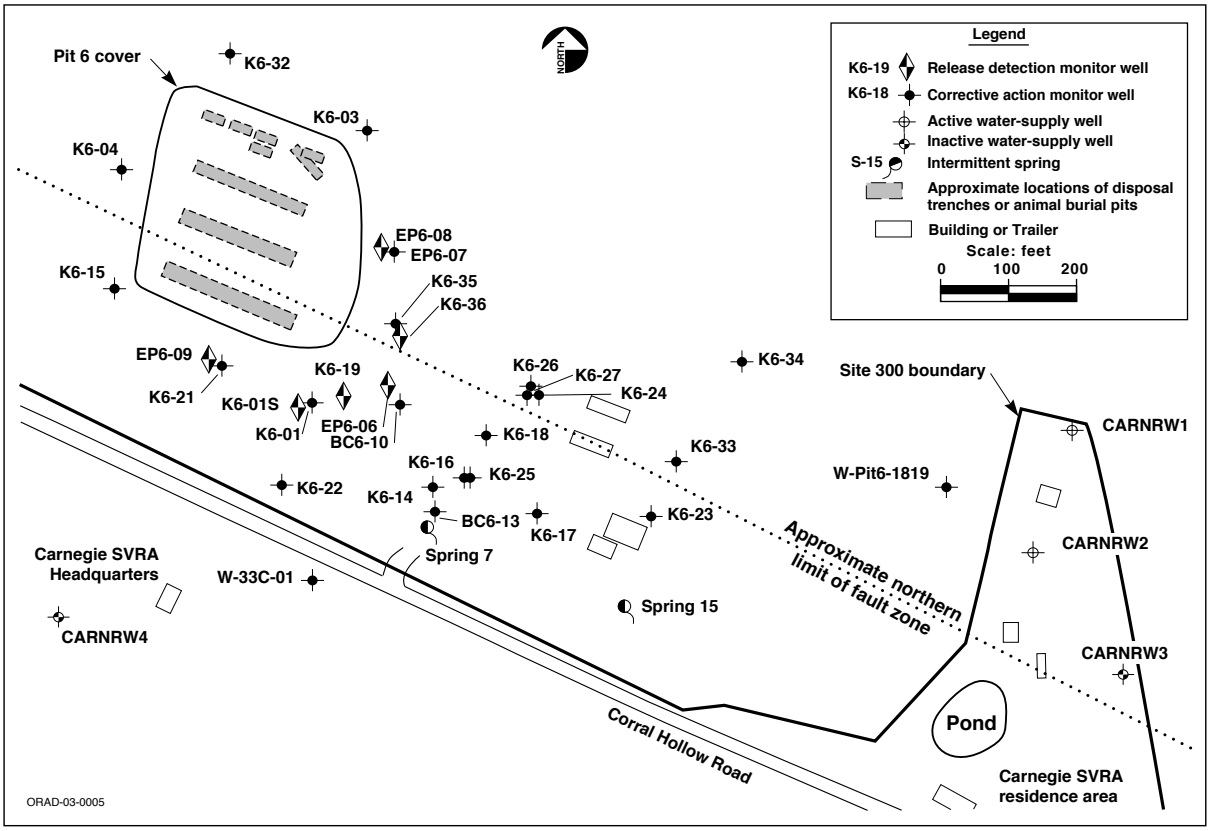

Figure 3. Locations of Pit 6 monitoring wells.

Monitoring Program Overview

The primary post-closure monitoring activity performed by LLNL at the Pit 6 Landfill is the collection of ground water samples for chemical and radioisotope analysis. Two ground water monitoring programs have been implemented at the Pit 6 Landfill to ensure compliance with regulations. The Detection Monitoring Program (DMP) detects any new releases of constituents of concern to ground water from wastes buried in the landfill. Constituents of concern, as defined by Title 23 of the California Code of Regulations (CCR), Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the Pit 6 Landfill. Twenty-four constituents of concern, including volatile organic compounds (VOCs) and radioisotopes, were identified for monitoring under the DMP in the Pit 6 Post-Closure Plan (Ferry et al., 1998). A select set of DMP wells are monitored quarterly for constituents of concern in compliance with the Pit 6 Post-Closure Plan (**Figure 3**). Field measurements of ground water physical parameters are collected at the time of sampling.

The Corrective Action Monitoring Plan (CAMP) monitors movement of historically-released contaminants of concern in ground water. Contaminants of concern are anthropogenic chemicals, metals, radionuclides, or other substances detected in environmental media that pose a risk to human or ecological receptors or a threat to ground water. VOCs and tritium were identified at the Pit 6 Landfill as ground water contaminants of concern for monitoring under the CAMP. CAMP wells are monitored at least semi-annually in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Compliance Monitoring Plan.

Perchlorate and nitrate were detected in ground water near Pit 6 during CERCLA site-wide surveys subsequent to the Pit 6 Post-Closure Plan and the Interim Site-Wide Record of Decision. Perchlorate was added to the list of constituents of concern to be monitored under the DMP. Since January 2003, nitrate and perchlorate were added as contaminants of concern to be monitored in an expanded set of CAMP wells (**Figure 3**). Additional changes to the monitoring program implemented since January 2003 are discussed in **Appendix D**.

As required by DOE Order 241.1, our measurements are reported in *Système Internationale* (SI) units. The SI unit for radioactivity is the becquerel (Bq), equal to 1 nuclear disintegration per second. The more commonly used unit, the picocurie (pCi), is equal to 1 nuclear disintegration per 27 seconds. As a convenience, maximum contaminant levels (MCLs) for radioactivity in drinking water are given in both becquerels per liter (Bq/L) and picocuries per liter (pCi/L) in **Table 1,** below. Note that MCLs are provided for reference only.

Table 1. MCLs for radioactivity in drinking water.

Radiological parameter	**MCL** (Bq/L)	**MCL** (pCi/L)
Gross alpha	0.555	15
Gross beta	1.85	50
Tritium	740	20,000
Uranium (total)	0.74	20

DMP objective. The primary DMP objective is to detect any new release of constituents of concern to ground water. Ground water is sampled quarterly from six wells located hydraulically downgradient of Pit 6 along the point of compliance. These wells are identified as EP6-06, EP6-08, EP6-09, K6-01S (K6-01 if K6-01S is dry), K6-19, and K6-36 in **Figure 3**. Water samples are sent to state-certified laboratories where they are analyzed quantitatively for the presence (or absence) of constituents of

concern (see **Table C-1** for the list of DMP constituents of concern). Gross alpha and gross beta radioactivity measurements are used as surrogates for seven radionuclide constituents of concern other than uranium and tritium. Additional field measurements of ground water general parameters are obtained quarterly at the time of sample collection.

Potential releases of constituents of concern from Pit 6 are indicated by comparing analytical results for ground water samples with statistically-determined limits of concentration, called statistical limits, or SLs (see **Appendix C**, **Table C-1**, for the list of constituents of concern and their respective SLs). If a constituent of concern measurement exceeds an SL, the measurement is investigated further to determine its validity. Consistent with state regulations, two independent ground water samples, called retest samples, are obtained at least one week apart from the associated monitoring well and analyzed for the suspect constituents of concern. If the constituent of concern is present in either sample at a concentration that exceeds the SL, then the initial analysis is deemed to be valid and it is reported as statistically significant evidence of a release. If neither retest sample measurement exceeds the SL, then the initial exceedance is not confirmed, and a release report is not made. Any further investigation of a constituent of concern is at the discretion of the Site 300 Remedial Project Managers (RPMs) and is conducted by LLNL under CERCLA.

CAMP objectives. The primary CAMP objectives are to: (1) evaluate the effectiveness of the corrective action; (2) evaluate natural attenuation of the ground water VOC and tritium plumes; (3) monitor perchlorate and nitrate in ground water; and (4) evaluate the need for implementing contingency actions. To accomplish the CAMP objectives, ground water measurements from the monitoring wells shown in **Figure 3** are evaluated on a quarterly basis as directed by the CAMP sampling plan.

Several VOCs, tritium, and perchlorate were released to ground water from Pit 6 prior to its closure. VOCs, primarily the solvents tetrachloroethene (PCE) and trichloroethene (TCE), have been described and evaluated previously in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Webster-Scholten, 1994), the *Final Feasibility Study for the Pit 6 Operable Unit, Lawrence Livermore National Laboratory Site 300* (Devany *et al*., 1994), the *Addendum to the Pit 6 Engineering Evaluation/Cost Analysis, Lawrence Livermore National Laboratory, Site 300* (Berry, 1996), the *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300* (Ferry *et al*., 1999), the *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300* (DOE, 2001), and the *Final Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300* (DOE, 2008).

The concentrations of all VOCs detected in GW monitoring wells in the Pit 6 area have been summed and are presented as Total VOCs (TVOCs) to be consistent with the reporting convention used in the CERCLA CAMPs. The concentrations of individual compounds contributing to the TVOC concentration in each well are included in **Appendix B, Table B-2**.

Tritium activity is above background in ground water downgradient from Pit 6, suggesting that a localized tritium release occurred prior to pit closure (Ferry *et al*., 1998). Monitored natural attenuation is the remedial action selected for the tritium plume.

Additional post-closure activities for Pit 6 include: (1) inspection of the landfill cap by LLNL technical staff annually and following major storms; (2) an annual comprehensive inspection of the landfill by an independent state-certified Professional Engineer (PE); (3) an annual pit cap elevation survey; (4) repairs as necessary to maintain the integrity of the landfill cap, its water diversion system, and its network of monitoring wells; and (5) preparation of reports. Reports of post-closure activities are provided quarterly to the participating regulatory agencies for their information and use.

Quality Assurance

To ensure data quality, LLNL works within the established Quality Assurance (QA) program of the LLNL Environmental Restoration Department (ERD). LLNL uses protocols and procedures that cover all aspects of ground water sampling, sample tracking, and data management. These written protocols and procedures are contained in the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Goodrich and Lorega, 2009), and the *Environmental Monitoring Plan* (Woods, 2005). Data quality is assessed by the following four methods: (1) analytical results for the routine and duplicate samples are compared by the analysts responsible for this report; (2) field blank samples are submitted to the analytical laboratories together with the routine ground water samples for identical analyses; (3) equipment blanks are prepared and analyzed to ensure that sampling equipment is properly cleaned before use; and (4) when samples are collected for VOC analysis, a trip blank (prepared at the analytical laboratory) is carried into the field. A summary of QA results may be found in **Appendix E, Table E-1**.

DMP Summary for 2009

This section summarizes the monitoring results for DMP constituents of concern. Constituents of concern measurements for the DMP wells are listed in Appendix A, Table A-1. Field measurements of ground water parameters and analytical laboratory measurements of total dissolved solids (TDS) for the DMP wells are listed in Appendix A, Table A-2. Data collected during the fourth quarter of 2009 do not differ significantly from past quarters (see Blake and Valett, 2009).

Total uranium activities in ground water samples collected at all DMP monitoring wells were below the SL during the fourth quarter 2009. Wells K6-36 and EP6-08 were again dry this quarter and not sampled.

Tritium and VOCs that were released to ground water from the landfill prior to its closure in 1998, continue to be detected (**Table A-1**). Tritium activities continue to exceed the SL of 3.7 Bq/L (100 pCi/L) in ground water samples from two down gradient DMP wells; K6-01S (4.2 Bq/L [113 pCi/L]), and K6-19 (10.0 Bq/L [270 pCi/L]). Tritium activities in K6-01S were below SLs for the second and third quarters of 2009 but were above the SL during the fourth quarter with a value of 4.4 Bq/L (118 pCi/L). Tritium activities detected in these wells have been relatively stable for 2009. Tritium activities in well K6-19, have historically dropped since September 1999 with a high of 93 Bq/L (2520 pCi/L). Since then, tritium activities in this well have remained relatively low or decreasing (Campbell 2007) and have remained well below the EPA drinking water MCL of 740 Bq/L (20,000 pCi/L). Historical tritium activities for these wells are displayed in Figure 4. For a more detailed account and map of the Pit 6 tritium activities and VOC concentrations, see the following CAMP summary.

The VOCs detected in Pit 6 DMP wells, including TCE, were not detected at concentrations greater than the SL in any ground water samples collected during the fourth quarter 2009 (**Table A-1**). Historical TCE concentrations for EP6-09, K6-01S, K6-19, and EP6-08 are displayed in Figure 5.

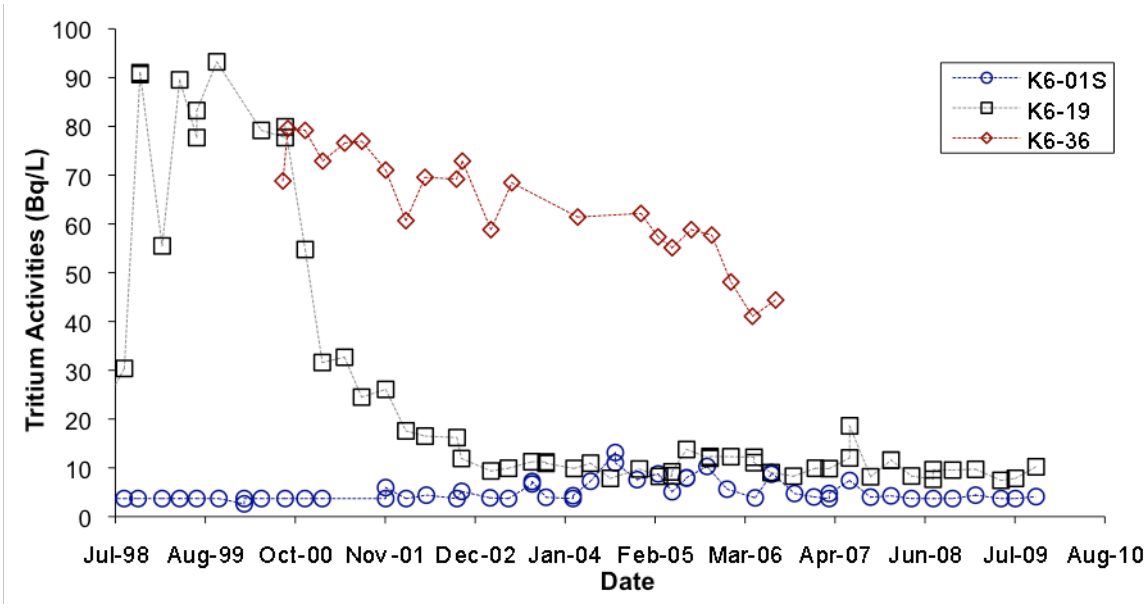

Figure 4. Historical tritium activities at Pit 6 for wells K6-01S, K6-19, and K6-36

Past detections of TCE above the SL likely originated from the existing VOC plume that resulted from releases at the landfill prior to its closure in 1998. Concentrations of TCE, which account for the largest proportion of TVOCs, generally appear to be stable or decreasing. A more detailed discussion and map of tritium activities and TVOC concentrations at Pit 6 are presented in the CAMP Summary.

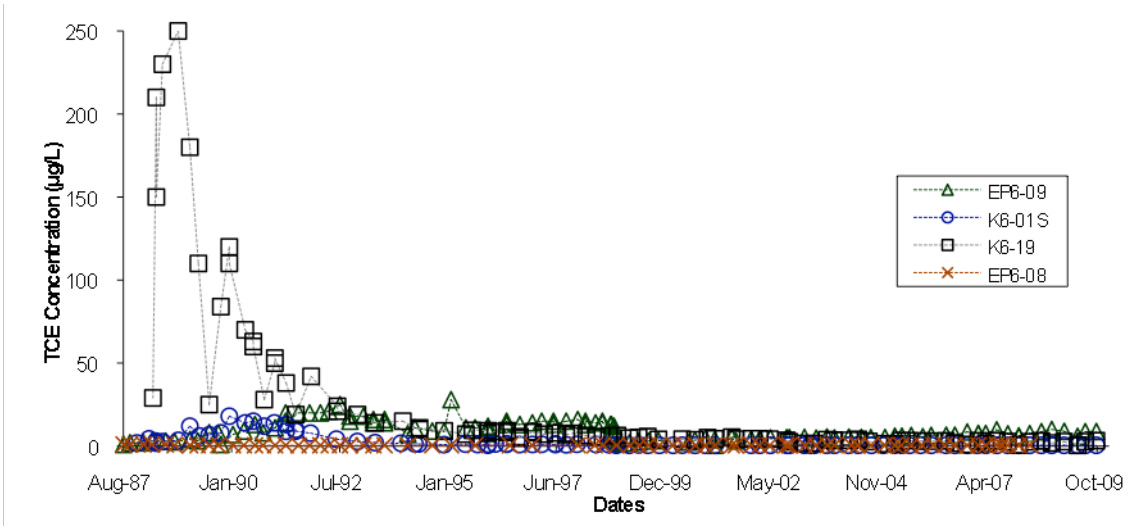

Figure 5. Historical TCE concentrations at Pit 6 monitoring wells EP6-08, EP6-09, K6-01S, and K6-19

CAMP Summary for 2009

This section summarizes an analysis of ground water elevation and contaminant of concern data collected as part of the CAMP monitoring during the fourth quarter of 2009. The primary CERCLA contaminants of concern for the Pit 6 area are several VOCs and tritium (Ferry *et al*., 1998). Perchlorate and nitrate were subsequently detected at concentrations above the State MCL for drinking water in ground water samples from several Pit 6 monitoring wells during site-wide investigations by LLNL. Perchlorate was designated a secondary contaminant of concern in 2000. Beginning in 2003, nitrate also became a secondary contaminant of concern. Ground water elevations for the fourth quarter of 2009 are listed in **Table B-1**. Detections of VOCs, tritium, perchlorate, and nitrate in ground water samples collected during the fourth quarter are listed in **Tables B-2, B-3,** and **B-4**, respectively. Ground water elevation and TVOC, tritium, perchlorate, and nitrate data are discussed in the following sections.

Ground water elevations (GWE). Figure 6 is a ground water elevation contour map for the fourth quarter of 2009. Ground water elevations beneath Pit 6 are approximately a minimum of 12 m (40 ft) below the buried waste trenches. Water elevations in several wells north of the fault zone are at or near historic lows.

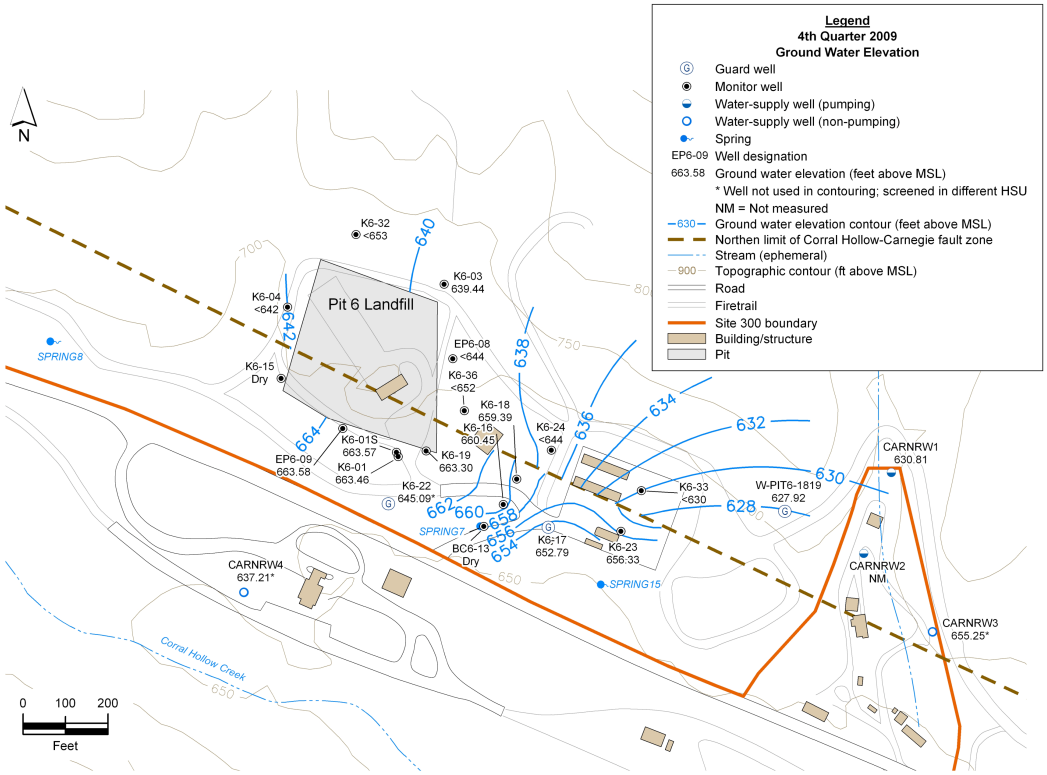

Figure 6. Ground water elevations (ft above MSL) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2009.

The predominantly southeast flow direction shown on **Figure 6** is consistent with potentiometric surface maps from previous quarters. Within the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.03. North of the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.01–0.02. Fractures in the Neroly formation $Tnbs_1$ stratigraphic unit play a dominant role in conveying ground water flow. A large component of the flow north of the fault is currently affected by pumping from offsite water-supply wells CARNRW1 and CARNRW2. During the measurement of the fourth quarter water elevations, the water level technician observed that CARNRW1 was not pumping; CARNRW2's operation was unknown. The low ground water elevation at W-PIT6-1819 in the eastern portion of **Figure 4**, relative to the elevation at CARNRW1, may arise from pumping at CARNRW2. Ground water elevations to the south, within the fault zone, do not appear to be strongly influenced by pumping.

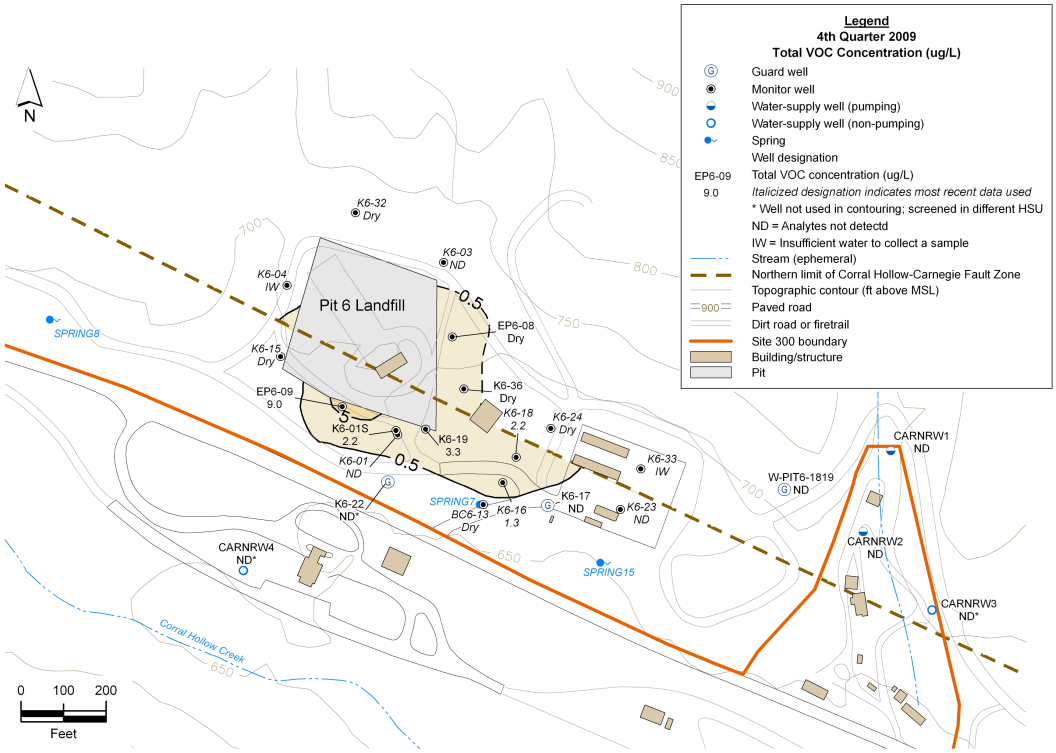

Figure 7. Ground water TVOC concentrations (μg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2009.

Ground water TVOC concentrations. As shown in **Figure 7**, the concentrations of all the VOCs detected in ground water samples collected at Pit 6 during the fourth quarter of 2009 have been summed and are presented as TVOCs. TCE and cis-1,2-DCE were the only VOCs detected at Pit 6 in ground water at concentrations above the method reporting limit of 0.5 micrograms per liter (μg/L) (for each compound) during the fourth quarter 2009.

The distribution of TVOCs depicted on **Figure 7** is similar to last quarter's. The maximum TVOC concentration this quarter was the 9 μg/L detected in the duplicate sample from well EP6-09; the only VOC detected in this sample was TCE. The routine sample from this well yielded a TVOC concentration of 8.8 μg/L, all of which was TCE. Last quarter, this well also yielded the maximum concentration of TVOCs at Pit 6 (8.7 μg/L). TVOCs were detected last quarter in ground water samples from monitoring

wells EP6-09, K6-01S, K6-16, K6-18, and K6-19. Two of the wells that yielded VOCs last quarter, wells K6-16 and K6-18, were not sampled this quarter and are only sampled twice a year (during the first and third quarters) per CERCLA Compliance Monitoring Plan (CMP) requirements. TVOCs were again detected in ground water samples from the remaining three wells during the fourth quarter. Wells K6-36 and EP6-08 have been dry since the fourth quarter 2006 and second quarter 2008, respectively. However, we have conservatively assumed that the water-bearing zone is saturated below the pump intake of the well screen in preparing Figure 7. When last yielding water, the samples from K6-36 and EP6-08 contained TVOC concentrations of 0.8 and 1.8 μg/L, respectively. Together, all these wells define a localized VOC plume that originates in the east-central portion of Pit 6.

Ground water TCE concentrations during the fourth quarter of 2009 were similar to those detected in previous quarters and years. The maximum TCE concentration at Pit 6 this quarter was 9 μg/L in the duplicate ground water sample collected from well EP6-09. This sample result and the 8.8 μg/L result from the EP6-09 routine sample, were the only sample results that met or exceeded the 5 μg/L MCL. One other well, K6-19, yielded a sample containing TCE (3.3 μg/L) in excess of the 0.5 μg/L detection limit, but below the MCL.

Ground water samples collected from well EP6-09 during the previous three quarters contained 8.7, 5.9, and 8.9 μg/L of TCE. The maximum historical TCE concentration for ground water from this well was 28 μg/L in January 1995. By year, the maximum TCE concentrations measured in ground water at Pit 6 were 6.3 μg/L in 2000 (well K6-18), 5.4 μg/L in 2001 (well K6-19), 5.1 μg/L in 2002 (well EP6-09), 5.5 μg/L in 2003 (well EP6-09), 5.4 μg/L in 2004 (well EP6-09), 6.4 μg/L in 2005 (well EP6-09), 8.5 μg/L in 2006 (well EP6-09), 9.8 μg/L in 2007 (well EP6-09), 10 μg/L (well EP6-09) in 2008, and 9 μg/L (well EP6-09) in 2009. Monitoring data do not indicate a new release of TCE, or other VOCs, to ground water from Pit 6 during this quarter or year.

As in the past, cis-1,2-DCE was detected in a ground water sample from Pit 6. During the fourth quarter of 2009, 2.2 μg/L of cis-1,2-DCE were detected in the ground water sample from well K6-01S. Cis-1,2-DCE has never been detected at or above the 70 μg/L Federal MCL, 60 μg/L State MCL or 100 μg/L State PHG in samples from any well in the Pit 6 area. Last quarter, cis-1,2-DCE was detected in one ground water sample, from well K6-01S, at a concentration of 2.0 μg/L. The most recent previous detections of cis-1,2-DCE (first, second, third, and fourth quarters of 2008 and first and second quarters of 2009) in samples from this well were 2.1, 2.2, 2.4, 2.1, 1.8, and 2.2 μg/L, respectively. The presence of cis-1,2-DCE, a degradation product of TCE, suggests that natural decomposition may be occurring.

This quarter, PCE was not detected in any ground water samples. However, the well which has most recently yielded PCE concentrations, EP6-08, was dry during the fourth and third quarters of 2009. PCE was last detected in a sample from well EP6-08 during second quarter 2008 at a concentration of 1.2 μg/L, below the 5 μg/L MCL for PCE. PCE was also detected in this well during the third and fourth quarters of 2007 and first quarter of 2008 at concentrations of 1.7, 1.3, and 1.1 μg/L, respectively.

Ground water tritium activity. **Figure 8** shows the areal distribution of tritium activities in ground water in the first water-bearing zone for the fourth quarter of 2009. This quarter, tritium activities in excess of the 3.7 Bq/L (100 pCi/L) detection limit in the first water bearing zone north of the fault zone were found in one ground water sample (W-PIT6-1819 at 5.8 Bq/L [156 pCi/L]). For wells north of the fault that could not be sampled due to dry conditions or insufficient water for sampling, the most recent tritium activities were used for plume contouring Within the fault zone, tritium was detected in samples from wells K6-01S (4.2 Bq/L [113 pCi/L]) and K6-19 (10.0 Bq/L [276 pCi/L]). The tritium plume depicted in **Figure 8** is similar in magnitude and slightly more extensive compared to the plume shown during third quarter 2009 (K6-01S yielded 113 pCi/L this quarter, but was <100 pCi/L during third quarter). Tritium was not detected at or above the 740 pCi/L (20,000 pCi/L) MCL or the 14.8 Bq/L (400 pCi/L) State PHG in samples from any wells in the Pit 6 area.

This quarter the highest tritium activity in Pit 6 ground water, 10.0 Bq/L (276 pCi/L), was found in the sample from well K6-19, located at the southeast corner of Pit 6. Last (third) quarter, the sample from this well yielded 8.1 Bq/L (218 pCi/L). As mentioned above, the sample from well W-PIT6-1819 contained 5.8 Bq/L (156 pCi/L) of tritium this quarter. This well is a guard well and is used to define the downgradient extent of the tritium plume north of the fault zone in the first water-bearing zone. It is located about 30 m (100 ft) west of the Site 300 boundary with the Carnegie State Vehicle Recreation Area residence area and about 60 m (200 ft) west of the CARNRW1 and CARNRW2 water-supply wells (**Figure 8**). Last quarter, the sample from well W-PIT6-1819 contained 4.7 Bq/L (126 pCi/L) of tritium. This well has historically yielded tritium activities varying between non-detect (< 3.7 Bq/L [100 pCi/L]) and 10.9 Bq/L (295 pCi/L). This quarter, $Tnbs_1$ guard well K6-34, located north of the fault approximately 200 feet northwest of W-PIT6-1819, yielded tritium at 4.3 Bq/L (117 pCi/L), however, the error range for this sample result is 73.8 pCi/L. This well is sampled quarterly and will continue to be closely monitored for tritium activity.

Tritium activities were below the detection level of 3.7 Bq/L (100 pCi/L) in the monthly ground water samples obtained during the fourth quarter of 2009 from the off-

site CARNRW wells. Based on these analyses and the results from other wells, the tritium plume appears to be relatively stable.

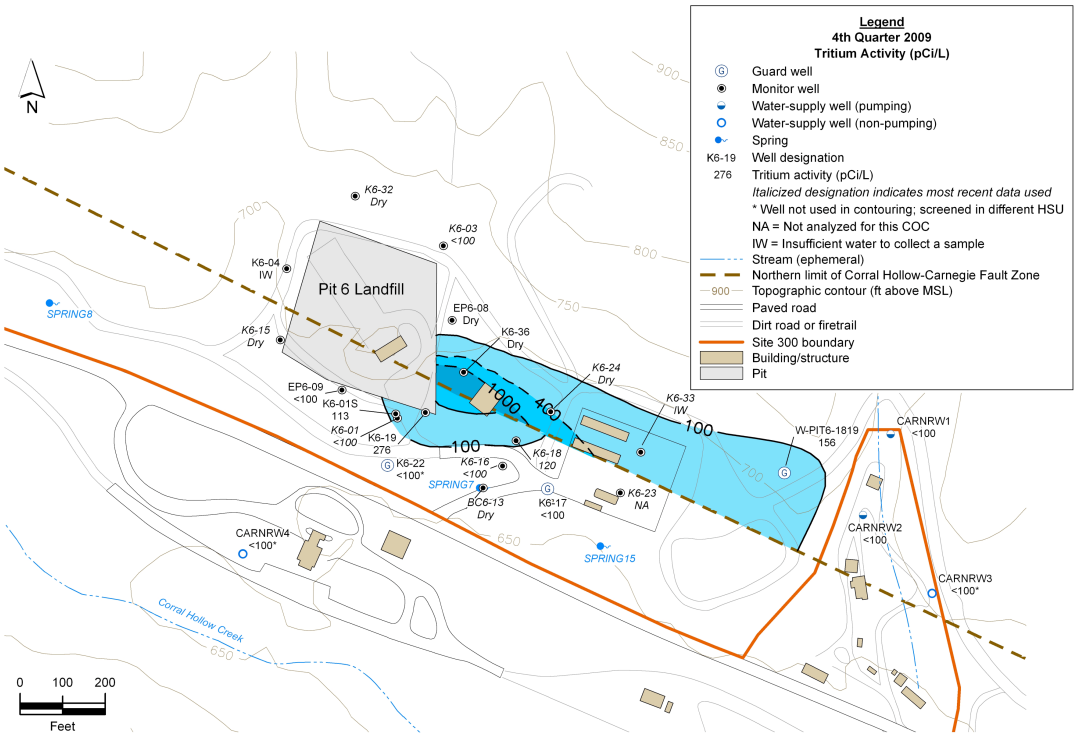

Figure 8. Ground water tritium activities (pCi/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2009.

Ground water perchlorate concentrations. A map showing fourth quarter 2009 perchlorate concentrations in ground water samples collected from the shallow water-bearing zone is presented in **Figure 9**. This quarter, as well as the last two quarters, there were no wells that yielded perchlorate at or in excess of the reporting limit of 4 µg/L or the 6 mg/L State PHG. During the first quarter of 2009, K6-18 yielded perchlorate at concentrations of 6.9 µg/L (duplicate) and 6.2 µg/L (routine). The State MCL for perchlorate in drinking water is 6 µg/L. In the past, the maximum perchlorate concentrations in ground water at Pit 6 have been measured at well K6-18 (15 µg/L in 2002, 14 µg/L in 2003, 14 µg/L in 2004, 10 µg/L in 2006, 6.6 µg/L in 2007, and 5.5 µg/L in 2008). Perchlorate was not detected in ground water samples collected

from the Pit 6 area during 2005. EP6-09 is the only other well that has yielded recent perchlorate detections, the most recent during first quarter 2009 at 4 µg/L.

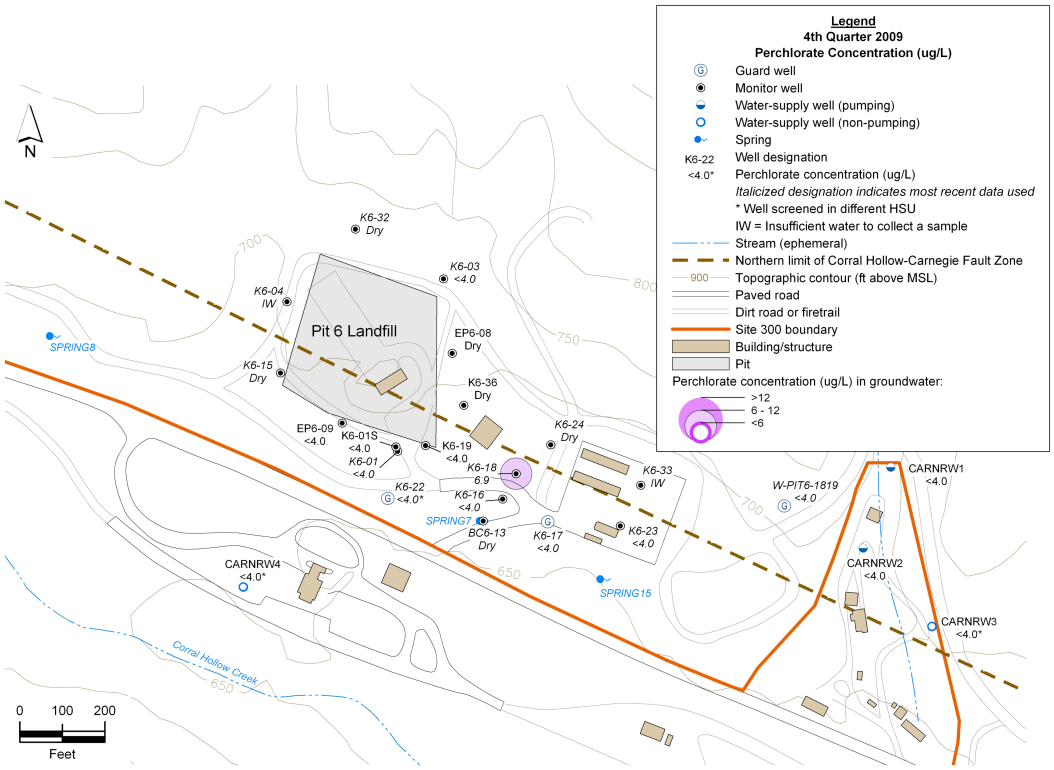

Figure 9. Ground water perchlorate concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2009.

Ground water nitrate concentrations. A map showing fourth quarter 2009 nitrate concentrations in the shallow water-bearing zone at Pit 6 is presented in **Figure 10**. This quarter, there were no wells that yielded nitrate above the 45 milligram per liter (mg/L) MCL. During the first and third quarters of 2009, nitrate was detected in a sample from well K6-23 above the MCL at concentrations of 170 and 180 mg/L, respectively. Ground water nitrate concentrations from this well are consistently the highest at Pit 6 and were 172, 165, 200, 200, 220, and 210 mg/L in 2003, 2004, 2005, 2006, 2007, and 2008 respectively. Well K6-23 is located in close proximity to the Building 899 septic system, which is a potential source of the nitrate at this location. Additionally, well K6-18 yielded nitrate above the MCL during first and third quarters at concentrations of 52 and 54 mg/L, respectively. Well K6-18 will continue to be monitored closely for

nitrate. The maximum second quarter 2009 nitrate concentration in monthly samples from the four CARNRW offsite water-supply wells (CARNRW1, CARNRW2, CARNRW3, and CARNRW4) was 0.8 mg/L in the December 2009 sample from CARNRW1.

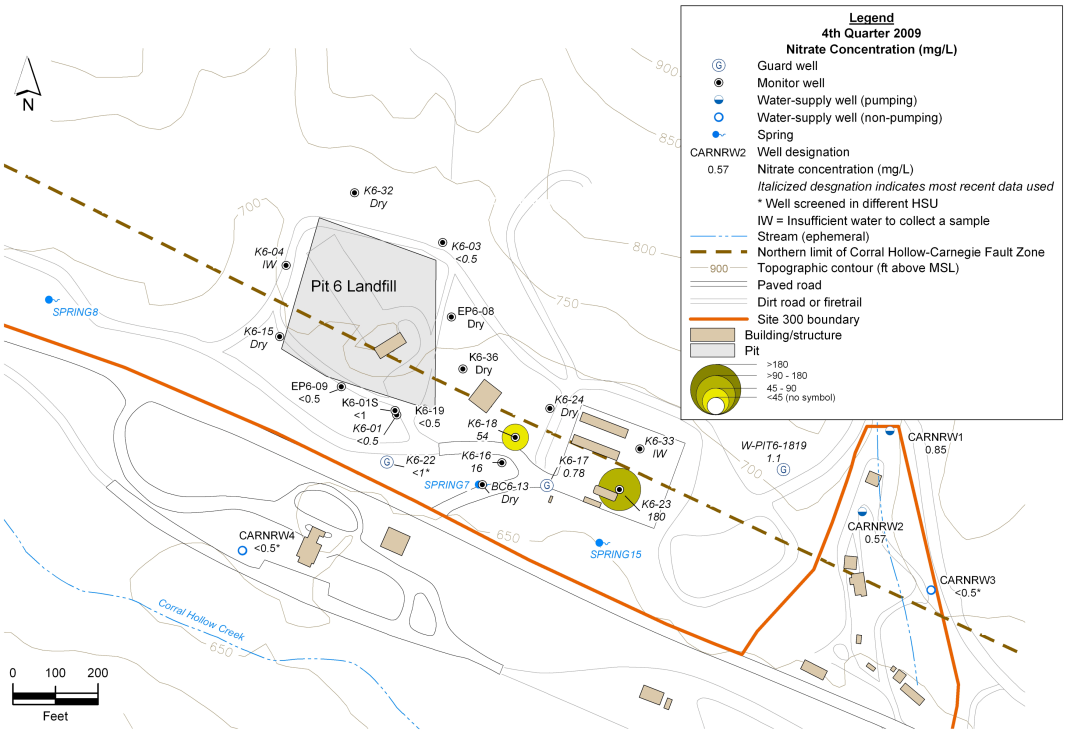

Figure 10. Ground water nitrate concentrations (mg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2009.

Inspection and Maintenance Summary

The inspection of the Pit 6 cap is performed annually or after a significant rain event by LLNL. No cap inspection was required this fourth quarter. The annual inspection was performed in the second quarter on May 7, 2009 by an independent Registered Professional Civil Engineering; Abri Environmental Engineering, Inc. and presented in (Appendix F) of that report. The visual cap inspections include a checklist of issues related to cap integrity, vegetation, and drainage. The engineer's report concluded that

the pit cap was in generally good condition. The report indicated there was no visible erosion of the cap; and the drainage system was in good condition and appeared to be functioning as intended. The ground water system appeared to be in good condition as well. Evidence of animal borrowing on the cap, and vegetation growth in the concrete lined drainage was observed. Recommendations for these observations have been completed by Site 300 staff. The pit cap and drainage structures continue to function adequately at Pit 6.

The annual permanent survey marker elevation survey for the Pit 6 cap was performed by a licensed surveyor during the third quarter of 2009 and the survey results were presented and compared in Appendix F of that report. No significant differences in elevations of the markers were found.

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Abbreviations and Acronyms

Bq	becquerel (international unit of radioactivity equal to 27 pCi)
CAMP	Corrective Action Monitoring Program
CB	Christy box
CC	control chart (statistical method)
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cis-1,2-DCE	Cis-1,2-dichloroethene
CL	concentration limit (background concentration of a chemical)
COC	constituent of concern
CVRWQCB	Central Valley Regional Water Quality Control Board
DEHP	di(2-ethylhexyl)phthalate, bis(2-ethylhexyl)phthalate
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
DUP	duplicate sample
EPA	U.S. Environmental Protection Agency
EPD	LLNL Environmental Protection Department
ERD	LLNL Environmental Restoration Department
ft	foot (used as a measure of elevation above MSL)
GWD	ground water depth
GWE	ground water elevation in feet above MSL
HSU	Hydrostratigraphic Unit
km	kilometer
L	liter
LLNL	Lawrence Livermore National Laboratory
m	meter
MCL	maximum contaminant level (for drinking water)
MSL	mean sea level (datum for elevation measurements)
mg	milligram
μg	microgram
nd	none detected
NM	not measured
PCB	polychlorinated biphenyl
PCE	perchloroethene, tetrachloroethene

pCi	picocurie (unit of radioactivity)
PE	Professional Engineer
PI	prediction interval (statistical method)
PQL	practical quantitation unit
QA	quality assurance
RA	restricted access
RL	reporting limit (contractual concentration near zero)
RPM	remedial project manager
RTN	routine sample
Site 300	Experimental Test Facility, LLNL
SL	statistically determined concentration limit
SOP	standard operating procedure
TCE	trichloroethene
TDS	total dissolved solids
THM	trihalomethane
$Tnbs_1$	Neroly Formation lower blue sandstone unit
TVOC	total volatile organic compound
VOC	volatile organic compound
WBZ	water bearing zone
yr	year

Appendix A

Tables of Ground Water Measurements for Detection Monitoring Wells

Table A-1. Pit 6 post-closure monitoring plan constituents of concern, detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2009.

				Quarter			
COC (units)	**Well**	**SL**	**MCL**	**First**	**Second**	**Third**	**Fourth**
Metals (μg/L)							
Beryllium	EP6-06	0.2	4	<1	<0.2	<2.5	<0.2
	EP6-09	0.2		<1	<0.2	<1	<0.2
	K6-01S	0.2		<1	<0.2	<1	<0.2
	K6-19	0.2		<1	<0.2	<1	<0.2
Mercury	EP6-06	0.2	2	<0.2	<0.2	<0.2	<0.2
	EP6-09	0.2		<0.2	<0.2	<0.2	<0.2
	K6-01S	0.2		<0.2	<0.2	<0.2	<0.2
	K6-19	0.2		<0.2	<0.2	<0.2	<0.2
Radioactivity (Bq/L)							
Tritium	EP6-06	3.7	740	-0.62	-1.1	-1.1	-0.31
	EP6-09	3.7		1	0.78	0.46	1.3
	K6-01S	3.7		4.4	2.9	2.1	4.2
	K6-19	3.7		9.7	7.4	7.8	10
Uranium (total)	EP6-06	0.13	0.74	0.02	0.02	0.01	0.02
	EP6-09	0.14		0.07	0.07	0.08	0.11
	K6-01S	1.00		0.13	0.18	0	0.15
	K6-19	0.27		0.13	0.09	0.09	0.1
Gross alpha	EP6-06	0.28	0.55	-0.08	-0.02	-0.01	-0.02
	EP6-09	0.18		-0.11	-0.07	0.06	0.11
	K6-01S	0.96		-0.12	0.11	0.06	0.12
	K6-19	0.34		0.06	-0.03	0.04	0.09
Gross beta	EP6-06	0.79	1.85	0.34	0.28	0.31	0.31
	EP6-09	0.79		0.35	0.3	0.37	0.27
	K6-01S	2.13		0.78	0.57	0.6	0.52
	K6-19	0.79		0.32	0.31	0.31	0.18
Volatile organic compounds (μg/L, EPA method 8260)							
Benzene	EP6-06	0.5	1	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
Carbon disulfide	EP6-06	5	none	<5	<5	<5	<5
	EP6-09	5		<5	<5	<5	<5
	K6-01S	5		<5	<5	<5	<5
	K6-19	5		<5	<5	<5	<5
Chloroform	EP6-06	0.5	80	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	1.5		<0.5	<0.5	<0.5	<0.5
1,2-dichloroethane	EP6-06	0.5	0.5	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
Cis-1,2-dichloroethene	EP6-06	0.5	6	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	7.0		1.8	2.2	2	2.2
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5

Table A-1. Pit 6 post-closure monitoring plan constituents of concern, detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2009.

				Quarter			
COC (units)	**Well**	**SL**	**MCL**	**First**	**Second**	**Third**	**Fourth**
Ethyl benzene	EP6-06	0.5	700	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
Methylene chloride	EP6-06	1	5	<1	<1	<1	<1
	EP6-09	1		<1	<1	<1	<1
	K6-01S	1		<1	<1	<1	<1
	K6-19	1		<1	<1	<1	<1
Tetrachloroethene	EP6-06	0.5	5	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
Toluene	EP6-06	0.5	150	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
1,1,1-trichloroethane	EP6-06	0.5	200	<0.5	<0.5	<0.5	<0.5
	EP6-09	0.5		<0.5	<0.5	<0.5	<0.5
	K6-01S	0.5		<0.5	<0.5	<0.5	<0.5
	K6-19	0.5		<0.5	<0.5	<0.5	<0.5
Trichloroethene (TCE)	EP6-06	0.5	5	<0.5	<0.5	<0.5	<0.5
	EP6-09	17		8.9	5.9	8.7	8.8
	K6-01S	1.5		<0.5	<0.5	<0.5	<0.5
	K6-19	13		2.7	<0.5	2.7	3.3
Xylenes (total)	EP6-06	1	1750	<1	<1	<1	<1
	EP6-09	1		<1	<1	<1	<1
	K6-01S	1		<1	<1	<1	<1
	K6-19	1		<1	<1	<1	<1
Perchlorate (μg/L)	EP6-06	4.7	6[(a)]	<4	<4	<4	<4
	EP6-09	4		<4	<4	<4	<4
	K6-01S	4		<4	<4	<4	<4
	K6-19	27.5		<4	<4	<4	<4

[(a)] California State Action Level.

Table A-2. Pit 6 detection monitoring quarterly ground water physical parameters for 2009.

Detection well	Quarter 2009	Date sampled	GWE[a] (ft)	Temp. (°C)	pH (pH units)	Specific conductivity (μmho/cm)	TDS[b] (mg/L)
EP6-06	1	12-Jan-09	654.65	20.5	7.85	1310	880
	2	5-May-09	660.7	22	7.65	1293	840
	3	9-Jul-09	659.71	21.8	7.18	1291	840
	4	8-Oct-09	659.74	21.7	7.62	1292	840
EP6-09	1	14-Jan-09	664.05	22.1	6.62	1658	1200
	2	5-May-09	663.58	22.4	7.19	1833	1100
	3	8-Jul-09	663.86	23.4	6.97	1777	1200
	4	8-Oct-09	663.6	22	8.07	1678	1300
K6-01S	1	12-Jan-09	663.84	22.1	7.16	3651	3000
	2	5-May-09	663.68	22.2	7.03	3716	2900
	3	8-Jul-09	663.71	22.5	6.9	3633	3000
	4	8-Oct-09	663.59	22	7.24	3599	3000
K6-19	1	12-Jan-09	663.56	23	7.86	1196	770
	2	5-May-09	663.46	23.7	7.94	1234	780
	3	8-Jul-09	663.35	23.9	7.02	1190	780
	4	8-Oct-09	663.26	22	7.91	1191	820

[a] Ground water elevation (water table elevation in feet above mean sea level).

[b] Total dissolved solids.

Appendix B

Tables of Ground Water Measurements for Corrective Action Monitoring Wells

Table B-1. Water elevation (GWE) measurements in Pit 6 ground water monitoring wells, fourth quarter 2009.

Well	Date sampled	GWE (ft above MSL)
BC6-10	6-Oct	657.6
BC6-13	6-Oct	DRY
CARNRW1	5-Oct	600
CARNRW1	6-Oct	630.8
CARNRW3	6-Oct	655.2
CARNRW4	6-Oct	637.2
EP6-06	6-Oct	659.8
EP6-06	8-Oct	659.7
EP6-07	6-Oct	662.8
EP6-08	6-Oct	DRY
EP6-09	6-Oct	663.6
EP6-09	8-Oct	663.6
K6-01	6-Oct	663.5
K6-01S	6-Oct	663.6
K6-01S	8-Oct	663.6
K6-03	6-Oct	639.4
K6-04	6-Oct	DRY
K6-14	6-Oct	657.8
K6-15	6-Oct	DRY
K6-16	6-Oct	660.5
K6-17	6-Oct	652.8
K6-18	6-Oct	659.4
K6-19	6-Oct	663.3
K6-19	8-Oct	663.3
K6-21	6-Oct	DRY
K6-22	6-Oct	645.1
K6-23	6-Oct	656.3
K6-24	6-Oct	DRY
K6-25	6-Oct	660.5
K6-26	6-Oct	639.3
K6-27	6-Oct	637.3
K6-32	6-Oct	DRY
K6-33	6-Oct	DRY
K6-34	6-Oct	629.9
K6-35	6-Oct	639.1
K6-36	6-Oct	DRY
W-33C-01	6-Oct	632.8
W-34-01	6-Oct	672
W-34-02	6-Oct	642.2
W-PIT6-1819	6-Oct	627.9

Table B-2. Volatile organic compounds detected in Pit 6 ground water samples, fourth quarter 2009.

Analytical method	VOCs detected	Well	Date sampled	Type	Result (μg/L)
EPA8260	cis-1,2-Dichloroethene	K6-01S	8-Oct	RTN	2.2
EPA8260	1,2-Dichloroethene (total)	K6-01S	8-Oct	RTN	2.2
EPA8260	Trichloroethene	EP6-09	8-Oct	RTN	8.8
EPA8260	Trichloroethene	EP6-09	8-Oct	DUP	9
EPA8260	Trichloroethene	K6-19	8-Oct	RTN	3.3

Table B-3. Tritium activity measurements in Pit 6 ground water samples, fourth quarter 2009.

Well	Date sampled	Routine or Duplicate	Activity (pCi/L)	Activity (Bq/L)
CARNRW1	5-Oct	RTN	<100	<3.7
CARNRW1	3-Nov	DUP	<100	<3.7
CARNRW1	3-Nov	RTN	<100	<3.7
CARNRW1	1-Dec	DUP	<100	<3.7
CARNRW1	1-Dec	RTN	<100	<3.7
CARNRW1	5-Oct	DUP	<100	<3.7
CARNRW2	5-Oct	RTN	<100	<3.7
CARNRW2	3-Nov	DUP	<100	<3.7
CARNRW2	3-Nov	RTN	<100	<3.7
CARNRW2	1-Dec	DUP	<100	<3.7
CARNRW2	1-Dec	RTN	108	4
CARNRW2	5-Oct	DUP	<100	<3.7
CARNRW3	5-Oct	RTN	<100	<3.7
CARNRW3	3-Nov	DUP	<100	<3.7
CARNRW3	3-Nov	RTN	<100	<3.7
CARNRW3	1-Dec	DUP	<100	<3.7
CARNRW3	1-Dec	RTN	100	3.7
CARNRW3	6-Oct	DUP	<100	<3.7
CARNRW4	6-Oct	RTN	<100	<3.7
CARNRW4	3-Nov	DUP	<100	<3.7
CARNRW4	3-Nov	RTN	<100	<3.7
CARNRW4	1-Dec	DUP	<100	<3.7
CARNRW4	1-Dec	RTN	<100	<3.7
CARNRW4	8-Oct	DUP	<100	<3.7
EP6-06	8-Oct	RTN	<100	<3.7
EP6-09	8-Oct	RTN	<100	<3.7
K6-01S	8-Oct	RTN	113	4.2
K6-17	5-Oct	RTN	<100	<3.7
K6-17	5-Oct	DUP	<100	<3.7
K6-19	8-Oct	DUP	276	10
K6-22	5-Oct	RTN	<100	<3.7
K6-34	5-Oct	RTN	117	4.3
W-PIT6-1819	5-Oct	RTN	156	5.8

Table B-4. Perchlorate and nitrate concentrations in Pit 6 ground water samples, fourth quarter 2009.

Well	Date sampled	Routine or duplicate	Perchlorate (μg/L)	Nitrate (as NO3) (mg/L)
CARNRW1	5-Oct	RTN	<4	<0.5
CARNRW1	5-Oct	DUP	<4	<0.5
CARNRW1	3-Nov	RTN	<4	<0.5
CARNRW1	3-Nov	DUP	<4	<0.5
CARNRW1	1-Dec	RTN	<4	0.8
CARNRW1	1-Dec	DUP	<4	<0.5
CARNRW2	5-Oct	RTN	<4	<0.5
CARNRW2	5-Oct	DUP	<4	0.6
CARNRW2	3-Nov	RTN	<4	<0.5
CARNRW2	3-Nov	DUP	<4	<0.5
CARNRW2	1-Dec	RTN	<4	<0.5
CARNRW2	1-Dec	DUP	<4	<0.5
CARNRW3	5-Oct	RTN	<4	<0.5
CARNRW3	5-Oct	DUP	<4	<0.5
CARNRW3	3-Nov	RTN	<4	<0.5
CARNRW3	3-Nov	DUP	<4	<0.5
CARNRW3	1-Dec	RTN	<4	<0.5
CARNRW3	1-Dec	DUP	<4	<0.5
CARNRW4	6-Oct	RTN	<4	<0.5
CARNRW4	6-Oct	DUP	<4	<0.5
CARNRW4	3-Nov	RTN	<4	<0.5
CARNRW4	3-Nov	DUP	<4	<0.5
CARNRW4	1-Dec	RTN	<4	<0.5
CARNRW4	1-Dec	DUP	<4	<0.5
EP6-06	8-Oct	RTN	<4	<0.5
EP6-09	8-Oct	RTN	<4	<0.5
EP6-09	8-Oct	DUP	<4	<0.5
K6-01S	8-Oct	RTN	<4	<1
K6-19	8-Oct	RTN	<4	<0.5

Table B-5. Pit 6 monitoring locations, monitoring functions, associated monitoring programs, COCs, monitoring frequencies, and fourth quarter 2009 sampling summary.

Monitoring location	Monitoring function	Monitoring program	COCs[a] (sampling frequency)	COCs analyzed	Reason(s), if not completed
K6-17	guard well	CAMP	P (Q), S (SA)	P	
K6-22	guard well	CAMP	P (Q), S (SA)	P	
K6-34	guard well	CAMP	P (Q), S (SA)	P	
W-PIT6-1819	guard well	CAMP	P (Q), S (SA)	P	
SPRING15	plume tracking spring	CAMP	P (A), S (A)	none	Not scheduled
BC6-10	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
BC6-13	plume tracking well	CAMP	P (A), S (A)	none	Not scheduled
EP6-07	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-01	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-03	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-04	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-14	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-15	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-16	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-18	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-21	plume tracking well	CAMP	P (A), S (A)	none	Not scheduled
K6-23	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-24	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-25	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-26	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-27	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-32	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-33	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-35	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
W-33C-01	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
EP6-06	release detection well	DMP	All (Q)	All	
EP6-08	release detection well	DMP	All (Q)	none	DRY
EP6-09	release detection well	DMP	All (Q)	All	
K6-01S	release detection well	DMP	All (Q)	All	
K6-19	release detection well	DMP	All (Q)	All	
K6-36	release detection well	DMP	All (Q)	none	DRY
CARNRW1	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW2	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW3	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW4	water supply well	CAMP	P (M), S (M)	P,S	

[a] "P" = primary contaminants of concern-tritium and VOCs. "S" = secondary contaminants of concern-perchlorate and nitrate. "All" = all DMP constituents of concern (see **Table C-1** for a list). "(M)" = sampled monthly. "(Q)" = sampled quarterly. "(SA)" = sampled semiannually (done first and third quarters of year). "(A)" = sampled annually (done first quarter of year).

Appendix C

Statistical Methods for Detection Monitoring

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Statistical Methods for Detection Monitoring

Monitoring and reporting provisions of the CERCLA closure and post-closure plan for the Pit 6 landfill require the use of statistical methods from the *California Code of Regulations* (CCR), Title 23, Division 3, Chapter 15, Section 2550.7 (Ferry *et al*., 1998).

We use statistically determined limits of concentration (SLs) to detect potential releases of constituents of concern (COCs) to ground water from solid wastes contained in the Pit 6 landfill. We employ two statistical methods, prediction intervals (PIs) and control charts (CCs), to generate SLs. Both methods are sensitive to COC concentration increases. Both methods are cost-effective, requiring only one measurement of a COC per quarter per monitoring well.

We prefer the PI method when COC concentrations in ground water are similar upgradient and downgradient from the monitored unit. We use parametric PI methods when the upgradient COC concentration data are all above the detection limit and the data are approximately normally distributed. We may use parametric methods on log-transformed data, if the transformed data follow a normal distribution. Nonparametric PI methods are more effective when the data cannot be transformed to a normal distribution, or when they contain nondetections.

When the concentration of a COC is spatially variable in the vicinity of a monitored unit, we develop a control chart for each downgradient monitoring well. The control chart compares each new quarterly COC measurement with its concentration history for that well.

Wherever sufficient historical detections exist, we calculate an SL such that any future measurement has approximately a 1-in-100 chance of exceeding the SL, when no change in concentration has actually occurred. This yields a statistical test with a significance level of approximately 0.01. Where historical detections exist, but nondetections constitute part of the data, we set the SL equal to the highest concentration measured. If historical analyses of a COC show all nondetections, then we set the SL equal to the analytical reporting limit (RL). When a routine COC measurement exceeds an SL, we perform two discrete retests. This method of data verification is in accordance with CCR Title 23, Chapter 15, Section 2550.7.

Constituents of Concern

COCs were identified for monitoring in the ground water at the Pit 6 landfill prior to its closure (Ferry *et al.,* 1998). COCs, as defined by CCR Title 22, Chapter 15, are

waste constituents, their reaction products, or hazardous constituents that are reasonably expected to be in or derived from waste buried in Pit 6. The current COCs for Pit 6 are listed in **Table C-1** below.

Table C-1. Pit 6 COCs, typical analytical reporting limit (RL), concentration limit (CL)[a] and statistical limit (SL) for each of the six detection monitoring wells.

Constituent of concern (COC)	Typical analytical RL (units)	Well EP6-06 CL; SL	Well EP6-08 CL; SL	Well EP6-09 CL; SL	Well K6-01S CL; SL	Well K6-19 CL; SL	Well K6-36 CL; SL
1,1,1-TCA	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
1,2-DCA	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Cis-1,2-DCE	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	5.4; 7.0	<RL; RL	<RL; RL
Chloroform	0.5 μg/L	<RL; RL	0.1; 1.0	<RL; RL	<RL; RL	0.2; 1.5	<RL; RL
Methylene chloride	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
PCE	0.5 μg/L	<RL; RL	0.4; 1.6	<RL; RL	<RL; RL	<RL; RL	0.5; 1.0
TCE	0.5 μg/L	<RL; RL	<RL; RL	14; 17	1.1; 1.5	8.2; 13	0.8; 2.1
Benzene	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Ethylbenzene	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Toluene	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Total xylenes	1.0 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Beryllium	0.5 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Mercury	0.2 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Carbon disulfide	5.0 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Perchlorate	4.0 μg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	10.2; 27.5	5.3; 14.4
Tritium	100 pCi/L	RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	2060; 2390
Uranium (total)	0.5 pCi/L	1.9; 3.6	1.2; 1.5	2.1; 3.7	6.6; 27	3.2; 7.2	0.5; 1.4
Gross alpha [b]	2 pCi/L	2.7; 7.7	0.9; 4.0	1.0; 4.9	7.0; 26	2.0; 9.2	<RL; RL
Gross beta [b]	2 pCi/L	8.6; 21	8.6; 21	8.6; 21	14; 58	8.6; 21	9.8; 26

[a] CL (concentration limit) is equivalent to the background concentration of a COC.

[b] Gross alpha and gross beta are surrogates for ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, and ^{232}Th.

Chlorinated VOCs (including TCE, PCE, 1,2-DCA, 1,1,1-TCA, methylene chloride, chloroform, benzene, toluene, ethylbenzene, and total xylenes) were detected historically in ground water and/or in soil adjacent to Pit 6. These VOCs are COCs.

Beryllium and mercury are COCs because they are listed in the waste disposal records for Pit 6.

Nine radionuclide COCs are associated with waste buried in Pit 6. They are ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, ^{232}Th, ^{238}U, and tritium. Gross alpha and gross beta

radioactivity are used as surrogates for seven of these nuclides, but not for uranium and tritium, which are measured separately (**Table C-1**).

A minor tritium release occurred prior to closure of Pit 6 and is the object of a continuing LLNL CERCLA investigation. The detection monitoring well BC6-12 was destroyed during year 2000, because it was screened across two water-bearing zones and could have provided a conduit for tritium in the shallower zone to contaminate ground water in the deeper zone. Well BC6-12 was replaced by well K6-36, which was constructed adjacent to it. Well K6-36 is screened only in the shallow water-bearing zone. Our calculated COC SLs for replacement well K6-36 are shown (**Table C-1)**.

A post-closure LLNL CERCLA study detected perchlorate in ground water downgradient of Pit 6. Consequently, perchlorate was added to the COC list and we have calculated SLs for this chemical (**Table C-1**).

Pesticides were not detected over an 18-month period (6 quarterly sampling events) following pit closure and were removed from the COC list.

Phthalates were not designated as COCs, because they were rarely detected prior to pit closure. However, since post-closure monitoring began in 1998, we have detected bis(2-ethylhexyl)phthalate (also known as di[2-ethylhexyl]phthalate, or DEHP) in ground water both upgradient and downgradient from Pit 6.

Table C-2 lists COCs that have indicated statistically significant evidence of release to ground water since post-closure monitoring began in 1998. **Table C-2** also lists the date of our 7-day letter notification to CVRWQCB and the status of any additional investigation of the COC. Note that 1,2-DCA has not been detected since 1998.

Table C-2. Pit 6 COCs showing statistical evidence of post-closure release.

COC	Date of 7-day letter report	Status of release investigation
1,2-DCA	10/13/98[a]	Transferred to ERD[b]
Perchlorate	11/08/02[c]	Retests did not confirm a release
Uranium	05/10/04[d]	Retest indicates a natural source
TCE	09/11/07[e]	Transferred to ERD[b]
Uranium	02/21/08[f]	Transferred to ERD[b]

[a] Galles, H. L., to S. Timm (1998), Letter: *Statistically Significant Evidence for a Release of 1,2-Dichloroethane from Pit 6* (WGMG98:282, October 13, 1998).

[b] LLNL Environmental Restoration Department.

[c] Raber, E., to T. Park, K. Setian, and S. Timm (2002), Letter*: Statistically Significant Evidence for a Release of Perchlorate from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG02-182, November 8, 2002).

[d] Raber, E., to T. Park, K. Setian, and S. Timm (2004), Letter: *Statistically Significant Evidence for a Release of Uranium from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG04-055, May 10, 2004).

[e] *Goodwin,S., to S. Timm (2007), Letter: Statistically Significant Evidence for a Release of Trichloroethene (TCE) from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG07-109, September 11, 2007).

[f] *Jackson, C.S., to S. Timm (2007), Letter: Statistically Significant Evidence for a Release of Total Uranium from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG08-022, February 21, 2008).

Appendix D

Changes in Monitoring Programs or Methods

Appendix D

Changes in Monitoring Programs or Methods

LLNL implemented a compliance monitoring program during the second quarter of 1998 for the CERCLA-closed Pit 6 landfill at Site 300. The program is described in detail in Ferry *et al.*, 1998.

During 2000, two new monitoring wells, designated K6-35 and K6-36, replaced monitoring wells BC6-11 and BC6-12, which were destroyed by grouting. Well K6-36, which is screened in the first (shallower) of two water-bearing zones, replaced well BC6-12 for release detection. Well K6-35, screened in the next deeper water-bearing zone, is used for corrective-action assessment.

By request of the CVRWQCB, we added perchlorate to the list of Pit 6 COCs during the third quarter of 2000.

By request of the CVRWQCB, since the third quarter of 2000, we have provided a table of information (**Table B-5)** that lists the Pit 6 CERCLA monitoring wells, their monitoring program assignments, their sampling frequencies, the COCs they monitor, and a reason if they were not sampled during the reported quarter.

During 2001, quarterly tritium monitoring was expanded to include CERCLA well K6-33 and the private, off-site, water-supply wells designated CARNRW1 and CARNRW2. During 2002 a new CERCLA guard well was completed downgradient from Pit 6 adjacent to the Site 300 boundary. This well is identified as W-PIT6-1819.

Beginning January 1, 2003 the CAMP sampling schedule and COCs have changed as described in the *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300* (Ferry, *et al.*, 2002). An expanded set of CAMP wells and springs will be sampled semiannually for tritium and VOCs, and annually for nitrate and perchlorate, while DMP well monitoring remains essentially unchanged. However, upgradient wells K6-03, K6-04, K6-15, and K6-32, which were formerly sampled quarterly for all the DMP COCs listed in **Table C-1**, are now designated to be CAMP plume-tracking wells and are sampled semiannually for tritium and VOCs and annually for nitrate and perchlorate only. As of fourth quarter 2004, VOCs have been reported as Total VOCs (TVOCs) to be consistent with other reports.

During 2006, reporting limits provided by the analytical laboratory for Environmental Protection Agency (EPA) Methods 200.8:Be, 601, and 624 changed due to a transition the contract laboratory's data management system. Essentially, the analytical laboratory had agreed to provide detection limits for EPA Methods 601 and

624, which were the same as EPA Method 8260. However, after the data management system change, the labs began reporting only what was specified in our contracts. As a result of this change in practice, the revisions have affected the reported non-detect concentrations for the following COCs: beryllium, benzene, chloroform, 1,2-dichloroethane (cis-1,2-DCE), cis-1,2-dichloroethene, ethylbenzene, PCE, toluene, 1,1,1-trichloroethane, and total xylenes. In all these cases, the different reporting limits represent practical quantitation limits (PQLs) selected by the analytical laboratory, not a change in measured concentrations. LLNL examined if contract modifications, changes in analytical suites, or a change of method would best solve the problem. Starting in second quarter 2007, we began reporting VOCs measured with EPA method 8260 and metals with the WGMGMET3 metal contract suite which provides detection limits consistent with, or lower than, past reports. No changes to this monitoring plan were made in 2009.

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Appendix E

Quality Assurance Sample Results

Table E-1. Quality assurance samples from Pit 6 during the fourth quarter 2009.

Date sampled: EP6-09 on 8-Oct-09

Constituent	EP6-09 Routine	EP6-09 Duplicate	PIT6FB*	Units
Total dissolved solids (TDS)	1300	1400	<6.7	mg/L
Beryllium	<0.2	<0.2	<0.2	µg/L
Mercury	<0.2	<0.2	<0.2	µg/L
Nitrate (as NO3)	<0.5	<0.5	<0.5	mg/L
Perchlorate	<4	<4	<4	µg/L
1,1,1-Trichloroethane	<0.5	<0.5	<0.5	µg/L
1,1,2,2-Tetrachloroethane	<0.5	<0.5	<0.5	µg/L
1,1,2-Trichloroethane	<0.5	<0.5	<0.5	µg/L
1,1-Dichloroethane	<0.5	<0.5	<0.5	µg/L
1,1-Dichloroethene	<0.5	<0.5	<0.5	µg/L
1,2-Dichloroethane	<0.5	<0.5	<0.5	µg/L
1,2-Dichloroethene (total)	<1	<1	<1	µg/L
1,2-Dichloropropane	<0.5	<0.5	<0.5	µg/L
cis-1,2-Dichloroethene	<0.5	<0.5	<0.5	µg/L
cis-1,3-Dichloropropene	<0.5	<0.5	<0.5	µg/L
2-Butanone	<10	<10	<10	µg/L
2-Chloroethylvinylether	<10	<10	<10	µg/L
2-Hexanone	<10	<10	<10	µg/L
4-Methyl-2-pentanone	<10	<10	<10	µg/L
Acetone	<10	<10	68	µg/L
Acrolein	<50	<50	<50	µg/L
Acrylonitrile	<50	<50	<50	µg/L
Benzene	<0.5	<0.5	<0.5	µg/L
Bromodichloromethane	<0.5	<0.5	<0.5	µg/L
Bromoform	<0.5	<0.5	<0.5	µg/L
Bromomethane	<0.5	<0.5	<0.5	µg/L
Carbon disulfide	<5	<5	<5	µg/L
Carbon tetrachloride	<0.5	<0.5	<0.5	µg/L
Chlorobenzene	<0.5	<0.5	<0.5	µg/L
Chloroethane	<0.5	<0.5	<0.5	µg/L
Chloroform	<0.5	<0.5	0.7	µg/L
Chloromethane	<0.5	<0.5	<0.5	µg/L
Dibromochloromethane	<0.5	<0.5	<0.5	µg/L
Dichlorodifluoromethane	<0.5	<0.5	<0.5	µg/L
Ethanol	<1000	<1000	<1000	µg/L
Ethylbenzene	<0.5	<0.5	<0.5	µg/L
Freon 113	<0.5	<0.5	<0.5	µg/L
Methylene chloride	<1	<1	<1	µg/L
Styrene	<0.5	<0.5	<0.5	µg/L
Tetrachloroethene	<0.5	<0.5	<0.5	µg/L
Toluene	<0.5	<0.5	<0.5	µg/L
Total xylene isomers	<1	<1	<1	µg/L
trans-1,2-Dichloroethene	<0.5	<0.5	<0.5	µg/L
trans-1,3-Dichloropropene	<0.5	<0.5	<0.5	µg/L
Trichloroethene	8.8	9	<0.5	µg/L
Trichlorofluoromethane	<0.5	<0.5	<0.5	µg/L
Vinyl acetate	<20	<20	<20	µg/L
Vinyl chloride	<0.5	<0.5	0.89	µg/L
Tritium	1.3 ± 1.5	1.6 ± 1.6	0.51 ± 1.5	Bq/L
Gross alpha	0.11 ± 0.060	0.24 ± 0.093	-0.0023 ± 0.023	Bq/L
Gross beta	0.27 ± 0.067	0.34 ± 0.084	0.021 ± 0.038	Bq/L
Uranium (total)	0.11 ± 0.019	0.089 ± 0.015	0.0010 ± 0.0015	Bq/L

* Field Blank

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