U.S. Department of Energy
National Nuclear Security Administration

Livermore Field Office, Livermore, California 94551

Lawrence Livermore National Laboratory

Lawrence Livermore National Security, LLC, Livermore, California 94551

LLNL-AR-579495

First Five-Year Review Report for Operable Units 3 and 8 at Lawrence Livermore National Laboratory Site 300

Authors:

M. Buscheck*
J. Valett*
M. Taffet
V. Dibley
V. Madrid
L. Ferry

Contributors:

A. Anderson*
A. Henke
T. Carlsen
G. Lorega
A. Helmig*
Z. Demir

June 2013

*Weiss Associates, Emeryville, California

Environmental Restoration Department

This work performed under the auspices of the U. S. Department of Energy/National Nuclear Security Administration by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.

9/12/13

Michael J. Taffet Date
California Professional Geologist
No. 5616
License expires: May 31, 2015
California Certified Hydrogeologist
No. 129
License expires: May 31, 2015

Approval for the First Five-Year Review for Operable Units 3 and 8 at Lawrence Livermore National Laboratory Site 300

Prepared by:

The United States Department of Energy
Livermore Field Office
Livermore, California

Approved:

Claire S. Holtzapple 9-16-13

Claire S. Holtzapple **Date**

Site 300 Remedial Project Manager
U.S. Department of Energy
National Nuclear Security Administration
Livermore Field Office

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

SEP 10 2013

Via USPS and email

Claire Holtzapple
U.S. Department of Energy
Livermore Environmental Programs Division
Lawrence Livermore National Laboratory
P.O. Box 808, L-574
Livermore, California 94551

Re: U.S. EPA Concurrence with Final First Five-Year Review Report for Operable Units 3 and 8, Lawrence Livermore National Laboratory Site 300, June 2013

Dear Ms. Holtzapple:

The U.S. Environmental Protection Agency ("EPA" or "Agency") has reviewed the final First Five-Year Review Report for the Operable Units 3 and 8 at the Lawrence Livermore National Laboratory (LLNL) Site 300 ("Site"), dated June 2013("Final Report")[1]. EPA appreciates that DOE has addressed the Agency's concerns with the Draft and Draft Final Reports including submittal of a Response to Comments ("RTC"). EPA agrees with the majority of the overall findings, conclusions and recommendations in the Final Report, as modified by the RTCs, and concurs with the short and long-term protectiveness statements for all of the sub-sites addressed by the two operable units ("OUs") with the exception of the Building 851 Firing Table Site[2].

EPA does not concur with the Final Report's protectiveness statement as it applies to long-term protectiveness at the Building 851 Firing Table. The remedy for OUs 3 and 8 is currently protective in the short-term, however for long-term protectiveness to be achieved overall for OUs 3 and 8, additional characterization and a remedy reevaluation must be implemented with respect to the Building 851 Firing Table in accordance with the specifications agreed to by the regulatory agencies.

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[1] The electronic file name of the document contained on the CD provided by DOE is the "Final Five Year Review Report". However, the document associated with that file name does not include the term "Final" in either the title on the cover page or the document name included in the header of each page.
[2] On August 22, 2013, DOE informed EPA about new information indicating the presence of significant levels of depleted uranium, which will require additional characterization.

The remedy is protective of human health and the environment for the Site's industrial land use with respect to on-site workers in the short term. While the remedial systems are operating, the remedy is protective of human health because exposure pathways that could result in unacceptable risk to on-site workers are being controlled by the implementation of on-site institutional controls (ICs), the LLNL Site 300 Health and Safety Plan, and the LLNL Site 300 Contingency Plan.

The remedy is protective of human health and the environment for the Site's industrial land use with respect to on-site workers in the long term. The cleanup standards for groundwater are drinking water Maximum Contaminant Levels (MCLs). For contaminants in subsurface soil, the cleanup standards are based on the reduction of concentrations to mitigate risk to on-site workers and prevent further impacts to groundwater. Because some contaminants may remain in subsurface soil following the achievement of the soil cleanup standards, proprietary controls are put into place. These prohibitions will remain in place until and unless a risk assessment is performed in accordance with current EPA risk assessment guidance and is agreed to by the Department of Energy, EPA, and the State agencies as adequately demonstrating no unacceptable risk for unrestricted use and unlimited exposure scenarios.

On the basis of the information presented in the Final Report, EPA has made the following protectiveness determination:

The remedy at LLNL Site 300, OUs 3 and 8, is expected to be protective upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. The remedy protects human health and the environment in the short term because there is no current exposure to site contamination and remedial treatment systems are effectively treating groundwater and soil gas. With exception of the Building 851 Firing Table, the remedy will protect human health and the environment in the long term because after the completion of active remedial activities Land Use Controls will prevent exposure pathways until such time it is demonstrated that there no longer is a risk to human health from unrestricted use and unlimited exposure scenarios. With regard to the Building 851 Firing Table, however, LLNL must further characterize the site to assess the risk and potentially modify the remedy accordingly, to be protective in the long term at Building 851.

This Five-Year Review identifies several recommendations which will be implemented as part of the routine administrative or programmatic processes that are already in place to optimize the operation of the remedy. EPA understands DOE is considering our prior request to develop a formal plan and schedule to consolidate the individual FYR documents, into two logical groupings for future deliverables. Please provide us with the plan at your earliest convenience so that we may update the FFA schedule accordingly.

We appreciate the opportunity to work with you on this project and look forward to continued success at LLNL Site 300. If you have any questions regarding this letter, please feel free to contact Andrew Bain at (415) 972-3167.

Sincerely,

Michael M. Montgomery
Assistant Director, Superfund Division
Federal Facilities and Site Cleanup Branch

cc by EMail: Leslie Ferry, LLNL
Jacinto Soto, DTSC
Aimee Phiri, CVRWQCB

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Lawrence Livermore National Laboratory Site 300, Pit 6 Landfill Operable Unit (OU) 3 and OU 8		
EPA ID: CA 2890090002		
Region: IX	State: California	City/County: San Joaquin/Alameda
SITE STATUS		
NPL status: Final		
Multiple OUs: Yes	Has the site achieved construction completion? Yes. OU 3: January 18, 2008 OU 8: Not Applicable	
REVIEW STATUS		
Lead agency: United States (U.S.) Department of Energy (DOE)/National Nuclear Security Administration (NNSA)		
Author name: M. Buscheck		
Author title: Project Hydrogeologist	Author affiliation: Weiss Associates - Emeryville, California	
Review period: January 1, 2007 to January 1, 2012		
Date(s) of site inspection: August 16, 2011		
Type of review: Statutory		
Review number: 1		
Triggering action date: OU 3: The Remedial Action Completion Report: January 18, 2008 OU 8: 2008 Site-Wide Record of Decision (ROD): July 10, 2008		
Due date: March 15, 2013		

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
Not applicable.				
Issues/Recommendations Identified in the Five-Year Review:				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. However, some follow-up actions are recommended to optimize remediation.			
	Recommendation #1: Monitor trichloroethene (TCE) concentrations in ground water at well EP6-09 over the next five years; if concentrations increase or remain above 5 micrograms per liter (µg/L), remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** Date by which monitoring of TCE concentrations trends in well EP6-09 will be completed.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #2: Remove 1,2-dichloroethane (1,2-DCA) as a ground water contaminant of concern (COC) because: (1) concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L Maximum Contaminant Level (MCL) cleanup standard and reporting limit in all Qt-$Tnbs_1$ hydrostratigraphic unit (HSU) wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), and (2) 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for volatile organic compounds (VOCs) by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,2-DCA) in the detection monitor wells. 1,2-DCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of 1,2-DCA as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #3: Remove cis-1,2-dichloroethene (cis-1,2-DCE) as a ground water COC because: (1) cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), (2) cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011), and (3) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including cis-1,2-DCE) in the detection monitor wells. Cis-1,2-DCE concentrations would still be reported/discussed as part of the evaluation of TCE monitored natural attenuation (MNA) and detection monitoring in the Compliance Monitoring Reports.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of cis-1,2-DCE as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #4: Remove trans-1,2-DCE as a ground water COC because concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including trans-1,2-DCE) in the detection monitor wells. Trans-1,2-DCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of trans-1,2-DCE as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #5: Remove tetrachloroethene (PCE) as a ground water COC because: (1) PCE has never been detected at concentrations exceeding its 5 µg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 µg/L in 1988), and (2) PCE has not been detected at concentrations above the 0.5 µg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including PCE) in the detection monitor wells. PCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of PCE as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #6: Remove 1,1,1-trichloroethane (1,1,1-TCA) as a ground water COC because: (1) 1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990), and (2) 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,1,1-TCA) in the detection monitor wells. 1,1,1-TCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of 1,1,1-TCA as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #7: Remove perchlorate as a ground water COC because perchlorate concentrations have decreased to and remained below the 4 µg/L reporting limit in all Pit 6 wells for over three years (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill. The perchlorate results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of perchlorate as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 801/ Pit 8 Landfill	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. However, some follow-up actions are recommended to optimize remediation.			
	Recommendation #1: Install additional monitor wells in the $Tnbs_1/Tnbs_0$ HSU in the vicinity of the Pit 8 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells located north of the landfill and potentially one monitor well located south of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, DOE/NNSA will request over-target funds to conduct this additional work. However, the schedule for completion of this work is contingent upon the timing of Congressional approval of this over-target funding.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 845 Firing Table/ Pit 9 Landfill	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. However, some follow-up actions are recommended to optimize remediation.			
	Recommendation #1: Install additional monitor wells in the $Tnsc_0$ HSU in the vicinity of the Pit 9 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells east of the landfill and potentially one monitor well west of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, DOE/NNSA will request over-target funds to conduct this additional work. However, the schedule for completion of this work is contingent upon the timing of Congressional approval of this over-target funding.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 833	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. Some follow-up actions are recommended.			
	Recommendation #1: No opportunities to improve remedy performance were identified. However, DOE/NNSA recommends removing cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells, including well W-833-30, screened in the deeper $Tnbs_1$ HSU. However, ground water samples from Building 833 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	March 30, 2018*

*** This milestone is complete based on regulatory concurrence for removal of cis-1,2-DCE as a ground water COC as indicated in Attachment B.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 851 Firing Table	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. However, some follow-up actions are recommended to optimize remediation.			
	Recommendation #1: Install additional monitor wells in the Tmss HSU in the vicinity of Building 851 to ensure full monitoring capability under the nearly flat ground water gradient. Up to two monitor wells located southwest and northwest of Building 851 are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date***
No	No	DOE	EPA/State	March 30, 2018*

*** Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, DOE/NNSA will request over-target funds to conduct this additional work. However, the schedule for completion of this work is contingent upon the timing of Congressional approval of this over-target funding.**

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT		
OU: OU 3 and OU 8	**Protectiveness Determination** Protective	**Addendum Due Date:** NA

Protectiveness Statement: The remedies at OU 3 (also called Pit 6 Landfill OU) and OU 8 currently protect human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

DOE/NNSA's recommendations to install additional monitor wells in the vicinity of the Pit 8 and Pit 9 Landfills and Building 851 will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions at the Pit 8 and Pit 9 Landfills and under the flat ground water gradient at Building 851.

The cleanup standards for ground water at Site 300 are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Implementing the cleanup standards for VOCs in subsurface soil reduce concentrations to mitigate risk to onsite workers and prevent further impacts to ground water to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide Record of Decision (ROD) requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substance s Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

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Attachment B

Attachment B1. Responses to Regulatory Comments on the Draft Five Year Review.

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1. Introduction

The United States (U.S.) Department of Energy/National Nuclear Security Administration (DOE/NNSA) has conducted a Five-Year Review of the remedial actions implemented at the Operable Unit (OU) 3 (the Pit 6 Landfill OU) and OU 8 (the Site-Wide OU) at Lawrence Livermore National Laboratory (LLNL) Site 300. Environmental cleanup is conducted under the oversight of the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) – Central Valley Region. DOE is the lead agency for environmental restoration at LLNL. The review documented in this report was conducted from January 2007 to January 2012. Parties providing analyses in support of the review include:

- U.S. DOE/NNSA, Livermore Field Office.
- LLNL, Environmental Restoration Department (ERD).
- Weiss Associates.

The purpose of a Five-Year Review is to evaluate the implementation and performance of a remedy to determine whether the remedy is currently and will continue to be protective of human health and the environment. The Five-Year Review report presents the methods, findings, and conclusions of the review. In addition, the Five-Year Review identifies issues or deficiencies in the selected remedy, if any, and presents recommendations to address them. The format and content of this document is consistent with guidance issued by DOE (DOE, 2002) and the U.S. EPA (EPA, 2001).

Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendment Reauthorization Act (SARA), requires that remedial actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. The National Contingency Plan further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment. Consistent with Executive Order 12580, Federal agencies are responsible for ensuring that Five-Year Reviews are conducted at sites where five-year reviews are required or appropriate.

LLNL Site 300 is a U.S. DOE/NNSA experimental test facility operated by the Lawrence Livermore National Security (LLNS), Limited Liability Corporation. It is located in the Eastern Altamont Hills 17 miles east of Livermore, California (Figure 1). At Site 300, DOE/NNSA conducts research development, and testing associated with high-explosive materials. Historic Site 300 operations involved the release of a number of contaminants to the environment. These releases occurred primarily from spills, leaking pipes, leaching from unlined landfills and pits, high explosive test detonations, and disposal of waste fluids in lagoons and dry wells (sumps). Nine Operable Units (OUs) have been designated at LLNL Site 300 based on the nature and extent of contamination to effectively manage site cleanup (Figure 2):

- General Services Area (GSA) (OU 1) including the Central and Eastern GSA.
- Building 834 (OU 2).

- Pit 6 Landfill (OU 3).
- High Explosives (HE) Process Area (OU 4) including Building 815, the HE Lagoons, and the HE Burn Pit.
- Building 850/Pit 7 Complex (OU 5).
- Building 854 (OU 6).
- Building 832 Canyon (OU 7) including Buildings 830 and 832.
- Site-Wide (OU 8) including Buildings 801, 833, 845, and 851 and the Pit 2, 8, 9 Landfills.
- Building 812 (OU 9).

With the exception of this five-year review for OUs 3 and 8, five-year reviews are currently conducted individually for each OU at Site 300. The Remedial Action Completion Report (Holtzapple, 2008) completed on January 18, 2008 and Site-Wide Record of Decision (ROD) (U.S DOE, 2008) completed on July 10, 2008 are the triggers for start of the first five-year review period for OUs 3 and 8, respectively, in accordance with U.S. EPA guidance (U.S. DOE, 2002). At the other OUs where construction began prior to the Site-Wide ROD as treatability studies and/or removal actions, DOE and the regulatory agencies agreed to use the completion of the OU-specific Remedial Design report as the trigger for start of the first five-year review period.

This is the first Five-Year Review for OUs 3 and 8. This review is considered a statutory review because: (1) contamination will remain onsite upon completion of the remedial action, (2) the Record of Decision was signed after October 17, 1986 (the effective date of the SARA), and (3) the remedial action was selected under the CERCLA.

Section 2 presents the Five-Year Review for the OU 3 (Pit 6 Landfill OU). Section 3 presents the Five-Year Review for OU 8 (Site-Wide). The background and description of OUs 3 and 8 are presented in Sections 2 and 3, respectively. The following sections include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300.

1.1. General Services Area (GSA) OU (OU 1)

The GSA OU has been separated into the Central GSA and the Eastern GSA based on differences in hydrogeology and the distribution of environmental contaminants. DOE has performed three Five-Year Reviews for the GSA OU (Ferry et al., 2001a; Dibley et al., 2006; and Valett et al., 2011). The Third Five-Year Review for the GSA determined that additional offsite land use controls are necessary for long-term protectiveness due to the presence of contamination in offsite ground water. The fourth Five-Year Review is scheduled for 2016.

1.1.1. Central GSA

Chlorinated solvents, mainly trichloroethene (TCE), were used as degreasing agents in craft shops in the Central GSA. Rinse water from these degreasing operations was disposed of in dry wells that were gravel-filled holes about 3 to 4 feet (ft) deep and two ft in diameter. As a result, subsurface soil and ground water was contaminated with volatile organic compounds (VOCs). There are no contaminants of concern (COCs) in surface soil in the central GSA. The Central

GSA dry wells were used until 1982. In 1983 and 1984, these dry wells were decommissioned and excavated.

Ground water cleanup began in the Central GSA in 1992 and soil vapor extraction started in 1994 as removal actions. In 1997, a Final ROD for the GSA OU (U.S. DOE, 1997) was signed and ground water and soil vapor extraction and treatment continued as a remedial action. The selected remedy for the Central GSA includes monitoring, risk and hazard management including land use controls, and ground water and soil vapor extraction and treatment. The remedial design was completed in 1998 and construction completion for the OU was achieved in September 2005.

Operation of the ground water and soil vapor extraction and treatment systems to remove VOCs from the subsurface is ongoing. Remediation has reduced maximum VOC concentrations in ground water from a historic maximum of 272,000 micrograms per liter (µg/L) to a 2011 maximum of 1,162 µg/L (March 2011) and has mitigated the risk to onsite workers from inhalation of VOCs inside Building 875.

1.1.2. Eastern GSA

The source of contamination in the Eastern GSA is an abandoned debris burial trench that received craft shop debris. Leaching of solvents from the debris resulted in the release of VOCs to ground water.

Ground water cleanup began in the Eastern GSA in 1991 as a removal action. In 1997, a Final ROD for the GSA OU was signed and ground water extraction and treatment continued as a remedial action. The remedial design was completed in 1998 and construction completion for the OU was achieved in September 2005. A ground water extraction and treatment system operated from 1991 to 2007 to remove VOCs from ground water.

As of July 2005, remediation had reduced VOC concentrations in on- and offsite ground water to meet cleanup standards. In February 2007, the treatment system was shut off and placed on standby with regulatory concurrence. Post-shutdown monitoring is being conducted to determine if VOC concentrations rebound above cleanup standards. If VOC concentrations remain below cleanup standards for five years, the treatment system and associated wellfield will be decommissioned. (Note: Although it falls outside this five-year review period, in February 2012, the five-year post-shutdown monitoring was completed. VOCs concentrations in Eastern GSA ground water remained below the cleanup standards during this five year monitoring period.)

1.2. Building 834 (OU 2)

From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface soil and rock and ground water with VOCs and silicone oils (tetrabutyl orthosilicate/tetrakis (2-ethylbutyl) silane [TBOS/TKEBs]). Nitrate in ground water may result from a combination of septic system discharge and naturally occurring nitrate in ground water. There are no COCs in surface soil.

Completed remedial activities include excavating VOC-contaminated soil (1983) and installing a surface water drainage system to prevent rainwater infiltration in the contaminant source area (1998). Ground water and soil vapor extraction and treatment began in 1986 as treatability studies. An area-specific Interim ROD for the Building 834 OU (U.S. DOE, 1995)

was superseded by the Interim ROD (U.S. DOE, 2001) and subsequent 2008 Site-Wide ROD. The Building 834 OU remedy includes monitoring, risk and hazard management including land use controls, and ground water and soil vapor extraction and treatment. Significant *in situ* bioremediation is occurring in Building 834 ground water and a treatability study was conducted that focused on understanding and enhancing this process. The remedial design was completed in 2002 and construction completion for the OU was achieved in September 2005.

Remediation has reduced VOC concentrations in ground water from a historic maximum of 1,060,000 µg/L to a 2011 maximum of 210,000 µg/L (February 2011). TBOS/TKEBs in ground water have also been reduced from a historic maximum concentration of 7,300,000 µg/L in 1995 to a 2011 maximum of 4,800 µg/L (February 2011). While nitrate concentrations have decreased from a historic maximum of 749 milligrams per liter (mg/L) in 2000 to a 2011 maximum of 300 mg/L (February 2011), the elevated nitrate concentrations continue to indicate an ongoing source of ground water nitrate. It is likely that there are multiple sources of nitrate at Building 834. One possible anthropogenic source is the septic system leach field located in the vicinity of wells W-834-S1. A second probable source is natural soil nitrate. Additional sources could be nitrogenous compounds, like nitric acid or barium nitrate, that might have inadvertently been discharged into the septic system via a test cell floor drain or to the ground during accidental spills and/or pipeline leaks that released TCE to the environment. Anaerobic bacteria in the Building 834 Core and T2 areas reduce nitrate locally by denitrification.

DOE has performed three Five-Year Reviews for the Building 834 OU (Ferry et al., 2002a, Dibley et al., 2007a, and Valett et al., 2012). The next Five-Year Review Report is scheduled for 2017.

1.3. High Explosive (HE) Process Area (OU 4)

From 1958 to 1986, surface spills at the drum storage and dispensing area for the former Building 815 steam plant resulted in the release of VOCs to ground water, subsurface soil, and bedrock. HE compounds, nitrate, and perchlorate detected in ground water are attributed to wastewater discharges to former unlined rinse water lagoons that occurred from the 1950s to 1985. VOCs, nitrate, and perchlorate have also been identified as COCs in ground water near the former HE Burn Pits. VOCs have been identified as COCs in surface water at Spring 5. HE compounds are the COCs in surface soil. HE compounds and VOCs are the COCs in subsurface soil. No further action was selected as the remedy for VOCs and High-Melting Explosive (HMX) in surface and subsurface soil.

The HE Open Burn Facility was capped under the Resource Conservation and Recovery Act (RCRA) in 1998. In 1999, DOE implemented a CERCLA removal action to extract ground water at the site boundary and prevent offsite TCE migration. The HE Process Area remedy includes: (1) ground water extraction and treatment for VOCs, HE compounds, and perchlorate, and (2) monitored natural attenuation (MNA) for nitrate (except at Building 829 where nitrate is extracted and treated), (3) monitoring, and (4) risk and hazard management including land use controls. The remedial design was completed in 2002. Construction completion for the OU was achieved in September 2007. Six ground water extraction and treatment systems currently operate in the OU.

Ground water remediation efforts have reduced total VOC concentrations from a historic maximum of 1,013 µg/L in 1993 to a 2011 maximum of 54 µg/L (July 2011). Perchlorate

concentrations have decreased from a historic maximum of 50 µg/L in 1998 to a 2011 maximum of 29 µg/L (May 2011). Research Department Explosive (RDX) in ground water has been reduced from a maximum historic concentration of 350 µg/L in 1988 to a 2011 maximum concentration of 163 µg/L (August 2011). Natural denitrification processes are reducing nitrate concentrations in ground water to background levels. Remediation has also mitigated risk to onsite workers in the HE Process Area OU.

DOE has performed two Five-Year Reviews for the High Explosives Process Area OU (Dibley et al., 2007b and Helmig et al., 2012). The Second Five-Year Review for the High Explosives Process Area determined that additional off-site land use controls are necessary for long-term protectiveness due to the presence of contamination in offsite ground water. The next Five-Year Review Report is scheduled for 2017.

1.4. Building 850/Pit 7 Complex (OU 5)

This OU has been divided into two areas for cleanup purposes: (1) the Building 850 Firing Table area, and (2) the Pit 7 Complex.

A Remedial Action Completion Report for the Building 850/Pit 7 Complex OU was completed in 2011 (Dibley et al., 2011b). The first Five-Year Review Report for this OU is scheduled for 2016.

1.4.1. Building 850 Firing Table (OU 5)

High-explosives experiments were conducted at the Building 850 Firing Table from 1958 to 2008. Tritium was used in some of these experiments, primarily between 1963 and 1978. As a result of the destruction and dispersal of test assembly debris during detonations, surface soil was contaminated with metals, polychlorinated biphenyls (PCBs), dioxins, furans, HMX, and depleted uranium. Leaching from firing table debris has resulted in tritium and depleted uranium contamination in subsurface soil and ground water. Nitrate and perchlorate are also COCs in ground water. Tritium is the only COC in surface water (Well 8 Spring).

Gravel was removed from the firing table in 1988 and placed in the Pit 7 Landfill. PCB-contaminated shrapnel and debris were removed from the area around the firing table in 1998. The Building 850 remedy consists of MNA of tritium in ground water, monitoring, and risk and hazard management including land use controls. A remedial design was completed in 2004. The remedial design included the excavation and off-site disposal of contaminated surface soil and sand pile. This remedy was not implemented due to a large increase in transportation and offsite disposal costs. DOE and the regulatory agencies agreed to perform remediation of contaminated surface soil as a non-time critical removal action. An Engineering Evaluation/Cost Analysis (Dibley et al., 2008a) and Action Memorandum (Dibley et al., 2008b) were completed in 2008. A removal action was completed in 2010 for the excavation and solidification of PCB-, dioxin-, and furan-contaminated soil and sand pile. Metals, HMX, and uranium in surface soil at Building 850 do not pose a risk to human health or threat to ground water, therefore a no further action remedy was selected. However, these constituents in surface soil were removed during the soil excavation/solidification removal action.

Natural attenuation has reduced tritium activities from a historic maximum of 566,000 picoCuries per liter (pCi/L) in 1985 to a 2011 maximum of 53,300 pCi/L (May 2011). Uranium activities are below the cleanup standard and are within the range of natural

background levels. The extent of nitrate with concentrations above cleanup standards is limited and does not pose a threat to human health or the environment. The maximum perchlorate concentration in 2011 was 74 µg/L (April 2011). A treatability study to evaluate *in situ* biodegradation of perchlorate is in progress.

1.4.2. Pit 7 Landfill Complex (OU 5)

The Pit 3, 4, 5, and 7 Landfills collectively comprise the Pit 7 Landfill Complex. Firing table debris containing tritium, depleted uranium, and metals was placed in the pits between 1958 and 1988. The Pit 4 and 7 Landfills were capped in 1992. The cap also covers about 30% of Pit 3. During years of above-normal rainfall (i.e., 1997-1998 El Niño event), ground water rose into the bottom of the landfills and the underlying contaminated bedrock. This resulted in the release of tritium, uranium, VOCs, perchlorate, and nitrate to ground water. There are no COCs in surface water or surface soil. Tritium and depleted uranium are COCs in subsurface soil.

DOE and the regulatory agencies agreed that the Pit 7 Complex required additional study. As a result, this area was not included in the 2001 Interim ROD and an area-specific Remedial Investigation/Feasibility Study (Taffet et al., 2005) was completed. An Amendment to the Interim ROD for the Pit 7 Complex was signed in 2007 (U.S. DOE, 2007) that described the selected remedy for the Pit 7 Complex including monitoring, risk and hazard management including land use controls, MNA, ground water extraction and treatment, and source control. The interim remedial design was completed in 2008. Construction of a drainage diversion system, designed to divert recharge away from the pits and minimize water table rises during intense rainfall events, was completed in 2008. Also, a ground water extraction and treatment system was constructed in 2009-2010 to treat uranium, nitrate, perchlorate, and VOCs in ground water.

Natural attenuation has reduced tritium activities in ground water from a historic maximum of 2,660,000 pCi/L in 1998 to a 2011 maximum of 575,000 pCi/L (April 2011) and has mitigated risk to onsite workers from inhalation of tritium vapors. Uranium activities have also decreased from a historic maximum of 781 pCi/L in 1998 to a 2011 maximum of 172 pCi/L (April 2011). VOC concentrations are currently near or below cleanup standards. Nitrate concentrations in ground water remain relatively stable, while perchlorate concentrations have decreased.

1.5. Building 854 (OU 6)

TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid, primarily between 1967 and 1984. Nitrate and perchlorate are also COCs in ground water. HE compounds (HMX), PCBs, dioxins, furans, tritium, and metals were identified as COCs in surface soil. No further action was selected as the remedy for metals, HMX, and tritium in surface soil.

In 1983, TCE-contaminated soil was excavated at the northeast corner of Building 854F. Ground water extraction and treatment has been conducted since 1999 to reduce VOC, nitrate, and perchlorate concentrations in ground water. PCB-, dioxin-, and furan-contaminated soil in the Building 855 former rinse water lagoon was excavated in 2005 (Holtzapple, 2005). The selected remedy for this OU includes monitoring, risk and hazard management including land use controls, and ground water and soil vapor extraction and treatment. The interim remedial design was completed in 2003. Construction completion for the OU was achieved in

September 2007. Three ground water extraction and treatment systems and one soil vapor extraction and treatment system currently operate in the OU.

Ground water remediation has reduced total VOC concentrations from a historic maximum of 2,900 µg/L in 1997 to a 2011 maximum of 120 µg/L (October 2011). Nitrate concentrations have decreased from a historic maximum of 260 mg/L in 2003 to a 2011 maximum of 180 mg/L (June 2011). Perchlorate concentrations in ground water have also decreased from 27 µg/L in 2003 to a 2011 maximum of 16.4 µg/L (October 2011). Risks to onsite workers from inhalation of VOC vapors and from exposure to PCBs, dioxins, and furans in surface soil have been mitigated.

A Five-Year Review of remediation in the Building 854 OU was completed in January 2009 (Dibley et al., 2009a). The second Five-Year-Review Report is scheduled for 2014.

1.6. Building 832 Canyon (OU 7)

Contaminants were released from Buildings 830 and 832 through piping leaks and surface spills during past activities at these buildings. VOCs, nitrate, and perchlorate are the COCs in ground water. VOCs are the COCs in surface water at Spring 3. VOCs, nitrate, and HMX are the COCs in subsurface soil. HMX is also a COC in surface soil. No further action was selected as the remedy for HMX in surface soil and HMX and nitrate in subsurface soil.

Ground water and soil vapor extraction and treatment have been conducted since 1999 to reduce contamination in ground water and subsurface soil. The Building 832 Canyon OU remedy includes monitoring, risk and hazard management including land use controls, MNA for nitrate, and ground water and soil vapor extraction and treatment. The interim remedial design was completed in 2006. Construction completion for the OU was achieved in September 2007. Three ground water extraction and treatment systems and two soil vapor extraction and treatment systems currently operate in the OU.

Remediation has reduced total VOC concentrations from a historic maximum of 13,000 µg/L in 2003 to a 2011 maximum of 3,800 µg/L (October 2011). Perchlorate concentrations have been reduced from a historic maximum of 51 µg/L in 1998 to a 2011 maximum of 14 µg/L (March 2011). Nitrate concentrations in ground water remain fairly stable, and are possibly the result of the ongoing contribution of nitrate from septic systems and natural bedrock sources. Natural denitrification processes continue to reduce nitrate concentrations to background levels near the site boundary. Remediation has also mitigated the risk to onsite workers at several locations in the Building 832 Canyon OU.

A Five-Year Review of remediation in the Building 832 Canyon OU was completed in August 2011 (Helmig et al., 2011). The second Five-Year-Review Report is scheduled for 2016.

1.7. Building 812 (OU 9)

The Building 812 Complex was built in the late 1950s-early 1960s and was used to conduct explosives tests and diagnostics until 2008. A Characterization Summary Report for this area was completed in 2005 (Ferry and Holtzapple, 2005). The Building 812 Complex was designated as OU 9 in March 2007 based on characterization results that indicated the presence of uranium, VOCs, HE compounds, nitrate, and perchlorate in environmental media. In 2008, a draft Remedial Investigation/Feasibility Study (RI/FS) describing the results of characterization

activities and remedial alternatives for the Building 812 OU was submitted to the regulatory agencies and a DOE task force. The DOE task force recommended additional characterization be performed at the OU and the regulatory agencies agreed. Additional characterization began in 2011 and will continue through 2012. A new RI/FS report is scheduled for 2014 following the completion of the characterization. A Proposed Plan will subsequently present the alternatives and a preferred remedy for public comment. A remedy will then be selected in an Amendment to the Site-Wide ROD.

1.8. Building 865/Advanced Test Accelerator

Building 865 facilities were used to conduct high-energy laser tests and diagnostics in support of national defense programs from 1980 to 1995. The Building 865 Complex housed a 275-foot linear electron accelerator called the Advanced Test Accelerator (ATA). The ATA was designed to produce a repetitively pulsed electron beam for charged particle beam research. In 2006, a Characterization Summary Report for this area was submitted to the regulatory agencies (Ferry and Holtzapple, 2006). Freon 113, Freon 11, and tetrachloroethene (PCE) were identified as COCs in ground water. A Building 865 Technical Memorandum in Support of a Record of Decision Amendment (TMSRA) is scheduled for 2013.

2. Five-Year Review for the Pit 6 Landfill OU (OU 3)

2.1. Pit 6 Landfill OU Site Chronology

The following is a chronological listing of significant environmental restoration events at the Pit 6 Landfill OU:

1964 to 1972

- Waste was buried in the Pit 6 Landfill.

1971

- DOE/LLNL excavated waste containing depleted uranium from the landfill.

1982

- Site investigations began at the Pit 6 Landfill.

1984

- Monitoring of ground water began in downgradient active water-supply wells CARNRW1 and CARNRW2.

1987

- VOCs were first detected in ground water at the Pit 6 Landfill.

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A Federal Facilities Agreement (FFA) was signed for Site 300.
- Monitoring of ground water began in downgradient inactive water-supply well CARNRW3.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued that included the Pit 6 Landfill OU.
- A Feasibility Study for the Pit 6 Landfill OU was issued.

1997

- The Pit 6 Landfill was capped and closed under CERCLA.

1998

- Limited short-term ground water extraction and treatment of VOCs in ground water was conducted as a treatability study.
- A Post-Closure Plan for the Pit 6 Landfill OU was issued (Ferry et al., 1998).

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Pit 6 Landfill OU (Ferry et al., 1999).

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified monitoring of ground water and surface water, risk and hazard management (e.g., land use controls) to prevent human exposure to contaminants and impacts to ecological receptors, and monitored natural attenuation of VOCs and tritium in ground water for OU 3. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD (Ferry et al., 2001).

2002

- The Compliance Monitoring Plan/Contingency Plan (CMP/CP) for Interim Remedies was issued (Ferry et al., 2002).

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were added in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued (Dibley et al., 2009b).

2.2. Pit 6 Landfill OU Background

2.2.1. Pit 6 Landfill OU Physical Characteristics

2.2.1.1. Pit 6 Landfill OU Site Description

The Pit 6 Landfill OU covers an area of 2.6 acres near the southwest corner of Site 300 (Figure 2). The LLNL buildings located in the OU are used to support firearms training operations by the LLNL Protective Forces Department. From 1964 to 1973, waste from the LLNL Livermore Site and Lawrence Berkeley Laboratory was buried in three unlined debris

trenches and six animal pits located at the Pit 6 Landfill (Figure 3). The waste included laboratory equipment, craft shop debris, and biomedical waste. DOE/LLNL excavated the portion of waste containing depleted uranium in 1971. VOCs, tritium, nitrate, and perchlorate were identified as COCs in ground water and VOCs as COCs in surface water when present in Spring 7. No COCs were identified in surface soil or subsurface soil/rock in the vadose zone. COCs are discussed in more detail in Section 2.2.5.

The Pit 6 Landfill was capped and closed in 1997 under CERCLA to prevent further leaching of contaminants that likely resulted from percolation of rainwater through the buried waste. The engineered, multi-layer cap is designed to prevent rainwater infiltration into the landfill, to mitigate potential damage by vegetation and burrowing animals, to prevent potential hazards from the collapse of void spaces in the buried waste, and to prevent the potential flux of VOC vapors from subsurface soil to air. Surface water flow onto the landfill is minimized by a diversion channel located on the north side and drainage channels located on the east, west, and south sides of the engineered cap.

Two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east and downgradient of the Pit 6 Landfill (Figure 4). They provide water for the nearby Carnegie State Vehicle Recreational Area (SVRA) Park and are monitored monthly. Water pumped from well CARNRW1 is used to fill a residence pond and for dust and fire suppression, and water from well CARNRW2 is piped across Corral Hollow Road to the Carnegie SVRA Park facilities. Offsite wells CARNRW3 and CARNRW4 are no longer actively pumped.

2.2.1.2. Pit 6 Landfill OU Hydrogeologic Setting

This section describes the general hydrogeologic setting for the Pit 6 Landfill OU, including the unsaturated zone, the hydrostratigraphic units (HSUs) underlying the landfill, and surface water located in the vicinity of the Pit 6 Landfill OU. A geologic cross-section is presented on Figure 5. The Pit 6 Landfill is located in the Corral Hollow-Carnegie fault zone, a series of subparallel, northwest-southeast trending strike-slip faults. Because this fault zone has a significant effect on the hydrogeology of the Pit 6 Landfill area, it is briefly described below.

The northern limit of the Corral Hollow-Carnegie fault zone (hereafter referred to as the fault zone) is located beneath the Pit 6 Landfill. It represents a structural discontinuity and hydraulic barrier that creates two ground water flow regimes in the bedrock. North of the fault zone, the Tertiary Neroly Lower Blue Sandstone ($Tnbs_1$) bedrock dips 10 to 20 degrees to the south-southwest. Within the fault zone, bedrock units are steep to vertically dipping. The $Tnbs_1$ bedrock within and north of the fault zone is unconformably overlain by Quaternary alluvial terrace (Qt) deposits. The fault does not extend into or offset these deposits. Hydrogeologic cross-sections showing the lateral and vertical distribution of total VOCs and tritium north of the fault zone, are shown on Figures 6 and 7, respectively. Hydrogeologic cross-sections showing the lateral and vertical distribution of total VOCs and tritium within the fault zone are shown on Figures 8 and 9, respectively.

Pit 6 Landfill OU Vadose (Unsaturated) Zone

Unconsolidated Qt deposits composed of silty and clayey sand and gravel beneath the Pit 6 Landfill are unsaturated to depths of approximately 25 to 45 ft below ground surface (bgs) north of the fault zone and variably saturated within the fault zone.

Pit 6 Landfill OU Saturated Zone

The three identified HSUs in the Pit 6 Landfill area are described below:

Qt-Tnbs$_1$ North HSU – Ground water in this HSU occurs in Qt deposits and fractured Neroly Tnbs$_1$ bedrock north of the Corral Hollow-Carnegie Fault Zone. Figure 10 presents a potentiometric surface map for the Qt-Tnsbs$_1$ HSU. Depth to ground water in this HSU ranges from 25 to over 80 feet bgs; approximately 30 to 35 ft below the base of the buried waste in Pit 6. As shown on Figure 10, ground water in this HSU flows to the east-southeast. Saturation in the Qt is laterally discontinuous and consists of, at most, a few feet of saturated silty gravel overlying the bedrock contact. Recharge for this unit occurs in the hills to the north. In recent years, water levels in some Qt-Tnbs$_1$ HSU wells north of the fault zone have gradually declined, in some cases dropping below the well screen and causing the well to go dry.

Qt-Tnbs$_1$ South HSU – Within the fault zone, the Qt-Tnbs$_1$ HSU consists of semi-consolidated Qt deposits that unconformably overlie vertically dipping, folded Neroly Tnbs$_1$ and Cierbo Formation (Tmss) bedrock. As shown on Figures 5 and 10, ground water elevations within this HSU are typically 15 to 20 ft higher than those north of the fault zone. The saturated thickness of the Qt-Tnbs$_1$ HSU within the fault zone is spatially and temporally variable, depending on geometry of fractures within the bedrock underlying the terrace deposits and the magnitude of seasonal rainfall. Ground water in this HSU within the fault zone generally flows to the east. This HSU received flow from the Qt-Tnbs$_1$ North HSU and direct infiltration. Discharge occurs locally at Springs 7, 8, and 15.

Tnbs$_1$ Deep HSU – A deeper water-bearing zone has been identified beneath a low-permeability confining layer at depth in the Tnbs$_1$ stratigraphic unit. Data indicate that this deeper Tnbs$_1$ water-bearing zone is not in hydraulic communication with the Qt and shallow Tnbs$_1$ fractured bedrock. Ground water levels in the deeper Tnbs$_1$ water-bearing zone do not respond to pumping of wells completed in the shallow Qt-Tnbs$_1$ HSU. Therefore, the deeper Tnbs$_1$ water-bearing zone is considered as a separate HSU. VOCs and tritium have sporadically been detected in this deeper Tnbs$_1$ HSU in the past, however, this HSU is currently not contaminated.

As part of this five-year review, the HSU in which each well is screened was re-evaluated based on recent hydraulic data. Based on responses to pumping of water-supply wells CARNRW1 and CARNRW2, as observed in water elevation hydrographs, wells EP6-07, K6-27, K6-34, and K6-35, which were previously assigned to the Tnbs$_1$ Deep HSU, were assigned to the Qt-Tnbs$_1$ North HSU.

There is also a water-bearing zone in Qal and Tts stratigraphic units that is restricted to the area south of Corral Hollow Road and consists of Quaternary alluvial deposits (Qal) associated with Corral Hollow Creek and the underlying Tesla Formations (Tts). Tts deposits are vertical and locally overturned in the area. Ground water elevations in the Qal-Tts HSU are typically 25 to 30 ft lower than in the Qt-Tnbs$_1$ HSU. Shallow ground water is ephemeral and present in the Qal only following significant precipitation. Ground water in the Qal flows eastward in the same general direction as stream flow in Corral Hollow Creek.

Pit 6 Landfill OU Surface Water

Three springs, Springs 7, 8 and 15, are located in the immediate vicinity of the Pit 6 Landfill and occur along traces of the fault zone (Figure 4). When present, water in these springs is derived from the Qt-Tnbs$_1$ South HSU within the fault zone. Spring 8 is a perennial spring

located about 550 ft southwest and hydraulically upgradient of the Pit 6 Landfill. Ground water flows into Spring 8 at approximately 1 gallon per minute (gpm).

Springs 7 and 15 are intermittent springs located approximately 200 and 550 feet southeast and downgradient of the Pit 6 Landfill, respectively. Spring 7 has been dry since the summer of 2000. When flowing, ground water flows into this spring at a rate of approximately 2 gpm. Spring 15 has been dry since late 1991. When flowing during the wet winter season, ground water flows into this spring at a rate of about 1 gpm.

A small man-made pond is located in the Carnegie SVRA, situated approximately 1,500 ft east-southeast of the Pit 6 Landfill. Ground water from offsite water-supply well CARNRW1 is used to fill the residence pond.

Influence of CARNRW1 pumping

As mentioned above, two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east of the Pit 6 Landfill (Figure 4). They provide water for the nearby Carnegie SVRA and are monitored monthly. CARNRW1 is generally pumped about once a week and CARNRW2 is used daily. LLNL has historically had only intermittent access to measuring water levels in CARNRW2 because the wellhead to CARNRW2 is sealed and does not allow water level measurements to be taken. However, this well is routinely sampled by collecting water from a sample port at the wellhead. Water levels in CARNRW1 have been measured on a routine basis since late 1991 (monthly from late 1991 to 1993 and quarterly since 1993). During the third quarter of 2009, LLNL placed water-level transducers in guard wells K6-34 and W-PIT6-1819 to continuously monitor the influence of routine pumping of wells CARNRW1 and CARNRW2 on water levels in these guard wells. As shown on Figure 4, both guard wells are located north of the fault zone, with K6-34 and W-PIT6-1819 approximately 400 and 200 feet west, respectively, of the CARNRW wells. Guard wells K6-34 and W-PIT6-1819 are screened in the shallower Qt-$Tnbs_1$ North HSU. Although the K6-34 data set is not as complete due to periodic equipment/recording issues, transducer data for both wells generally indicate that water levels in these wells are influenced by pumping of the CARNRW wells.

Figure 11 shows the transducer data for W-PIT6-1819, as well as hydrographs (from hand water-level measurements) for CARNRW1 and other Qt-$Tnbs_1$ North HSU wells from 2009 through 2011. The influence of daily CARNRW2 pumping is observed in the small daily variation in the transducer data (usually 1 to 2 ft), whereas the influence of weekly CARNRW1 pumping on water levels in W-PIT6-1819 is observed in the larger weekly variation in the transducer data (usually 5 to 10 ft).

Due to insufficient water, ground water samples from EP6-08 and K6-24 have not been collected since April 2008 and January 2011, respectively. During the first semester of 2012, two new wells were drilled in the Qt-$Tnbs_1$ North HSU in the vicinity of these wells, but were screened at greater depths. As shown on Figure 4, well W-PIT6-2816 was drilled 30 feet east-southeast of EP6-08 and well W-PIT6-2817 was drilled 50 feet east-southeast of K6-24. Sample results (after well development) for these new wells are discussed in the remediation optimization evaluation section (Section 2.5.2) of this report.

2.2.2. Pit 6 Landfill OU Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7,000-acre property-area is developed.

The LLNL buildings located within the OU boundary are used to support firearms training operations by the LLNL Protective Forces Department. Pistol and rifle ranges are operated in the OU. After demolition prior to capping, the rifle range was re-built on top of the Pit 6 Landfill cap.

The Pit 6 Landfill OU lies along the southern boundary of Site 300. The Carnegie SVRA, located across Corral Hollow Road from the Pit 6 Landfill OU, is an outdoor recreational facility operated by the California Department of Parks and Recreation for riding and racing private and commercial off-road motorcycles and four-wheel drive vehicles. The Carnegie SVRA continues to expand the park property towards the southwest of the OU. In addition, the Carnegie SVRA owns a parcel of land north of Corral Hollow Road at the eastern boundary of the OU that contains some residences and a pond used for firefighting and dust-suppression water.

There are no active onsite water-supply wells in the Pit 6 Landfill OU. However, as previously mentioned, two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east of the Pit 6 landfill (Figure 4).

Site 300 has unique environmental qualities, largely because livestock have not grazed upon it for over 50 years and it contains several habitat types and numerous special status species (e.g., threatened and endangered species, migratory birds, and rare plants). Annual grasslands cover the majority of the Pit 6 Landfill OU, with some blue oak woodlands occurring in the northeast corner of the OU. Wetlands are associated with Spring 8 (along the southwest boundary of the OU). Spring 7, located southwest of Spring 15, does not have significant wetland development as surface water has been absent from this location for the past 12 years. Small numbers of the big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, have been observed in the OU in the past, but the plant is not currently present. The critical habitat for the federally endangered large-flowered fiddleneck (*Amsinckia grandiflora*) occurs along the western boundary of the OU. The pond within the SVRA residence area provides breeding habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*), while the wetland associated with Spring 8 provides additional aquatic habitat. The entire OU resides within the upland dispersal habitat for this species. The Pit 6 Landfill OU is also within the critical habitat for the federally threatened Alameda whipsnake (*Masticophis lateralis euryxanthus*).

A five-year ecological review reported in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases within the Pit 6 Landfill OU. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the Pit 6 area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

2.2.3. Pit 6 Landfill OU History of Contamination

From 1964 to 1973, approximately 2,000 cubic yards (yd^3) of solid waste were buried in nine separate trenches that comprised the Pit 6 Landfill (Figure 3). Consistent with historical disposal practices, the trenches were not lined. Three large trenches contain 1,700 yd^3 of solid waste that includes empty drums, glove boxes, lumber, ducting, and capacitors. Six smaller trenches contain 300 yd^3 of biomedical waste. Minor releases of VOCs, tritium, and perchlorate occurred from the Pit 6 Landfill prior to the installation of a CERCLA engineered cap in 1997. The septic system for the pistol range, located about 600 ft southeast of the Pit 6 Landfill is the likely source of nitrate contamination in ground water, although there may also be some contribution of nitrate from natural sources. The dissolved-phase masses of VOCs, tritium, and perchlorate released from the landfill are relatively small based on their low concentrations and limited extent in ground water.

2.2.4. Pit 6 Landfill OU Initial Response

DOE/LLNL began environmental investigations at the Pit 6 Landfill OU in 1982. Since then, 39 boreholes have been drilled; all of which were completed as ground water monitor wells (Figure 4). Three wells have since been abandoned to prevent downward migration of contaminants through long well screens and sand packs. The geologic and chemical data from these wells and boreholes are used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminant concentrations. Site characterization also included soil vapor and geophysical (electromagnetic and radiation) surveys, geological logging of a trench wall within the Corral Hollow Creek-Carnegie fault zone, and hydraulic testing of wells.

Remediation activities at the Pit 6 Landfill OU conducted prior to the Interim Site-Wide ROD included excavation of landfill waste containing depleted uranium in 1971. The Pit 6 Landfill was capped and closed in 1997 under CERCLA to prevent further leaching of contaminants resulting from percolation of rainwater through the buried waste. The engineered, multi-layer cap is intended to prevent rainwater infiltration into the landfill, mitigate potential damage by burrowing animals and vegetation, prevent potential hazards from the collapse of void spaces in the buried waste, and prevent the potential flux of VOC vapors from subsurface soil to air. Surface water flow onto the landfill is minimized by a diversion channel on the north side and drainage channels on the east, west and south sides of the engineered cap. EPA, DTSC, and the RWQCB approved the post-closure monitoring plan in May 1998.

In 1998, a short-term treatability test was conducted in which ground water was extracted from one well and treated using a potable treatment unit to remove VOCs.

2.2.5. Pit 6 Landfill OU Contaminants of Concern

COCs identified in ground water in the Pit 6 Landfill OU include: (1) VOCs (primarily TCE, but also chloroform, 1,2-dichloroethane [DCA], cis-1,2-dichloroethene [DCE], trans-1,2-DCE, PCE, and 1,1,1-trichloroethane [1,1,1-TCA]), (2) tritium, (3) perchlorate, and (4) nitrate. VOCs, tritium, and nitrate are present in ground water in the Qt-$Tnbs_1$ North and South HSUs. Perchlorate has historically been present at low concentrations in the Qt-$Tnbs_1$ North and South HSUs; but has not been detected in any Pit 6 ground water sample since early 2010. In the past, COCs have also been sporadically detected in the $Tnbs_1$ Deep HSU and Qal-Tts HSU, but are

not currently present in these HSUs. The distribution and concentration of contaminants in ground water is described in detail in Section 2.5.1 below. VOCs (cis-1,2-DCE, trans-1,2-DCE, PCE, and TCE) have also been identified as COCs in surface water at Spring 7 when water is present. No COCs were identified in surface soil or subsurface soil/rock in the vadose zone.

VOCs, primarily TCE, a suspected human carcinogen, are present in the Pit 6 waste, ground water, and surface water (when present in Spring 7). The baseline human health risk assessment estimated the following cancer risks and hazard indices in OU 3:

1. Pit 6 Landfill – Cumulative risk of 5×10^{-6}, hazard index (HI) less than 1 to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period.
2. Spring 7 – Cumulative risk of 4×10^{-5}, HI of 1.5 to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period.
3. The Carnegie State Vehicular Recreation Area pond (offsite, east of the Pit 6 Landfill) – Cumulative risk of 3×10^{-6}, HI less than 1 to offsite residence from VOCs volatilizing from the State Vehicular Recreation Area pond. This risk scenario assumed no cleanup actions would be taken and that VOCs would migrate to the water-supply wells CARNRW-1 and CARNRW-2 used to fill the pond.

The baseline ecological risk assessment for the Pit 6 Landfill identified a HI greater than one for inhalation of VOCs in burrow air for ground squirrels and the San Joaquin kit fox. Risk mitigation progress is discussed in Section 2.5.4.

While tritium, a potential human carcinogen, occurs naturally at low activities in the environment, it is present in ground water in the Pit 6 Landfill OU above background (but below its cleanup standard/Maximum Contaminant Level [MCL]) as a result of releases from the landfill prior to capping of the pits. No unacceptable human health risk or hazard was identified for tritium in ground water.

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (EPA, 2005). Perchlorate has historically been detected in Pit 6 Landfill ground water at concentrations above the 6 μg/L drinking water MCL (historical maximum concentration of 65.2 μg/L in 1998), but concentrations have been below the 4 μg/L reporting limit since 2010.

Nitrate in ground water probably results from septic system effluent but may also have resulted from natural sources. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. Nitrate has been detected in Pit 6 Landfill ground water at concentrations above the 45 mg/L drinking water MCL (historical maximum concentration of 240 μg/L in 2000). Nitrate concentrations in ground water currently exceed the MCL cleanup standard in two wells.

2.2.6. Pit 6 Landfill OU Summary of Basis for Taking Action

Remedial actions were initiated in the Pit 6 Landfill OU to address unacceptable human health risks and ecological risk identified in Section 2.2.5.

2.3. Pit 6 Landfill OU Remedial Actions

2.3.1. Pit 6 Landfill OU Remedy Selection

The remedy selected for the Pit 6 Landfill OU is intended to achieve the following Remedial Action Objectives (RAOs):

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.
- Prevent human inhalation of VOCs volatilizing from waste in the Pit 6 Landfill to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human inhalation of VOCs volatilizing from surface water in Spring 7 to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative HI greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

In the 2001 Interim Site-Wide ROD, the remedy for the Pit 6 Landfill OU was selected based on its ability to contain contaminant sources, prevent further plume migration, and protect human health and the environment. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Pit 6 Landfill OU consists of:

1. Monitoring ground water and surface water to evaluate the effectiveness of the remedy in achieving cleanup standards and to ensure there is no impact to downgradient water-supply wells.
2. Risk and hazard management to prevent onsite worker exposure to VOCs volatilizing from Spring 7. Land use controls to prevent human exposure to contamination and to protect the integrity of the remedy.

3. MNA to reduce VOC and tritium concentrations in ground water to cleanup standards.
4. Inspecting the Pit 6 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

2.3.2. Pit 6 Landfill OU Remedy Implementation

Monitoring of ground water and surface water at the Pit 6 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 6 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.
- Monitoring of surface water (springs) that could be affected by a release from the landfill.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. Detection monitoring and results for the Pit 6 Landfill is discussed in Section 2.5.2. As part of the remedial action monitoring program, ground water samples are collected from wells and analyzed for ground water COCs. This program includes:

- Monthly monitoring of offsite water-supply wells owned and operated by the Carnegie State Park.
- Monitoring of guard wells located downgradient of the ground water plumes and upgradient of the Carnegie State Park wells to provide an early indication of movement of contaminants toward the water-supply wells.
- Monitoring of all wells to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, evaluate the effectiveness of natural attenuation of VOCs and tritium to meet remedial action objectives, and verify the attainment of cleanup standards.

Surface water at Spring 7 is also monitored, when present, to determine if risk and hazard management measures, such as access restrictions, are necessary to prevent VOC inhalation exposure by onsite workers.

The results of ground water and surface water monitoring are discussed in Section 2.5.1.

The results of the detection and remedial action monitoring, as well as landfill inspections and maintenance, are reported quarterly and annually in the Compliance Monitoring Program Reports submitted by the LLNL Environmental Functional Area.

The results of remedial action ground water and surface water monitoring, remediation progress, risk re-evaluations, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

Land Use Controls have been implemented to prevent damage to the landfill cap and inadvertent exposure to the waste (see Section 2.3.4).

2.3.3. Pit 6 Landfill OU Operation and Maintenance

The remedy for the Pit 6 Landfill OU is operating as designed and no significant operational, performance, or cost issues were identified during this five-year review. All required

documentation is in place, and the landfill cap maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Post-Closure Plan for the Pit 6 Landfill Operable Unit at LLNL Site 300 (Ferry et al., 1998).
- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300 (Dibley et al., 2009).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Lorega, 2009).

The major maintenance activities for the Pit 6 Landfill interim remedy include:

- Annual elevation survey of the pit cap to detect any differential settling or other earth movement.
- Annual inspection of the pit cap by a state-certified Professional Engineer to detect any excessive erosion, animal burrowing, or other penetrative damage.
- As necessary, repairs to the pit cap are made to correct problems identified during inspections.
- Annual inspections of the surface water runoff and drainage system for the landfill and after each major storm event to detect any erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the quarterly and annual Pit 6 Post-Closure Monitoring Reports submitted by the LLNL Environmental Functional Area. The budgeted and actual environmental restoration costs for the Pit 6 Landfill OU are tracked closely and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011. (Note: Although it falls outside this five-year review period, in July 2012, DOE proposed and the regulatory agencies agreed to modify the detection monitoring and reporting program for the Pit 6 Landfill for consistency with the Detection Monitoring Program in the Compliance Monitoring Plan. DOE will submit an Addendum to the Compliance Monitoring Plan to incorporate the Pit 6 Detection Monitoring and Reporting Program which will supercede the 1998 Post-Closure Monitoring Plan.)

2.3.4. Pit 6 Landfill OU Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that

helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as Federal Facility Agreements (FFAs), that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term "land use controls" is used to encompass institutional controls, engineered controls, and physical barriers.

The land use controls and requirements described herein are only applicable to the Pit 6 Landfill OU and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The landfill inspection results are currently reported in the quarterly Pit 6 Post-Closure Reports.

Land use controls for the Pit 6 Landfill OU are described in Table 2, that presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Pit 6 Landfill OU. Figure 12 shows the specific areas of the Pit 6 Landfill OU where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Pit 6 Landfill OU by objective, and the status of the land use controls are summarized below.

2.3.4.1. Pit 6 Landfill OU Land Use Control Objectives

Land use control objectives were established for the Pit 6 Landfill OU in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Pit 6 Landfill include:

1. ***Risk Driver*** – VOCs and nitrate concentrations in ground water onsite exceed MCL cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** – Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
   - Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

3. ***Risk Driver*** – The baseline risk assessment identified a risk of 4×10^{-5} for onsite workers from inhalation of VOCs volatilizing from Spring 7 into outdoor air.

   Land use control objective:

   - Prevent onsite site worker inhalation exposure to VOCs at Spring 7 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.

4. ***Risk Driver*** – Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

No COCs were identified in surface soil or subsurface soil/rock in the vadose zone in the Pit 6 Landfill OU.

2.3.4.2. Pit 6 Landfill Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the Pit 6 Landfill OU implemented to address the risk reduction objectives, and provides the current status of the controls.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL implements multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Pit 6 Landfill OU until ground water cleanup standards are met. The land use controls include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well. During this five-year review period, there were no dig permit applications to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Pit 6 Landfill OU.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

Contamination in the Pit 6 Landfill OU is limited to onsite ground water. TCE is present in only one well at a concentration slightly exceeding the drinking water standard; all other VOCs in ground water are below drinking water standards. Nitrate is detected at a concentration exceeding the drinking water standard in only one well. The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.

During this five-year review period, there were no proposals brought to the Work Induction Board to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Pit 6 Landfill OU.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cap and ground water monitoring system. Landfill cap maintenance and inspection requirements are currently specified in the Pit 6 Landfill Post-Closure Plan and are reported in quarterly Post-Closure Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work. During this five-year review period, there were no dig permit applications for excavation or construction activities at the Pit 6 Landfill.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 6 Landfill. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Pit 6 Landfill OU.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Governmental Institutional Controls
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 6 Landfill OU.

Prevent Inadvertent Exposure of Onsite Workers and Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers and unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Fences.
  - Security Force.
  - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review period. The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

- Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD.

The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA

risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

2.3.4.3. Summary of the Status of Pit 6 Landfill Land Use Controls

The review of the land use controls for the Pit 6 Landfill OU for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Pit 6 Landfill OU for as long as necessary to keep the selected remedy protective of human health and the environment.

2.4. Pit 6 Landfill OU Five-Year Review Process

2.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

2.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Pit 6 Landfill OU at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- John Valett, Hydrogeologist, Weiss Associates.

2.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).

- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Construction Completion Report for the Pit 6 Landfill Operable Unit at Lawrence Livermore National Laboratory Site 300 (Holtzapple, 2008).
- Post-Closure Plan for the Pit 6 Landfill Operable Unit Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1998).
- Semi-annual ERD Compliance Monitoring Reports that include evaluations of remediation progress in the Pit 6 Landfill OU (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

2.5. Pit 6 Landfill OU Data Review and Evaluation

A review and evaluation were conducted of data collected during this review period to: (1) evaluate changes in contaminant distribution, concentrations, and remediation progress (Section 2.5.1), (2) landfill detection monitoring (Section 2.5.2), (3) identifying performance issues (Section 2.5.3), and (4) mitigating risk associated with COCs (Section 2.5.4).

2.5.1. Pit 6 Landfill OU Contaminant Distribution, Concentration, and Remediation Progress

VOCs, tritium, perchlorate, and nitrate are the COCs identified in ground water at the Pit 6 Landfill OU. Table 3 summarizes the historical and current concentrations/activities of TCE, tritium, perchlorate, and nitrate in the Pit 6 Landfill OU compared to ground water cleanup standards.

The distribution, concentrations, and remediation progress for VOCs, tritium, perchlorate, and nitrate in ground water in the Pit 6 Landfill OU, as well as a summary of the status of these COCs in offsite water-supply wells and springs, are described in Section 2.5.1.1 through 2.5.1.4.

2.5.1.1. VOC Distribution, Concentrations, and Remediation Progress

The VOC COCs in Pit 6 Landfill ground water include chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-TCA, and TCE. Of these VOCs, only TCE and cis-1,2-DCE have been detected consistently; the remaining VOCs have been detected sporadically.

Chloroform, 1,1,1-TCA and PCE have never been detected in ground water samples from wells in the Pit 6 area at concentrations above their MCL cleanup standards. For example, the

maximum historical concentration of chloroform detected in Pit 6 ground water at concentrations was 14 µg/L (1994), significantly below the 80 µg/L MCL cleanup standard for total trihalomethanes (THMs). The maximum historical concentration of PCE detected was 3.2 µg/L (1988), below its 5 µg/L MCL cleanup standard. 1,1,1-TCA has been detected at concentrations of up to 13 µg/L (1990), well below its 200 µg/L MCL cleanup standard. Chloroform, 1,1,1-TCA, and PCE are not currently detected in Pit 6 ground water above the 0.5 µg/L reporting limit.

TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA have historically been detected in Pit 6 ground water at concentrations above their MCL cleanup standards. However, only TCE currently remains at a concentration above its 5 µg/L MCL cleanup standard in one well (EP6-09) as of the fourth quarter of 2011. Concentrations of TCE have decreased from a historical maximum of 250 µg/L in 1988 to a fourth quarter 2011 maximum of 5.9 µg/L (EP6-09). Concentrations of cis-1,2-DCE have decreased from a historical maximum of 12 µg/L in (1990) to a fourth quarter 2011 maximum of 2.2 µg/L; below its 6 µg/L MCL cleanup standard. Cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 ground water monitor well (K6-01S). Trans-1,2-DCE concentrations have decreased from a historical maximum of 33 µg/L (1990) to below the 0.5 µg/L reporting limit in all wells by 1993. Concentrations of 1,2-DCA have decreased from a historical maximum of 3.5 µg/L to below its 0.5 µg/L MCL cleanup standard in all wells by 1998.

VOC concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.1.1. VOC Concentrations and Distribution by HSU:

Qt-Tnbs$_1$ HSU

VOC contamination (primarily TCE, with minor concentrations of cis-1,2-DCE) in Pit 6 Landfill OU ground water is present primarily in the Qt-Tnbs$_1$ HSUs, with the greatest extent historically present in the Qt-Tnbs$_1$ South HSU. Concentrations and the distribution of total VOCs in the Qt-Tnbs$_1$ HSUs in the second semester of 2011 are presented on Figure 13. Unless otherwise indicated, the total VOC concentrations posted on Figure 13 are comprised wholly of TCE. Wells K6-36 and EP6-08 have been dry since 2006 and 2008, respectively, so the most recent available VOC concentrations from these wells (August 2006 and April 2008, respectively) were used for plume contouring. VOC concentrations and distribution in the Qt-Tnbs$_1$ North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - Within the Qt-Tnbs$_1$ North HSU, the VOC plume (concentration contour greater than 0.5 µg/L) extends from the pit to immediately east of well K6-36 (Figure 13). As shown on Figure 14, total VOC concentrations in the Qt-Tnbs$_1$ North HSU have decreased from a historic maximum of 7.7 µg/L (K6-24, May 1990, comprised of 6.9 µg/L of 1,1,1-TCA and 0.8 µg/L of TCE) to a most recent maximum of 1.8 µg/L (EP6-08, April 2008, comprised of 1.2 µg/L of PCE and 0.6 µg/L of TCE). VOCs have not been detected in well K6-24 since 1994, and well EP6-08 has been dry since 2008. Prior to going dry, well EP6-08 exhibited a generally stable VOC concentration trend. The third well shown on Figure 14, well K6-36, also shows a generally stable VOC concentration trend from 2000 (year drilled) to 2006 (year well went dry).

Because water levels in several Qt-Tnsb$_1$ North HSU wells have declined significantly or have gone dry in recent years, DOE installed two new monitor wells W-PIT6-2816 and W-PIT6-2817

adjacent to wells EP6-08 and K6-24, respectively, in order to collect ground water samples in areas where wells had previously gone dry. VOCs were not detected in ground water samples from these wells.

Qt-Tnbs$_1$ South HSU - Within the Qt-Tnbs$_1$ South HSU, the VOC plume extends from the pit to approximately halfway between well K6-16 and guard well K6-17 (Figure 13). VOCs have not been detected in guard well K6-17 since 2005. VOC concentrations in Qt-Tnbs$_1$ South HSU ground water have decreased from a historic maximum of 253 µg/L (K6-19, 1988) to a five-year review period maximum of 10 µg/L (EP6-09, October 2008) to a fourth quarter 2011 maximum of 5.9 µg/L (EP6-09).

As shown on Figure 13, the highest VOC concentrations (greater than 5 µg/L) at Pit 6 occur in the Qt-Tnbs$_1$ South HSU immediately south of the pit, in the vicinity of well EP6-09. This well (EP6-09) is the only Pit 6 well still containing TCE concentrations above the cleanup standard of 5 µg/L. Well K6-01S is the only well currently containing VOCs other than TCE, with cis-1,2-DCE detected at a concentration of 2.2 µg/L, below the 6 µg/L MCL cleanup standard. Cis-1,2-DCE has not been detected in Pit 6 wells above 6 µg/L since 1993. The presence of cis-1,2-DCE, a degradation product of TCE, in well K6-01S suggests that natural dechlorination may be occurring in the vicinity of this well.

As shown on Figure 15(a), total VOC concentrations in wells within the Qt-Tnbs$_1$ South HSU have decreased from a historic maximum of 253 µg/L (K6-19, November 1988, comprised of 250 µg/L of TCE and 3.2 µg/L of PCE) to a fourth quarter 2011 maximum of 5.9 µg/L, comprised entirely of TCE (EP6-09). Wells K6-19 and EP6-09 are located immediately adjacent to the southeast corner, and south-central portions of the pit, respectively. VOC concentrations in well K6-19 show a significant decrease from 1988 to 2001, and show a stable trend (below 5 µg/L) since 2006. Wells K6-16 and K6-18 show a trend similar to well K6-19. VOC (TCE) concentrations in well EP6-09 gradually increased from 1984 to 1992, gradually decreased from 1992 to 1994, and then gradually increased again from 1994 to late 1998. For two months in late 1998, ground water was extracted from well EP6-09 and treated to determine the effect on TCE trends. During this period, TCE concentrations decreased from 14 to 1.4 µg/L. Since 1998, TCE concentrations in well EP6-09 have rebounded to a maximum of 10 µg/L in October 2008, and remained relatively stable since then. The VOC (TCE) rebound in EP6-09 is shown in detail on Figure 15(b), which presents total VOC concentration trends for Qt-Tnbs$_1$ South HSU wells from 2000 through 2011. TCE concentrations in well EP6-09 have exceeded 5 µg/L since 2004. Concentrations of TCE in all other wells have been below 5 µg/L since 2001.

Acetone has sporadically been detected in Qt-Tnbs$_1$ South HSU well EP6-09 since July of 2008 with concentrations ranging from 12 to 220 µg/L. Analyses of ground water samples from well EP6-09 for acetone (EPA Method 8260) has occurred only since April of 2007. Acetone has also been detected in seven discrete one-time samples from seven other wells (primarily in the Qt-Tnbs$_1$ South HSU) near the Pit 6 Landfill between 1990 and 2003 with concentrations ranging from 5.4 to 78 µg/L. Of these seven samples, four were collected in late October 1990 and may reflect laboratory contamination. One of the remaining three sample results is 28 µg/L reported in a February 17, 2000 sample from well K6-01S. The duplicate sample collected from this well on this date contained no acetone above the 20 µg/L reporting limit. Of the other two samples, the most recent result was 78 µg/L of acetone in a sample collected from Qt-Tnbs$_1$ South HSU well EP6-08 in October 2003. Since the second quarter of 2011, duplicate ground water samples have been collected from well EP6-09 on a quarterly basis. From second quarter

2011 through first semester 2012, acetone has been detected in only one EP6-09 sample (12 µg/L in a duplicate sample from October, 2011). These results indicate that acetone in Pit 6 ground water occurs very sporadically and at low levels, and recently only in the vicinity of well EP6-09. Additionally, there is no State or Federal MCL for acetone, and the concentrations mentioned above are well below the taste and odor threshold of 300,000 µg/L.

A comparison of the 1988, 2007, and 2011 total VOC concentrations in the Qt-$Tnbs_1$ HSUs (Figure 16) shows the extent and magnitude of the VOC plume to decrease over time. Data from 1988 was used to represent the pre-remediation time period because this was the year of maximum VOC concentrations, as previously depicted on Figure 15(a). Also as shown on Figure 16, portions of the plume above 10 µg/L no longer exist. The portion of the plume above 5 µg/L has shifted slightly, from the southeast corner of the pit in 1988 to the south-central portion of the pit (vicinity of EP6-09) in 2007 and 2011.

$Tnbs_1$ Deep HSU

Carbon tetrachloride and PCE were detected at 2.1 and 0.6 µg/L, respectively, in one sample collected from $Tnbs_1$ Deep HSU well K6-26 in April 1991. 1,1,1-TCA was detected from K6-26 at 0.9 µg/L in November 1991. One sample collected from Qal-Tts HSU well W-33C-01 in May 1990. Neither carbon tetrachloride, PCE, or 1,1,1-TCA nor any other VOCs have been detected above the 0.5 µg/L reporting limit in any other samples from $Tnbs_1$ Deep HSU wells.

Qal-Tts HSU

The VOC 1,1,1-TCA was detected at a concentration of 4.8 µg/L in one sample collected from Qal-Tts HSU well W-33C-01 in May 1990; well below the MCL cleanup standard of 200 µg/L. Neither 1,1,1-TCA nor any other VOCs have been detected above the 0.5 µg/L reporting limit in any other samples from Qal-Tts HSU wells.

2.5.1.1.2. Water-Supply Wells

As discussed in Section 2.2.2, CARNRW1, CARNRW2, CARNRW3, and CARNRW4 are offsite wells owned and operated by the Carnegie SVRA Park; only CARNRW1 and CARNRW2 are used as active water-supply wells. CARNRW1 is screened across the Qt-$Tnbs_1$ North and $Tnbs_1$ Deep HSUs. CARNRW2 and CARNRW3 are screened in the $Tnbs_1$ Deep HSU, and CARNRW4 is screened Qal-Tts HSU. DOE monitors these wells monthly for VOCs.

No VOCs have ever been detected in water-supply well CARNRW1 since monitoring began in 1984. VOCs are not detected in water-supply well CARNRW2, except for sporadic THM detections at concentrations below the total THM MCL of 80 µg/L (as a result of routine chlorination of this well). TCE was detected once in well CARNRW3 (2.8 µg/L, August 2005), however, the duplicate sample did not contain TCE (<0.5 µg/L). No other VOCs have ever been detected in CARNRW3. No VOCs have ever been detected in well CARNRW4.

Guard well W-PIT6-1819 was drilled upgradient of active water-supply wells CARNRW1 and CARNRW2 in 2002 to provide an early indication of migration of the VOC plume towards these wells. VOCs have not been detected in samples from well W-PIT6-1819 since monitoring began in 2002.

2.5.1.1.3. Springs

TCE has historically been detected in shallow well BC6-13, which monitors Spring 7, at concentrations of up to 110 µg/L. This well (and spring) has been dry since 2000. TCE was detected in the last sample collected before the well and spring went dry at a concentration of

4 µg/L. DOE continues to monitor for the presence of water in well BC6-13, and if detected, will collect a sample.

Spring 8, located upgradient of Pit 6, has not yielded detectable TCE concentrations when sampled. VOCs have been detected in Spring 15 once at a concentration of 1.2 µg/L (November 1991), however, this spring has been dry since 1991.

2.5.1.1.4. VOC Remediation Progress Summary

In general, VOCs in ground water near Pit 6 exhibit decreasing trends and the VOC plume extent is stable to decreasing. VOC concentrations in Pit 6 ground water have decreased from a historic maximum of 253 µg/L in 1988 to a fourth quarter 2011 maximum of 5.9 µg/L. The remediation progress summary for VOC COCs (chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-TCA, and TCE) in Pit 6 Landfill ground water include:

1,2-DCA concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L MCL cleanup standard and reporting limit in all Qt-$Tnbs_1$ HSU wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells.

Cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). Cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit, but below its 6 µg/L MCL cleanup standard in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011). Cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells.

Trans-1,2-DCE concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

PCE has never been detected at concentrations exceeding its 5 µg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 µg/L in 1988). PCE has not been detected at concentrations above the 0.5 µg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990). 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

Concentrations of chloroform have decreased to below the 0.5 µg/L reporting limit in all Pit 6 wells.

TCE is currently present above its 5 µg/L MCL cleanup standard in only one well (5.9 µg/L in EP6-09), located immediately adjacent to the south-central portion of the pit. Because TCE concentrations rebounded in well EP6-09 following two months of extraction and treatment from this well in 1998 and have remained relative stable since 2008, DOE will monitor TCE in this

well over the next five years. If TCE concentrations increase or remain above 5 µg/L cleanup standards, remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.

No VOCs are currently detected in any of the Carnegie SVRA water-supply wells, or in upgradient guard well W-PIT6-1819. VOCs exceed the MCL cleanup standard in only one well, located onsite approximately 1,300 ft upgradient of the these offsite water-supply wells. Both the guard well and water-supply wells will continue to be monitored for VOCs to provide an early indication of changes that could result in impacts to the water-supply wells. No VOCs have been detected in Spring 8, and Springs 7 and 15 have been dry since 2000 and 1991, respectively.

Therefore, the remedy for VOCs in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective. DOE is recommending the removal of 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, and 1,1,1-TCA as COCs in Section 2.9.

2.5.1.2. Tritium Concentrations, Distribution, and Remediation Progress

Tritium has never been detected at activities near or above the 20,000 pCi/L MCL cleanup standard in Pit 6 ground water. Tritium activities have decreased from a historic maximum of 3,420 pCi/L in 2000 to a fourth quarter 2011 maximum of 190 pCi/L. Tritium activities and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.2.1. Tritium Activities and Distribution by HSU:

Qt-Tnbs$_1$ HSU

Tritium contamination in the Pit 6 Landfill OU ground water has historically been detected in both the Qt-Tnbs$_1$ North and South HSUs. Tritium activities in the Qt-Tnbs$_1$ HSU ground water have decreased from a historic maximum of 3,420 pCi/L (BC6-13, 2000) to a five-year review period maximum of 503 pCi/L (K6-19, 2007) to a current maximum of 190 pCi/L (K6-19). Well BC6-13 has been dry since 2000. Historically, only three tritium samples have been collected from well BC6-13. The tritium activities for these samples are <200 pCi/L (November 1991), 1,210 pCi/L (January 2000), and 3,420 pCi/L (May 2000).

The distribution of tritium activities in the Qt-Tnbs$_1$ HSUs in the second semester of 2011 is presented on Figure 17. Tritium activities and distribution in the Qt-Tnbs1 North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - Within the Qt-Tnbs$_1$ North HSU, the tritium plume (activity contour greater than 100 pCi/L) extends from the pit to immediately east of guard well W-PIT6-1819. Guard well W-PIT6-1819 was drilled in 2002, and tritium activities in this well have ranged from <100 to 295 pCi/L.

As shown on Figure 17, the highest tritium activities (greater than 1,000 pCi/L) occur in the Qt-Tnbs$_1$ North HSU immediately east of the pit and in the vicinity of well K6-36. Well (K6-36) has been dry since 2006, and the tritium activity in this well from August 2006 (1,200 pCi/L) was used for plume contouring.

As shown on Figure 18, tritium activities in Qt-Tnbs$_1$ North HSU wells have decreased from a historic maximum of 2,150 pCi/L (K6-36, August 2000) to a current maximum of 270 pCi/L (W-PIT6-1819, July 2011). Due to dry conditions, samples have not been collected from wells K6-36 and K6-24 since August 2006 and January 2011, respectively. Tritium activities in well

K6-36 show a significant decreasing trend from 2000 to 2006. Tritium activities in well K6-24 show an increasing trend from 1998 to 1999 and then a decreasing trend from 1999 to January 2011. Tritium activities in well K6-33 show an increasing trend from 1997 to 2000 and then a decreasing trend from 2000 to 2011. Guard well W-PIT6-1819 has shown a generally stabilized trend since 2002.

DOE collected samples for tritium analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-Tnsb$_1$ North HSU wells had gone dry. Tritium was detected at an activity of 122 pCi/L in a ground water sample collected from well W-PIT6-2817 and was not detected above the 100 pCi/L reporting limit in W-PIT6-2817.

Qt-Tnbs$_1$ South HSU - Within the Qt-Tnbs$_1$ South HSU, the tritium plume extends from the pit to immediately east of well K6-18. Tritium has not been detected in guard well K6-17. As shown on Figure 19, tritium activities in Qt-Tnbs$_1$ South HSU wells have decreased from a historic maximum of 2,520 pCi/L (K6-19, October 1999) to a current maximum of 190 pCi/L in the same well (October 2011). Well K6-19 is located immediately adjacent to the southeast corner of the pit. Qt-Tnbs$_1$ South HSU well BC6-13, which yielded the historic maximum tritium activity in the Pit 6 OU, is not shown on Figure 19 because it has been dry since 2000. Tritium activities in well K6-19 show a significant increase from 1997 to 1998, a stable trend greater than 1,000 pCi/L from 1998 to 2000, a significant decrease from 2000 to 2003, and a generally stable to slightly decreasing trend since 2003. Tritium activities in wells K6-16 and K6-18 show an increase from 1997 to 2003. Since 2003, well K6-16 shows a significant decreasing trend and well K6-18 shows a generally stable trend. Tritium was not sampled for in wells K6-16 and K6-18 from 1998 to 2002. Tritium activities in well K6-01S show an increase from 1998 to 2004, and a significant decrease since 2004.

A comparison of the 1998, 2007, and 2011 tritium activities in the Qt-Tnbs$_1$ HSU (Figure 20) shows the general extent and magnitude of the tritium plume has decreased over time. Although the landfill was capped in 1997, data from 1998 was used to represent the pre-remediation time period because this was the beginning of the time period (1998 to 2000) when the maximum tritium activities occurred (greater than 1,000 pCi/L in K6-19). Tritium activities from 1998 were contoured using an estimate of 1998 tritium activity in guard well W-PIT6-1819, which was drilled in 2002.

Tnbs$_1$ Deep HSU

Tritium has been detected in samples collected from Tnbs$_1$ Deep HSU well K6-26 four times: 400 pCi/L in February 1998, 1,680 pCi/L in May 1999, 126 pCi/L in January 2004, and 108 pCi/L in March 2009. Tritium has not been detected in any other samples from Tnbs$_1$ Deep HSU wells.

Qal-Tts HSU

Except for the detection of tritium in two samples collected from well CARNRW4 at activities slightly above the reporting limit (109 and 192 pCi/L in July and October 2005, respectively), tritium has never been detected in Qal-Tts HSU ground water.

2.5.1.2.2. Water-Supply Wells

Tritium has not been detected in water-supply wells CARNRW1, CARNRW2, or CARNRW3. Tritium activities have been below the reporting limit in well CARNRW4, except for two samples collected from well CARNRW4 (109 and 192 pCi/L in July and October 2005, respectively).

2.5.1.2.3. Springs

Tritium has been detected in shallow well BC6-13, which monitors Spring 7, at a historical maximum concentration of 3,420 pCi/L in May 2000. However, this well and spring have been dry since 2000, so DOE/LLNL have been unable to collect more recent samples since then. Tritium has not been detected in Springs 8 or 15.

2.5.1.2.4. Tritium Remediation Progress Summary

Tritium has never been detected near or above the 20,000 pCi/L MCL cleanup standard. Tritium activities in Pit 6 ground water have decreased from a historic maximum of 3,420 pCi/L in 2000 to a fourth quarter 2011 maximum of 190 pCi/L, indicating that natural attenuation is effective in reducing tritium activities towards background levels.

No tritium is currently detected in any of the Carnegie SVRA water-supply wells above the 100 pCi/L reporting limit. While tritium is currently detected in the upgradient guard well W-PIT6-1819, its activity (270 pCi/L) is several orders of magnitude below the MCL cleanup standard. Both the guard well and water-supply wells will continue to be monitored for tritium to provide an early indication of changes that could result in impacts to the water-supply wells. No VOCs have been detected in Spring 8, and Springs 7 and 15 have been dry since 2000 and 1991, respectively.

Tritium activities in ground water continue to decrease toward background levels of 100 pCi/L and remain significantly below the 20,000 pCi/L cleanup standard, and the tritium plume extent is stable to decreasing. Therefore, the MNA remedy for tritium in ground water at the Pit 6 Landfill OU 3 is considered to be effective, and no optimization measures are needed.

2.5.1.3. Perchlorate Concentrations, Distribution, and Remediation Progress

Perchlorate concentrations in Pit 6 ground water have decreased from a historic maximum of 65.2 µg/L in 1998 to below the 4 µg/L reporting limit in all wells during 2011. Perchlorate concentrations (all less than 4 µg/L) in the Qt-$Tnbs_1$ HSUs in the first semester of 2011 are presented on Figure 21. Some wells north of the fault zone have been dry the last several years, and perchlorate samples have not been collected.

Perchlorate concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.3.1. Perchlorate Concentrations and Distribution by HSU:

Qt-$Tnbs_1$ HSU

Perchlorate contamination in the Pit 6 Landfill OU ground water has historically been detected primarily in the Qt-$Tnbs_1$ HSUs. Perchlorate concentrations in the Qt-$Tnbs_1$ HSUs have decreased from a historic maximum of 65.2 µg/L (K6-19, Qt-Tnbs1 South HSU, 1998) to a five-year review period maximum of 6.9 µg/L (K6-18, 2009) to below the 4 µg/L reporting limit in all wells during 2011. Perchlorate concentrations in the Qt- Qt-$Tnbs_1$ North and South HSUs are discussed below.

Qt-$Tnbs_1$ North HSU - As shown on Figure 22, perchlorate concentrations in Qt-$Tnbs_1$ North HSU wells have decreased from a historic maximum of 9.8 µg/L (K6-24, May 2000) to below the 4 µg/L reporting limit by 2005. Well K6-36 shows a decreasing trend from 2000 to 2004 and concentrations less than 4 µg/L from 2005 to 2006, before going dry in 2006. Perchlorate has not been detected in Qt-$Tnbs_1$ North HSU guard well W-PIT6-1819.

DOE collected samples for perchlorate analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-Tnsb$_1$ North HSU wells had gone dry. Perchlorate was not detected in ground water samples collected from wells W-PIT6-2816 and W-PIT6-2817.

Qt-Tnbs$_1$ South HSU - As shown on Figure 23, perchlorate concentrations in Qt-Tnbs$_1$ South HSU wells have decreased from a historic maximum of 65.2 µg/L (K6-19, 1998) to below the 4 µg/L reporting limit in 2010. Wells K6-16 and K6-19 both show a significant decreasing trend with concentrations consistently below 4 µg/L after 2001. Well K6-18 shows a significant decreasing trend from 1999 to 2000, a more moderate decreasing trend from 2000 to 2009, and concentrations consistently below 4 µg/L after 2009. Perchlorate was detected sporadically in well EP6-09 between 2002 and 2009. Perchlorate has not been detected in Qt-Tnbs1 South HSU guard well K6-17.

Tnbs$_1$ Deep HSU

Perchlorate has never been detected in Tnbs$_1$ Deep HSU ground water monitoring wells.

Qal-Tts HSU

Perchlorate has never been detected in Qal-Tts HSU ground water.

2.5.1.3.2. Water-Supply Wells

Perchlorate has not been detected in water-supply wells CARNRW1, CARNRW3, or CARNRW4. Perchlorate has been detected in one ground water sample from water-supply well CARNRW2 (4.3 µg/L, October 2001), however, the duplicate sample result was below the reporting limit of 4 µg/L.

2.5.1.3.3. Springs

Perchlorate results from samples collected from the Pit 6 springs, when sufficient water was available from which to sample, have been below the reporting limit of 4 µg/L.

2.5.1.3.4. Perchlorate Remediation Progress Summary

Perchlorate concentrations in Pit 6 ground water have decreased significantly from a historical maximum of 65.2 µg/L in 1998 to below the 4 µg/L reporting limit in all wells since 2009 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). No perchlorate is currently detected in any of the Carnegie SVRA water-supply wells or the upgradient guard well W-PIT6-1819 above the 4 µg/L reporting limit. Both the guard well and water-supply wells will continue to be monitored for perchlorate to provide an early indication of changes that could result in impacts to the water-supply wells. No perchlorate has been detected in the springs in the vicinity of Pit 6.

Therefore, the remedy for perchlorate in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective. DOE is recommending the removal of perchlorate as COC in Section 2.9.

2.5.1.4. Nitrate Concentrations, Distribution, and Remediation Progress

Nitrate concentrations in Pit 6 OU ground water have decreased from a historic maximum of 240 mg/L (K6-23, 2000) to a current maximum of 150 mg/L in the same well. Nitrate concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.4.1. Nitrate Concentrations and Distribution by HSU:

Qt-Tnbs$_1$ HSU

At the Pit 6 Landfill OU, nitrate concentrations in ground water in excess of cleanup standards have historically been detected in the Qt-Tnbs$_1$ HSUs. Nitrate concentrations in the Qt-Tnbs$_1$ HSU ground water have decreased from a historic maximum of 240 mg/L (K6-23, 2000) to a five-year review period maximum of 220 mg/L (K6-23, 2007) to a current maximum of 150 mg/L in the same well. Nitrate concentrations in the Qt-Tnbs$_1$ HSUs for the first semester of 2011 are presented on Figure 24. As shown on Figure 24, nitrate concentrations in two wells currently exceed the 45 mg/L MCL cleanup standard: K6-23 (130 mg/L) within the Qt-Tnbs$_1$ South HSU and K6-24 (62 mg/L) in the Qt-Tnbs$_1$ North HSU. Nitrate concentrations in the Qt-Tnbs$_1$ North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - As shown on Figure 25, nitrate concentrations in Qt-Tnbs$_1$ North HSU ground water have been well below the 45 mg/L MCL cleanup standard with the exception of two samples from well K6-24 collected in 2011. Nitrate concentrations in well K6-24 shows a generally stable trend at low concentrations (less than 2 mg/L) until 2011 when the concentration increased significantly to 62 mg/L in January and 63 mg/L in April, before going dry in second semester 2011. Wells K6-04 and EP6-08 show generally stable trends until 2004 and decreasing trends since then. Some Qt-Tnbs$_1$ North HSU wells have been dry the last several years, and therefore samples have not been collected. However, DOE collected samples for nitrate analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-Tnsb$_1$ North HSU wells had gone dry. Nitrate was detected at concentrations of 2.1 mg/L in a ground water sample collected from well W-PIT6-2816, and was not detected above the reporting limit in well W-PIT6-2817.

Qt-Tnbs$_1$ South HSU - As shown on Figure 26, nitrate concentrations in South HSU wells have decreased from a historic maximum of 240 mg/L (K6-23, May 2000) to a current maximum of 150 mg/L (July 2011) in the same well. This well (K6-23), as shown on Figure 25, has consistently yielded nitrate concentrations in excess of the 45 mg/L MCL cleanup standard (ranging in concentration between 130 and 240 mg/L). Well K6-23 is located in close proximity to the Building 899 septic system, a potential source of the nitrate. The nitrate time-series for well K6-18 (Figure 25) shows that nitrate exceeded the MCL cleanup standard in 1998 and 2009, but otherwise shows a general decreasing trend. Nitrate concentrations in wells K6-16 and EP6-09 show generally stable to slightly increasing trends, with concentrations well below the MCL cleanup standard.

Tnbs$_1$ Deep HSU

Nitrate has never been detected in Tnbs$_1$ Deep HSU ground water monitoring wells.

Qal-Tts HSU

Nitrate has historically been detected in Qal-Tts HSU ground water, however, concentrations have been significantly below the 45 mg/L MCL cleanup standard and within the range of background levels.

2.5.1.4.2. Water-Supply Wells

While nitrate is sporadically detected in downgradient active water-supply wells CARNRW1 and CARNRW2 above the reporting limit, nitrate concentrations detected in these well (less than 5.2 mg/L) are well below the 45 mg/L MCL cleanup standard, and within the range of background levels. Nitrate has also been detected in cross-gradient well CARNRW4, however

concentrations have been significantly below the 45 mg/L MCL cleanup standard and within the range of background levels. Nitrate has not been detected in downgradient well CARNRW3.

2.5.1.4.3. Springs

Nitrate has not been detected from Pit 6 springs, when sampled.

2.5.1.4.4. Nitrate Remediation Progress Summary

Nitrate concentrations in Pit 6 ground water have decreased from a historic 240 mg/L in 2000 to a current maximum of 150 mg/L. Nitrate is currently present above the 45 mg/L MCL in only two wells; K6-23 and K6-24. Nitrate continues to be detected above the 45 mg/L cleanup standard in well K6-23, with concentrations ranging from 130 to 240 mg/L. The nitrate concentrations in this well may be attributable to the septic system at Building 899B. Nitrate was also detected during the first semester 2011 for the first time above the 45 mg/L cleanup standard in well K6-24 (62 mg/L in January and 63 mg/L in April), before going dry in second semester 2011. While the remedy for nitrate in ground water at the Pit 6 Landfill OU 3 is considered to be effective, DOE will continue to investigate the cause/source of the high nitrate concentrations in wells K6-23 and K6-24.

Nitrate concentrations in the Carnegie SVRA water-supply wells and the upgradient guard well W-PIT6-1819 have always been well below the 45 mg/L MCL cleanup standard and within the range of background levels. Both the guard well and water-supply wells will continue to be monitored for nitrate to provide an early indication of changes that could result in impacts to the water-supply wells. No nitrate has been detected in the springs in the vicinity of Pit 6.

Therefore, the remedy for nitrate in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective.

2.5.2. Pit 6 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 6 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Pit 6 Post-Closure Plan. As part of the detection monitoring program, ground water samples are collected from wells located upgradient and wells directly downgradient of the landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill.

Twenty-four constituents of concern, including VOCs, beryllium, mercury, perchlorate, tritium, uranium, and gross alpha/beta as surrogates for seven other radionuclides, are currently monitoring quarterly in the Pit 6 detection monitoring wells (EP6-06, EP6-08, EP6-09, K6-01S, K6-19, and K6-36). Field measurements of ground water physical parameters are collected at the time of sampling.

Statistical analyses and comparison of upgradient and downgradient concentrations of these constituents are used to determine if additional releases have occurred from the landfill.

Statistical analysis of detection monitoring results started in 1998. Since then, three statistically significant evidence of releases have been reported based on comparisons to statistical limits as follows:

- In 1998, well EP6-09 exceeded its 1,2-DCA statistical limit of 0.5 µg/L with a concentration of 0.68 µg/L.
- In 2007, well EP6-08 exceeded its TCE statistical limit of 0.5 µg/L with a concentration of 0.8 µg/L.
- In 2008, well EP6-08 exceeded its uranium statistical limit of 1.62 pCi/L with an activity of 2.97 pCi/L.

These statistical limit exceedances were evaluated at the time, and the RWQCB concurred that they were not indicative of new releases because (1) both 1,2-DCA and TCE are known to have been released to ground water prior to the capping of Pit 6 as VOCs have historically been detected in both EP6-08 and EP6-09; (2) naturally occurring uranium is known to be present in Site 300 ground water, concentrations detected in well EP6-08 have always been within the background range for natural uranium, and the uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratio measured in Pit 6 detection monitor wells indicate that the uranium is natural (0.007); and (3) these concentration variances from the statistical limits, which are near reporting limits in these wells, are attributable to changes in hydrogeologic conditions.

A number of factors could cause a constituent's concentration in ground water to increase without being indicative of a new release from the landfill. Hydrogeologic conditions can change quickly even if they have been stable for a number of years. For example, if a high rainfall year occurs following several years of drought, especially immediately downgradient of a recharge area, it can cause water levels to rise and pick up residual VOCs or other constituents in the vadose zone that were released prior to capping. Similarly, increases in concentration of naturally occurring metals can result if water levels rise into soil or rock containing residual metal salts that were previously deposited when water levels dropped during drought periods. Additionally, DOE/LLNL briefly pumped and treated ground water from well EP6-09. After an initial decrease in VOC concentrations in this well, TCE concentrations increased when pumping ceased.

Based on evaluations of detection monitoring results since 1998, there have been no new releases of COCs since the landfill was capped.

2.5.3. Pit 6 Landfill OU Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup. Therefore, no performance issues were identified.

2.5.4. Pit 6 Landfill OU Risk Mitigation Remediation Progress

This section summarizes the results of the annual risk re-evaluations conducted for the Pit 6 Landfill OU to assess the progress of the remedy in mitigating risk associated with VOCs in the pit waste, at Spring 7, and in ground water that could migrate to the Carnegie SVRA Park wells and pond. The risks from COCs at the Pit 6 OU Landfill were summarized in Section 2.2.5 and are discussed in more detail in the 2008 Site-Wide ROD.

The cancer risks and hazard indices identified in the baseline human health risk assessment for OU 3 and the status/progress of the remedy in mitigating those risks and hazards are as follows:

- Pit 6 Landfill – A cumulative risk of 5×10^{-6} was estimated for onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period. The landfill cap, installed as part of a CERCLA removal action in 1997, mitigated the inhalation risk associated with VOCs in the landfill waste.
- The Carnegie SVRA pond (offsite, east of the Pit 6 Landfill) – A cumulative hypothetical risk of 3×10^{-6} was estimated for offsite residence that could potentially inhale VOC vapors volatilizing from the Carnegie SVRA pond and migrating into outdoor air. Although water-supply well CARNRW1 is actually used to fill the Carnegie SVRA pond, the baseline risk assessment conservatively assumed that in the future, well CARNRW2, which has a much longer well screen than CARNRW1, could be used to provide water to the SVRA pond. The baseline risk assessment indicated that if the VOC source in the Pit 6 Landfill OU was not controlled, contaminated ground water could migrate to well CARNRW2 and result in an unacceptable risk from inhaling VOC vapors volatilizing from the pond. However, an engineered cap was placed over the Pit 6 Landfill preventing infiltration of precipitation and further releases of contaminants from the landfill. The VOC plume originating from the Pit 6 Landfill has not impacted CARNRW2. In addition, ground water VOC concentrations upgradient have substantially decreased, and are below the MCL cleanup standards, except for TCE in one well located onsite approximately 1,300 ft upgradient of CARNRW2. Therefore, no unacceptable risk or hazard exists at the Carnegie SVRA pond.
- Spring 7 – A cumulative risk of 4×10^{-5} and HI of 1.5 was estimated for onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the Spring 7 and migrating into outdoor air over a 25-year period. The CMP/CP requires that the risk associated with volatile contaminants in surface water migrating upward into outdoor ambient air and being inhaled by workers be re-evaluated annually using current data and reported in the annual ERD Compliance Monitoring Reports. DOE, EPA, and the State regulatory agencies agreed that the risk would be considered successfully mitigated and risk management would be complete when the estimated risk is below 10^{-6} for two consecutive years. Risk re-evaluation and reporting for VOC inhalation in outdoor air near Spring 7 was initiated in 2003. No one regularly works in the vicinity of Spring 7 and this spring has been dry since 2000. Therefore, there is currently no potential for VOC inhalation from this spring. In addition, Spring 7 is fed by ground water and VOC concentrations in ground water in the Pit 6 Landfill area have decreased significantly. Therefore DOE/NNSA assumes that if surface water were present in this spring, the risk associated with the inhalation of VOCs has likely been reduced. The spring is and will continue to be monitored for the presence of surface water or green hydrophilic vegetation, and if either is observed, ambient air in the vicinity of the spring will be sampled to evaluate risk.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the Integrated Risk Information System (IRIS) (EPA, 2011). The updated cancer inhalation unit risk (IUR) for TCE is 4.0×10^{-6} $(\mu g/m^3)^{-1}$ and the non-cancer

reference concentration (RfC) for TCE is 2.0 x 10^3 mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As part of this report, onsite worker inhalation risks associated with vapor intrusion from the subsurface into indoor and outdoor air in the Pit 6 Landfill OU were evaluated using the new TCE toxicity values. The Jury model (Jury et al., 1983) was used to assess the risk to onsite workers breathing in outdoor air containing TCE. The estimated risk level in outdoor air from TCE was 4.7 x 10^{-19} and the hazard quotient was 1.4 x 10^{-10}. For indoor air at Building 899B, the current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991). The incremental risk from vapor intrusion of TCE to indoor air was 1.3 x 10^{-9} and the hazard quotient was 1.4 x 10^{-9}, assuming a maximum TCE concentration in ground water of 3.5 µg/L, sampled on March 9, 2009 in nearby well K6-18.

The only other VOC currently detected above the reporting limit at the Pit 6 Landfill OU is cis-1,2-DCE; which is detected in only one monitor wells (K6-01S). There have been no changes to the toxicity criteria for cis-1,2-DCE in the past five years. Therefore, the inhalation risk and hazard for 1,2-DCA were not re-evaluated. No other VOCs besides TCE and 1,2-DCA are detected in ground water in this area**.**

No unacceptable risk or hazard was identified for the vapor inhalation pathway at the Pit 6 Landfill. Therefore, the protectiveness of the remedy is not affected.

The baseline ecological assessment indicated an inhalation risk for individual ground squirrels and kit fox from VOCs volatilizing from the Pit 6 Landfill (the combined inhalation Hazard Indices exceeded 1 for these species).

A burrow air-sampling program was conducted in 2004 to determine actual exposure concentrations. The results of the ecological survey program reported in the First Semester 2004 Compliance Monitoring Report (Dibley et al., 2004) indicated that burrow air did not contain VOCs at concentrations that would result in a HI or hazard quotient greater than 1. Since there is no potential for ecological harm, VOCs in burrow air were deleted from the list of ecological COCs and are no longer evaluated and reported in the Compliance Monitoring Reports. In addition, surveys for sensitive species at the Pit 6 Landfill have been discontinued. (Note: kit foxes have never been observed in any ecological surveys at Site 300 or by Site 300 personnel working at the site. Risk for this sensitive species was evaluated due to the presence of potential habitat at Site 300.)

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Pit 6 Landfill OU. No information was identified during this review to question the ecological protectiveness of the remedy.

2.6. Pit 6 Landfill OU Interviews and Site Inspection

DOE/NNSA and LLNL meet monthly with the EPA, RWQCB, and DTSC Remedial Project Managers (RPMs) and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 6 Landfill cap and associated drainage ways are annually inspected by an independent Registered Professional Civil Engineer. LLNL conducts

self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs request periodic site inspections. The U.S. EPA performed the construction completion inspection on February 5, 2008. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and quarterly and annually by the LLNL Environmental Functional Area and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes that are distributed following the meetings.

2.7. Pit 6 Landfill OU Technical Assessment

The protectiveness of the remedy was assessed by determining if:

1. The remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the remedy into question.

2.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential remedy failure were identified.
- Costs have generally been within budget.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- The Pit 6 Landfill cap is performing as designed, and new releases from the landfill have been detected since the cap was installed.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

2.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

The assumptions used in the decision-making process was determined to still be valid because:

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.

- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific applicable or relevant and appropriate requirements (ARARs) or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA National Pollution Discharge Elimination System (NPDES) Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Pit 6 OU remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. The updated cancer IUR for TCE is 4.0×10^{-6} $(\mu g/m^3)^{-1}$ and the non-cancer RfC for TCE is 2.0×10^{3} mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 2.5.4, the inhalation risks associated with TCE vapor intrusion from the subsurface into indoor and outdoor air for onsite workers at the Pit 6 Landfill OU were evaluated using the new EPA toxicity values for TCE. The Jury model (Jury et al., 1983) was used to assess the inhalation risk to onsite workers posed by TCE volatilizing into outdoor air. The risk level in outdoor air from TCE was 4.7×10^{-19} and the hazard quotient was 1.4×10^{-10}. For indoor air at Building 899B, the current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991). The incremental risk from vapor intrusion of TCE to indoor air was 1.3×10^{-9} and the hazard quotient was 1.4×10^{-9}, assuming a maximum TCE concentration in ground water of 3.5 µg/L, sampled on March 9, 2009 in nearby well K6-18. The only other VOC currently detected above the reporting limit at the Pit 6 Landfill OU is cis-1,2-DCE; which is detected in only one monitor wells (K6-01S). There have been no changes to the toxicity criteria for cis-1,2-DCE in the past five years. Therefore, the inhalation risk and hazard were not re-evaluated. No other VOCs besides TCE and 1,2-DCA are currently detected in ground water in this area**.** Although EPA released updated toxicity values for PCE in February 2012, PCE has not been detected above the reporting limit in ground water in any Pit 6 well during the past five years. Therefore, although the toxicity criteria for PCE were updated within the five-year review period, the re-evaluation of risk and hazard for PCE was not warranted. No unacceptable risk or hazard were identified for the vapor inhalation pathway. Therefore, the protectiveness of the remedy is not affected.
- The review found that the remedy is making progress toward meeting the RAOs.

2.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Pit 6 Landfill OU.

2.8. Pit 6 Landfill OU Issues

No issues were identified during this evaluation.

2.9. Pit 6 Landfill OU Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Over the next five years, monitor TCE concentrations in ground water at well EP6-09; if concentrations increase or remain above 5 µg/L, remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.
2. Remove 1,2-DCA as a ground water COC because: (1) concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L MCL cleanup standard and reporting limit in all Qt-$Tnbs_1$ HSU wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), and (2) 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,2-DCA) in the detection monitor wells. 1,2-DCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
3. Remove cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), (2) cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011), and (3) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including cis-1,2-DCE) in the detection monitor wells. Cis-1,2-DCE concentrations would still be

reported/discussed as part of the evaluation of TCE MNA and detection monitoring in the Compliance Monitoring Reports.

4. Remove trans-1,2-DCE as a ground water COC because concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including trans-1,2-DCE) in the detection monitor wells. Trans-1,2-DCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
5. Remove PCE as a ground water COC because: (1) PCE has never been detected at concentrations exceeding its 5 µg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 µg/L in 1988), and (2) PCE has not been detected at concentrations above the 0.5 µg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including PCE) in the detection monitor wells. PCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
6. Remove 1,1,1-TCA as a ground water COC because: (1) 1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990), and (2) 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,1,1-TCA) in the detection monitor wells. 1,1,1-TCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
7. Remove perchlorate as a ground water COC because perchlorate concentrations have decreased to and remained below the 4 µg/L reporting limit in all Pit 6 wells for over three years (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill. The perchlorate results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations

and Distribution section of these reports unless it is detected in the remedial action monitor wells.

No other follow-up actions were identified related to this Five-Year Review.

2.10. Pit 6 Landfill OU Protectiveness Statement

The remedy at the Pit 6 Landfill OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) tritium activities in ground water are below cleanup standards and are decreasing toward background levels, the extent of VOCs and nitrate with concentrations exceeding cleanup standards are limited to a few wells, and perchlorate is not detected in ground water, (2) the VOC inhalation risk to onsite workers has been mitigated by the installation of the landfill cap, (3) ground water monitoring will provide an early indication of migration of contaminants towards the site boundary and offsite water-supply wells, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Pit 6 Landfill OU ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

3. Five-Year Review for the Site-Wide OU (OU 8)

The Site 300 Site-Wide OU is comprised of release sites where there was no significant contamination found that can impact human health or the environment. For this reason, OU 8 contains the Site 300 areas with final remedies consisting of monitoring, risk and hazard

management, and landfill inspection selected in the 2008 ROD. The Site-Wide OU (OU 8) consists of the following areas of Site 300:

- Building 801 and Pit 8 Landfill (Section 3.1)
- Building 845 Firing Table and Pit 9 Landfill (Section 3.2)
- Building 833 (Section 3.3)
- Building 851 Firing Table (Section 3.4)
- Pit 2 Landfill (Section 3.5)

The Pit 2 Landfill was moved from OU 5 to OU 8 after the Interim ROD.

3.1. Building 801 and Pit 8 Landfill

3.1.1. Building 801 and Pit 8 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 801 and Pit 8 Landfill:

1955–1999

- Building 801 Firing Table was used for explosives testing from 1955 until 2001.
- Gravel was removed from the Building 801 Firing Table under oversight of the RWQCB in 1988.
- The Building 801D Dry Well was active from the late 1950s to about 1984 when it was decommissioned and filled with concrete.
- The Pit 8 Landfill was constructed in 1958.
- Debris from the Building 801 Firing Table was disposed of in Pit 8 until 1974 when an earthen native soil cover was installed.

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A FFA was signed for Site 300.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included Building 801 and the Pit 8 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs in subsurface soil at the Building 801 Dry Well and ground water monitoring as components of the remedy for Building 801 and the Pit 8 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.
- Outdoor firing experiments were discontinued when an indoor test chamber (the Contained Firing Facility) was built on the site of the former firing table.

2002

- The CMP/CP for Interim Remedies was issued.
- The Contained Firing Facility (CFF) began operating.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established.

2009

- The revised CMP/CP was issued.

3.1.2. Building 801 and Pit 8 Landfill Background

3.1.2.1. Building 801 and Pit 8 Landfill Physical Characteristics

3.1.2.1.1. Building 801 and Pit 8 Landfill Site Description

Building 801 and the Pit 8 Landfill are part of the Building 801 Complex located in the northeastern portion of Site 300 (Figure 2). The Building 801 Complex covers approximately 90 acres and consists of the Building 801 Firing Table (replaced by the CFF in 2001), Buildings 801A, 801B, 801C, and 801D, the Flash X-ray facility, Pit 8 Landfill, an HE storage magazine, and a corporation yard. The Building 801 Complex is located at the base of a wide and shallow valley (Figure 27).

Explosives testing was initiated at the Building 801 Firing Table in 1955. Use of the firing table was suspended briefly in 1988, and the firing table gravel and some underlying soil were removed and disposed of in the Pit 1 Landfill in 1988 under oversight of the RWQCB (Lamarre and Taffet, 1989). Outdoor firing experiments resumed and continued until 2001, when an indoor test chamber, the CFF, was built on the site of the former firing table.

A dry well, located under Building 801D, was used to dispose of rinsewater from a sink in the machine shop at Building 801D from the late 1950s to about 1984. The dry well was decommissioned and filled with concrete in 1984 (Lamarre and Taffet, 1989).

The Pit 8 Landfill is an unlined landfill that was constructed in 1958 immediately northeast of the Building 801 Complex. Debris from the Building 801 Firing Table was disposed of in Pit 8 until 1974 when an earthen cover was installed. The total estimated volume of material disposed of in the Pit 8 Landfill is about 24,700 yd^3.

3.1.2.1.2. Building 801 and Pit 8 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 801 and Pit 8 Landfill area, including the unsaturated zone, the underlying HSU, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 801 and Pit 8 Landfill area is shown on Figure 28.

Building 801 and Pit 8 Landfill Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam on the slopes above Building 801 and in valley bottoms and underlying unsaturated $Tnbs_1$ bedrock. The upper $Tnbs_1$ bedrock is unsaturated to a depth of approximately 130 to 150 ft bgs.

Building 801 and Pit 8 Landfill Saturated Zone

The Building 801 and Pit 8 Landfill area is underlain by a single HSU, the $Tnbs_1/Tnbs_0$ HSU. This HSU consists of the $Tnbs_1$ and the basal blue sandstone ($Tnbs_0$). Ground water is present in the $Tnbs_1/Tnbs_0$ HSU under unconfined to confined conditions. Depth to water averages about 130 to 150 ft bgs. Recharge for this HSU occurs within alluvial channels. Since monitoring of the existing well network began in 1989, ground water flow direction in the $Tnbs_1/Tnbs_0$ HSU has ranged approximately 105 degrees northeast to southeast beneath Building 801 and the Pit 8 Landfill (Figure 27). The exact causes of the observed variability in ground water flow direction are unknown but may include changes in relative contributions of percolation from different recharge areas (both from construction [of impermeable surfaces] at the Building 801 CFF and natural factors), aquifer heterogeneity and variability in porous versus fracture flow, and long term changes in rock hydraulic properties due to seismicity and other processes. The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft.

Building 801 and Pit 8 Landfill Surface Water

Natural surface water in the Building 801 and Pit 8 Landfill area is the result of runoff from precipitation. Natural surface runoff is rarely present, and only occurs briefly during more significant (greater than 0.3 inches/hour) or prolonged (greater than 2 hours) storms. There are no surface water bodies (i.e., springs) in the Building 801 and Pit 8 Landfill area.

3.1.2.2. Building 801 and Pit 8 Landfill Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than five percent of Site 300's 7000-acre property-area is developed.

The Building 801 and Pit 8 Landfill area is located in the central portion of Site 300, approximately 5,000 feet southwest of the Site 300 northeastern boundary. Outdoor firing experiments at the Building 801 Firing Table were discontinued in 2001 when the Contained Firing Facility indoor test chamber was built on the site of the former firing table. The Building 801 Contained Firing Facility continues to be regularly used for explosive testing. Use of the Pit 8 Landfill was discontinued and a cover installed in 1974. The Pit 8 Landfill area has not been used for site activities since that time.

There are no active onsite water-supply wells in the Building 801 and Pit 8 Landfill area.

A large area of native perennial grasslands occurs to the south and east of Building 801 and Pit 8 Landfill, whereas annual grasslands occur to the north and west of these facilities, and a small amount of coastal sage scrub occurs to the southeast of the facility. Large numbers of the big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, are routinely mapped around Building 801 and Pit 8 Landfill. The facilities occur within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed near the facilities. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 801 or Pit 8 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified.

Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.1.2.3. Building 801 and Pit 8 Landfill History of Contamination

No environmental contamination has been identified associated with Building 801 Firing Table activities. Waste fluid discharges to the Building 801 Dry Well resulted in low concentrations of VOCs in the surrounding surface and subsurface soil and ground water. Contaminants have not been detected in the vicinity of or beneath the Pit 8 Landfill.

3.1.2.4. Building 801 and Pit 8 Landfill Initial Response

Investigations began in 1982 at the Building 801 and Pit 8 Landfill area to identify any potential contaminant release sites and contaminants in soil, bedrock, and ground water. Since then, 14 boreholes have been drilled; five of these boreholes have been completed as ground water monitor wells (Figure 27). The geologic, hydrologic, and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Firing table gravel and underlying soil and rock samples were also collected from five of the boreholes. Ground water monitoring has been conducted to evaluate VOCs released from the Building 801 Dry Well and to detect any potential future releases from the Pit 8 Landfill.

3.1.2.5. Building 801 and Pit 8 Landfill Contaminants of Concern

The following COCs have been identified in $Tnbs_1/Tnbs_0$ HSU ground water at Building 801: (1) VOCs including chloroform, TCE, and 1,2-DCA, and (2) nitrate. The distribution and concentration of contaminants in ground water is described in Section 3.1.5.1. TCE has also been identified as a COC in subsurface soil and rock in the vicinity of the former Building 801 dry well. No COCs have been identified in surface soil, subsurface soil/rock, or in ground water associated with the Pit 8 Landfill. No unacceptable risk or hazard to human receptors was identified associated with COCs at Building 801 or Pit 8 Landfill in the baseline risk assessment. Modeling conducted for this area in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that the TCE in the vadose zone does not represent a significant threat to ground water.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from Building 801 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil. Cadmium surface soil sampling was conducted in November 2011; six samples were collected and all samples contained less than 0.5 milligrams per kilogram (mg/kg) of cadmium (reporting limit) (further detailed in Section 3.1.5.3, Figure 29, and Table 4).

3.1.2.6. Building 801 and Pit 8 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards and the landfill remains in place.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. However, site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. Therefore, no active remediation was required.

3.1.3. Building 801 and Pit 8 Landfill Remedial Actions

3.1.3.1. Building 801 and Pit 8 Landfill Remedy Selection

The remedy selected for the Building 801 and Pit 8 Landfill is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

A remedy was selected for the Building 801 and Pit 8 Landfill in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 801 and Pit 8 Landfill consists of:

1. No further action for VOCs in subsurface soil.
2. Monitoring ground water to detect any future releases from the Pit 8 Landfill or changes in contaminant concentrations in ground water that could impact human health or the environment.
3. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
4. Inspecting the Pit 8 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.1.3.2. Building 801 and Pit 8 Landfill Remedy Implementation

Monitoring of ground water at the Building 801 and Pit 8 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 8 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. The detection monitoring and results for the Pit 8 Landfill is discussed in Section 3.1.5.2.

As part of the remedial action monitoring program, ground water samples are collected from downgradient wells and analyzed for ground water COCs to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, to meet remedial action objectives, and verify the attainment of cleanup standards. The remedial action monitoring results are discussed in Section 3.1.5.1.

Land Use Controls have been implemented to prevent damage to the landfill cap (see Section 3.1.3.4).

The results of the detection and remedial action monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.1.3.3. Building 801 and Pit 8 Landfill Operation and Maintenance

The remedy for the Building 801 and Pit 8 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cover maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 8 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cover to detect differential settling or other earth movement.
- Annual inspection of the pit cover by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cover are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the

Building 801 and Pit 8 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.1.3.4. Building 801 and Pit 8 Landfill Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (U.S. EPA 2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as FFAs, that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers. The land use controls and requirements described herein are only applicable to the Building 801/Pit 8 Landfill and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 801/Pit 8 Landfill are described in Table 5 which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 801/Pit 8 Landfill area. Figure 30 shows the specific areas of the Building 801/Pit 8 Landfill where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 801/Pit 8 Landfill by objective, and the status of the land use controls are summarized below.

3.1.3.4.1. Building 801/Pit 8 Landfill Land Use Control Objectives

Land use control objectives were established for the Building 801/Pit 8 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 801/Pit 8 Landfill include:

1. ***Risk Driver*** - VOC concentrations in ground water onsite exceed cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** - Potential exposure to VOCs at depth in subsurface soil near the former location of the Building 801 dry well. (Note: the VOCs at depth in subsurface soil do not pose a risk to onsite workers via the pathway where VOCs could volatilize and migrate through the vadose zone into outdoor air. However, risk for onsite worker exposure to VOCs at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

   Land use control objectives:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

3. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
   - Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

4. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 8 Landfill. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 801 Firing Table and Pit 8 Landfill in the baseline risk assessment.

3.1.3.4.2. Building 801/Pit 8 Landfill Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 801/Pit 8 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL implements multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Building 801 area until ground water cleanup standards are met. The land use controls include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well before a dig permit is issued. During this five-year review period, there were no dig permit applications to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Building 801/Pit 8 Landfill area.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

Currently, 1,2-DCA is the only VOC detected above its cleanup standard in the Building 801/Pit 8 Landfill area (see Section 3.1.5.1). VOCs in ground water are likely the result of releases from the former Building 801 dry well, which have migrated downgradient from Building 801 to the area beneath the landfill. The 2011 maximum 1,2-DCA concentration of

1.8 µg/L was detected in ground water collected from well K8-01 (immediately downgradient of Building 801 and upgradient of Pit 8 Landfill).

During this five-year review period, there were no proposals brought to the Work Induction Board to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Building 801/Pit 8 Landfill area.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work. During this five-year review period, there were no dig permit applications for excavation or construction activities in the Building 801/Pit 8 Landfill area.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation of subsurface soil. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Building 801/Pit 8 Landfill area.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cover and ground water monitoring system. Landfill cover maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfill: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place are the same as those discussed in the *Control Excavation Activities: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 8 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Excavation Activities: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 8 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers and Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers and unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Fences.
  - Security Force.
  - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300.

The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review period. The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD. The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391. 1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

3.1.3.4.3. Summary of the Status of Building 801/Pit 8 Landfill Land Use Controls

The review of the land use controls for the Building 801/Pit 8 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 801/Pit 8 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.1.4. Building 801 and Pit 8 Landfill Five-Year Review Process

3.1.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

3.1.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 801 and Pit 8 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.1.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).

- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 801 and Pit 8 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.1.5. Building 801 and Pit 8 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentration, and remediation progress (Section 3.1.5.1), (2) Pit 8 Landfill detection monitoring and results (Section 3.1.5.2), (3) performance issues (Section 3.1.5.3), and risk mitigation remediation progress (Section 3.1.5.3).

3.1.5.1. Building 801 and Pit 8 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

The VOCs chloroform, 1,2-DCA, TCE, and perchlorate and nitrate are the COCs identified in ground water at Building 801. TCE is a COC in the vadose zone in the vicinity of the former Building 801 dry well. There are no COCs in ground water, vadose zone, or surface soil attributable to releases from the Pit 8 Landfill. VOCs detected in samples from wells adjacent to Pit 8 originate from releases from the former Building 801D dry well that has migrated downgradient to the vicinity of the landfill. A list of COCs and their historic maximum and 2011 maximum concentrations for Building 801 and Pit 8 Landfill is detailed in Table 6. Figure 27 shows the 2011 concentrations of ground water COCs.

VOCs detected in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 8 Landfill area result from releases from the former Building 801 dry well, which have migrated downgradient from Building 801 to the area beneath the landfill.

During 2011, 1,2-DCA was the only VOC detected above its 0.5 µg/L MCL cleanup standard. However, the 2011 maximum 1,2-DCA concentration of 1.8 µg/L detected in well K8-01 (immediately downgradient of Building 801 and upgradient of Pit 8 Landfill) represents a decrease from: (1) the historic maximum 1,2-DCA concentration of 5 µg/L measured in the same well most recently in 1990, as well as (2) the five-year review period maximum 1,2-DCA concentration of 2.5 µg/L (K8-01, 2007). Time-series plots of 1,2-DCA trends since ground water monitoring for this compound began in 1987 are presented on Figure 31.

TCE concentrations have decreased from the historic maximum concentration of 6 µg/L (K8-01) to a fourth quarter 2011 maximum of 3.3 µg/L (K8-01). TCE has historically only been detected above the 5 µg/L MCL cleanup standard in one well (K8-01) and TCE concentrations in this well have decreased to and remained below the cleanup standard since April 1992. TCE has never been detected above the 5 µg/L MCL cleanup standard in the other wells since monitoring began in 1988. The presence of VOCs in ground water samples from well K8-04, located immediately downgradient of the Pit 8 Landfill, indicates a continuation of the VOC plume originating at the Building 801 dry well and is not due to a release from the Pit 8 Landfill. Time-series plots of TCE data since ground water monitoring for this compound began in 1987 are presented on Figure 32.

Chloroform has never been detected in Building 801/Pit 8 Landfill monitor wells at concentrations near or above the 80 µg/L MCL cleanup standard since monitoring for this constituent began in 1987 (maximum historical concentration of 2.4 µg/L in 1992). Chloroform concentrations have decreased to and remained below the 0.5 µg/L reporting limit in all wells since 2008.

Perchlorate has never been detected in Building 801/Pit 8 Landfill monitor wells at concentrations above the 6 µg/L MCL cleanup standard since monitoring for this constituent began in 1998. Perchlorate concentrations have decreased from the historic maximum concentration of 5 µg/L (K8-04, 2003) to below the 4 µg/L reporting limit in all wells since 2010.

Concentrations of nitrate in ground water in the vicinity of Building 801/Pit 8 Landfill have been relatively stable over time. The 2011 maximum nitrate concentration in the area was 57 mg/L (K8-04, May 2011). In 2011, a sample from well K8-04 and a duplicate sample from well K8-01 (both 47 mg/L, in May 2011) were the only detections in area wells that exceeded the 45 mg/L cleanup standard for nitrate. The historic maximum nitrate concentration is 64 mg/L (K8-01, 2002) and the five-year review period maximum nitrate concentration is 61 mg/L (K8-04, 2009). Overall, nitrate concentrations in ground water at the Building 801/Pit 8 Landfill generally are similar to previous years. Time-series plots of nitrate data since monitoring began in 1998 are presented on Figure 33.

In summary, VOCs, nitrate, and perchlorate have been identified as COCs in the $Tnbs_1/Tnbs_0$ HSU ground water due to the historic releases from the Building 801 dry well. Of these ground water COCs, only 1,2-DCA and nitrate currently exceed ground water cleanup standards. TCE concentrations are currently below its cleanup standards. Chloroform has never been detected at concentrations above its cleanup standard, and it has not been detected in ground water since 2008. Perchlorate has never been detected at concentrations above the cleanup standard, and it has not been detected in ground water since 2010.

3.1.5.2. Pit 8 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 8 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program for the Pit 8 Landfill, ground water samples are collected from two monitor wells located upgradient and three monitor wells located directly downgradient of the landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed of in the landfill.

The constituents of concern for the Pit 8 Landfill include VOCs, nitrate, perchlorate, tritium, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

While TCE and 1,2-DCA are detected in wells downgradient of the landfill, concentrations of these VOC COCs are also detected in wells upgradient of the landfill at higher concentrations. This data indicate that these constituents have migrated downgradient for the Building 801D former dry well area, and do not represent a release of VOCs from the Pit 8 Landfill.

While nitrate was detected at concentrations above the 45 mg/L MCL cleanup standard in well K8-04 located downgradient of the landfill, nitrate was also detected at concentrations exceeding the cleanup standard in well K8-01, located upgradient of the landfill.

Perchlorate is not detected above the 4 µg/L reporting limit in wells located up- or downgradient of the Pit 8 Landfill.

Tritium activities in all samples collected during 2011 were below the reporting limit (<100 pCi/L), except for the regular and duplicate May 2011 samples from well K8-01 (144 ± 60.0 and 104 ± 75.3 pCi/L, respectively) and the regular November 2011 sample collected from the same well (155 ± 94.1 pCi/L). These activities are all within the range of background and well K8-01 is located upgradient of the landfill.

Since monitoring began, concentrations/activities of HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride in ground water samples collected from wells upgradient and downgradient of the Pit 8 Landfill have either been below reporting limits or within the range of background concentrations.

No contaminant releases have been identified from the Pit 8 Landfill. However, as discussed in Section 3.1.2.1.2 and shown on Figure 27, historic ground water elevation data indicate that the flow direction has ranged from northeast to southeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

During the five-year review period, LLNS Maintenance and Utilities Services Department staff annually inspected the Pit 8 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that may have lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled some animal burrows but otherwise, no significant issues (including subsidence) were reported during annual inspection of the landfill surface.

3.1.5.3. Building 801 and Pit 8 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress towards meeting cleanup standards.

3.1.5.4. Building 801 and Pit 8 Landfill Risk Mitigation Remediation Progress

In the baseline risk assessment, no unacceptable human health risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 801 Dry Well or Pit 8 Landfill.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). The updated cancer IUR for TCE is 4.0×10^{-6} $(\mu g/m^3)^{-1}$ and the non-cancer RfC for TCE is 2.0×10^3 mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As part of this report, onsite worker inhalation risks associated with vapor intrusion

from the subsurface into indoor and outdoor air were evaluated using the new TCE toxicity values. The Jury model (Jury et al., 1983) was used to assess the risk to onsite workers breathing in outdoor air near Building 801. The risk level in outdoor air from TCE was 3.2 x 10^{-19} and the hazard quotient was 3.7 x 10^{-16}. For indoor air at Building 801, the current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991). The incremental risk from vapor intrusion of TCE to indoor air was 1.1 x 10^{-7} and the hazard quotient was 3.2 x 10^{-2}, assuming a maximum TCE concentration in ground water of 3.8 µg/L, sampled on May 19, 2011 in nearby well K8-01. While 1,2-DCA is currently detected in Building 801/Pit 8 Landfill area, there were no changes to the toxicity criteria for 1,2-DCA during the five-year review period. Therefore, the inhalation risk and hazard for 1,2-DCA were not re-evaluated. Although EPA released updated toxicity values for PCE in February 2012, PCE has not been detected above the reporting limit in ground water in any Building 801/Pit 8 Landfill well during the past five years. Therefore, although the toxicity criteria for PCE were updated within the five-year review period, the re-evaluation of risk and hazard for PCE was not warranted. No other VOCs besides TCE and 1,2-DCA are detected in ground water in this area. No unacceptable risk or hazard was identified for the vapor inhalation pathway at Building 801/Pit 8 Landfill. Therefore, the protectiveness of the remedy is not affected.

The baseline ecological risk assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 801 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil.

Cadmium surface soil sampling was performed in November 2011 by an LLNL ecologist (Dibley, et al., 2012). A map of historical sampling locations including the November 2011 samples is depicted on Figure 29 and Table 4 provides a historical summary of cadmium analytical results used to calculate the 95% Upper Confidence Limit of the mean (UCL), including the November 2011 samples. The 95% UCL was below the Site 300 background for cadmium (1.9 mg/kg). There is clearly little ecological risk from cadmium in the Building 801 area, as areas with existing elevated cadmium concentrations are very small and isolated. Therefore, cadmium in surface soil will no longer be considered a contaminant of ecological concern in this area.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 801 and Pit 8 Landfill. No information was identified during this review to question the ecological protectiveness of the remedy.

3.1.6. Building 801 and Pit 8 Landfill Interviews and Site Inspection

DOE/NNSA and LLNL meets monthly with the U.S. EPA, RWQCB, and DTSC RPMs and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 8 Landfill cap and associated drainages are annually inspected by LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes that are distributed following the meetings.

3.1.7. Building 801 and Pit 8 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

3.1.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

3.1.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.

- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 801/Pit 8 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. The updated cancer IUR for TCE is 4.0×10^{-6} $(\mu g/m^3)^{-1}$ and the non-cancer RfC for TCE is 2.0×10^3 mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.1.5.3, the Baseline Risk Assessment did not identify any human health risks in the Building 801 and Pit 8 Landfill. However, as part of this report, onsite worker inhalation risks associated with vapor intrusion from the subsurface into indoor and outdoor air were evaluated using the new TCE toxicity values. The Jury model (Jury et al., 1983) was used to assess the risk to onsite workers breathing in outdoor air. The risk level in outdoor air from TCE was 3.2×10^{-19} and the hazard quotient was 3.7×10^{-16}. For indoor air at Building 801, the current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991). The incremental risk from vapor intrusion of TCE to indoor air at Building 801 was 1.1×10^{-7} and the hazard quotient was 3.2×10^{-2}, assuming a maximum TCE concentration in ground water of 3.8 µg/L, sampled on May 19, 2011 in nearby well K8-01. While 1,2-DCA is currently detected in Building 801/Pit 8 Landfill area, there were no changes to the toxicity criteria for 1,2-DCA during the five-year review period. Therefore, the inhalation risk and hazard for 1,2-DCA were not re-evaluated. No other VOCs besides TCE and 1,2-DCA are detected in ground water in this area. No unacceptable risk or hazard was identified for the vapor inhalation pathway at Building 801/Pit 8 Landfill. Therefore, the protectiveness of the remedy is not affected.
- The review found progress toward meeting the RAOs.

3.1.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 801 and Pit 8 Landfill area.

3.1.8. Building 801 and Pit 8 Landfill Issues

No issues were identified during this evaluation. However, as discussed in Section 3.1.2.1.2 and shown on Figure 27, historic ground water elevation data indicate that the flow direction in the $Tnbs_1/Tnbs_0$ HSU has ranged from northeast to southeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

3.1.9. Building 801 and Pit 8 Landfill Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the $Tnbs1/Tnbs_0$ HSU in the vicinity of the Pit 8 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells located north of the landfill and potentially one monitor well located south of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

3.1.10. Building 801 and Pit 8 Landfill Protectiveness Statement

The remedy at the Building 801 and Pit 8 Landfill currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) VOC concentrations are decreasing towards the cleanup standard (TCE and chloroform are below the cleanup standard), and perchlorate concentrations are below reporting limits, (2) human health risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were not identified for the Building 801 Dry Well or Pit 8 Landfill, (3) no COCs have been identified in surface soil, subsurface soil/rock, or in ground water associated with the Pit 8 Landfill and there have been no releases from the landfill, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of the Pit 8 Landfill will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions.

The cleanup standards for Building 801 and Pit 8 Landfill ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

3.2. Building 845 Firing Table and Pit 9 Landfill

3.2.1. Building 845 Firing Table and Pit 9 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 845 Firing Table and Pit 9 Landfill:

1958–1968

- Explosives experiments were conducted at the Building 845 Firing Table from 1958 until 1963.
- Approximately 4,400 yd^3 of debris from the Building 845 Firing Table were deposited in the Pit 9 Landfill prior to 1968.

1988

- A total of 1,942 yd^3 of gravel from the Building 845 Firing Table, and 390 yd^3 of soil from the Building 845 Firing Table berm were removed and disposed of at the Nevada Test Site (Lamarre and Taffet, 1989).

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A FFA was signed for Site 300.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 845 firing table and Pit 9 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for HMX and uranium in subsurface soil and bedrock and

monitoring as components of the remedy for Building 845 and the Pit 9 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.

- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was issued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.2.2. Building 845 Firing Table and Pit 9 Landfill Background

3.2.2.1. Building 845 Firing Table and Pit 9 Landfill Physical Characteristics

3.2.2.1.1. Building 845 Firing Table and Pit 9 Landfill Site Description

The Building 845 Firing Table and Pit 9 Landfill are located toward the center of Site 300 (Figure 2). The Building 845 Firing Table and Pit 9 Landfill cover approximately 6 acres. The Pit 9 Landfill is located within the upper portions of a U-shaped valley that opens to the north. Building 845 is located about 200 ft northeast of the landfill (Figure 34).

High explosives experiments were conducted at the Building 845 Firing Table from 1958 to 1963. The Pit 9 Landfill was used until 1968 to dispose of approximately 4.400 yd^3 of debris generated at the Building 845 Firing Table (Lamarre and Taffet, 1989). In 1988, firing table gravel and soil from a berm at the firing table were removed and disposed of at the Nevada Test Site.

Currently, Building 845 houses the Explosives Waste Treatment Facility that consists of the open detonation table, open burn pan, and open burn cage.

3.2.2.1.2. Building 845 Firing Table and Pit 9 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 845 and Pit 9 Landfill area, including the unsaturated zone and the HSU underlying the area, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300, including the Building 845 Firing Table and Pit 9 Landfill area, is shown on Figure 28.

Building 845 Firing Table and Pit 9 Landfill Vadose (Unsaturated) Zone

The vadose zone consists of up to 110 ft of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and underlying unsaturated lower $Tnbs_1$ bedrock.

Building 845 Firing Table and Pit 9 Landfill Saturated Zone

The Building 845 Firing Table and Pit 9 Landfill area is underlain by a single water-bearing zone: the $Tnsc_0$ HSU. This HSU consists of the Tertiary Neroly Formation $Tnsc_0$ basal claystone unit. Ground water is generally confined, and depth to water averages about 110 ft beneath Building 845. Recharge for this HSU occurs on hilltops and within alluvial channels. Since monitoring of the existing well network began in 1988, ground water flow direction in the

$Tnsc_0$ HSU has ranged approximately 75 degrees northwest to northeast beneath Building 845 and the Pit 9 Landfill (Figure 34). The exact causes of the observed variability in ground water flow direction are unknown but may include changes in relative contributions of percolation from different recharge areas (both from construction [of impermeable surfaces] at the nearby Explosives Waste Treatment Facility and natural factors, aquifer heterogeneity and variability in porous versus fracture flow, and long term changes in rock hydraulic properties due to seismicity and other processes. The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft.

Building 845 Firing Table and Pit 9 Landfill Surface Water

Natural surface water in the Building 845 and Pit 9 Landfill area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 845 and Pit 9 Landfill area.

3.2.2.2. Building 845 Firing Table and Pit 9 Landfill Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7000-acre property area is developed.

The Building 845 Firing Table and Pit 9 Landfill are near the center of Site 300, approximately 4,500 feet west of the closest (eastern) site boundary. As stated previously, the Building 845 area houses the Explosives Waste Treatment Facility that consists of the open detonation table, open burn pan, and open burn cage. The open detonation table is used for six to eight detonations a year at no more than 8 pounds each. Any explosives waste put on the open burn pan is completely gone after treatment. There is a small amount of ash that remains from the open burn cage that is collected in a drum for up to nine months near the open burn units. The drums of ash are shipped offsite as hazardous waste through the LLNL Radioactive and Hazardous Waste Management organization to a permitted treatment, storage or disposal facility. The California Department of Toxic Substances Control regulates the disposal and performs annual inspections of the facility and LLNL waste management practices. Details of these operations have not changed in the last five years.

There are no active onsite water-supply wells in the Building 845 Firing Table and Pit 9 Landfill area.

Large areas of native perennial grasslands occur to the southeast and northwest of Building 845 Firing Table and Pit 9 Landfill, with annual grasslands covering the remainder of the area. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, has also been mapped in the area around Building 845 Firing Table and Pit 9 Landfill. The facilities occur within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed near the facilities. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 845 Firing Table or Pit 9 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact

ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.2.2.3. Building 845 Firing Table and Pit 9 Landfill History of Contamination

Leaching of uranium-238 and HE compounds from Building 845 Firing Table debris resulted in contamination of shallow subsurface soil and bedrock underlying the firing table. No contaminants have been detected in ground water under the Building 845 Firing Table. Soil, rock, and ground water monitoring data indicate that contaminants have not been released from the Pit 9 Landfill.

3.2.2.4. Building 845 Firing Table and Pit 9 Landfill Initial Response

Investigations began at the Building 845 Firing Table and the Pit 9 Landfill in 1982 to identify potential contaminant release sites and contaminants in soil, bedrock, and ground water. Since then, nine boreholes have been drilled; four of these boreholes have been completed as ground water monitor wells (Figure 34). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Firing table gravel and soil and rock samples were also collected from several boreholes located in this area. As stated previously, firing table gravel and the soil berm at the Pit 9 Landfill were removed and disposed of at the Nevada Test Site in 1988. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 9 Landfill.

3.2.2.5. Building 845 Firing Table and Pit 9 Landfill Contaminants of Concern

There are no COCs in $Tnsc_0$ HSU ground water, surface water, or surface soil in the Building 845 area. Uranium-238 and the HE compound HMX have been identified as COCs in the vadose zone underlying the Building 845 Firing Table. No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 9 Landfill. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 845 Firing Table and Pit 9 Landfill in the baseline risk assessment. Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that the uranium and HMX in the vadose zone do not represent a significant threat to ground water.

3.2.2.6. Building 845 Firing Table and Pit 9 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human or ecological health risks or hazards, however, monitoring is required while the landfill remains in place.

3.2.3. Building 845 Firing Table and Pit 9 Landfill Remedial Actions

3.2.3.1. Building 845 Firing Table and Pit 9 Landfill Remedy Selection

The Site 300 Human Health and Environmental Protection RAOs are not applicable to the remedy selected for the Building 845 Firing Table and Pit 9 Landfill because there is no ground water contamination or human health or ecological risks or hazards identified.

A remedy for the Building 845 Firing Table and Pit 9 Landfill was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 845 Firing Table and Pit 9 Landfill consists of:

1. No further action for HMX and uranium in subsurface soil/rock.

2. Continued monitoring ground water to detect any future releases from the Pit 9 landfill that could impact human health or the environment.
3. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
4. Inspecting Pit 9 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.2.3.2. Building 845 and Pit 9 Landfill Remedy Implementation

Monitoring of ground water at the Building 845 Firing Table and Pit 9 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 9 Landfill.
- Monitoring of ground water for subsurface soil/rock COCs (uranium and HMX) to determine if these contaminants impact ground water.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. Detection monitoring and results for the Pit 9 Landfill are discussed in Section 3.2.5.2.

Land Use Controls have been implemented to prevent damage to the landfill cover and inadvertent exposure to the waste (see Section 3.2.3.4).

The results of the detection monitoring and ground water monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.2.3.3. Building 845 Firing Table and Pit 9 Landfill Operation and Maintenance

The remedy for the Building 845 Firing Table and Pit 9 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cover maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 9 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cap to detect differential settling or other earth movement.
- Annual inspection of the pit cap by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cap are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.

- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the Building 845 Firing Table and Pit 9 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.2.3.4. Building 845 Firing Table and Pit 9 Landfill Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (U.S. EPA 2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as FFAs, that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers. The land use controls and requirements described herein are only applicable to the Building 845/Pit 9 Landfill and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the

Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 845/Pit 9 Landfill are described in Table 5, which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 845/Pit 9 Landfill area. Figure 35 shows the specific areas of the Building 845/Pit 9 Landfill where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 845/Pit 9 Landfill by objective, and the status of the land use controls are summarized below.

3.2.3.4.1. Building 845/Pit 9 Landfill Land Use Control Objectives

Land use control objectives were established for the Building 845/Pit 9 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 845/Pit 9 Landfill include:

1. ***Risk Driver*** - Potential exposure to depleted uranium and HMX at depth in subsurface soil. (Note: Risk for onsite worker exposure to uranium and HMX at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

Land use control objectives:

- Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

2. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

Land use control objectives:

- Maintain the integrity of landfill cover as long as the pit waste remains in place.
- Control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
- Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
- Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

3. ***Risk Driver*** - Potential exposure to contaminated environmental media.

Land use control objective:

- Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 9 Landfill. There are no COCs in ground water, surface water, or surface soil in the Building 845 area. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 845 Firing Table and Pit 9 Landfill in the baseline risk assessment.

3.2.3.4.2. Building 845/Pit 9 Landfill Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 845/Pit 9 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work. During this five-year review period, there were no dig permit applications in the Building 845/Pit 9 Landfill area.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation in the Building 845 Firing Table area. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Building 845/Pit 9 Landfill area.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cover and ground water monitoring system. Landfill cover maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to maintain the integrity of the Pit 9 Landfill cover: Dig Permit and Work Induction Board processes.

Dig Permit Process: The Dig Permit process reviews all onsite excavation. Any proposed excavation would be approved by the LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 9 Landfill cover. During this five-year review period, there were no dig permit applications for excavation activities in the Pit 9 Landfill area.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 9 Landfill cover. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Pit 9 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 9 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers and Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers and unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Fences.
  - Security Force.
  - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review period. The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination Proprietary Controls

Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD. The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in

Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

3.2.3.4.3. Summary of the Status of Building 845/Pit 9 Landfill Land Use Controls

The review of the land use controls for the Building 845/Pit 9 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 845/Pit 9 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.2.4. Building 845 Firing Table and Pit 9 Landfill Five-Year Review Process

3.2.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

3.2.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 845 and Pit 9 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.

- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.2.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 845 Firing Table and Pit 9 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.2.5. Building 845 Firing Table and Pit 9 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.2.5.1), (2) detection monitoring and results for the Pit 9 Landfill (Section 3.2.5.2), (3) performance issues (Section 3.2.5.3), and (4) risk mitigation remediation progress (Section 3.2.5.4).

3.2.5.1. Building 845 Firing Table and Pit 9 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

No COCs have been identified in surface soil, vadose zone, or ground water for the Pit 9 Landfill. Detection monitoring results for the landfill are discussed in Section 3.2.5.2.

There are no ground water COCs at the Building 845 Firing Table. Uranium-238 and HMX are COCs in the vadose zone underlying the Building 845 Firing Table (Table 7). In the past, leaching of Building 845 Firing Table debris and gravel resulted in minor depleted uranium and HMX contamination of shallow subsurface soil and bedrock underlying the firing table. Accordingly, ground water in this area is monitored for these constituents. Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) concluded that HMX and uranium in the vadose zone do not pose a threat to ground water.

The historic maximum HMX concentration measured in soil is 0.54 mg/kg (1988), well below the U.S. EPA Regional Screening Level (RSL) (Table 7). HMX concentrations in ground water samples remain below the 1 µg/L reporting limit. The historic maximum uranium-238

activity measured in soil is 1.2 picocuries per gram (pCi/g) (1988), below the Industrial Preliminary Remediation Goal (PRG) for uranium-238 of 1.8 pCi/g and the Site 300 background activity of 3.1 pCi/g. Uranium activities in ground water samples from area wells remain very low (<1 pCi/L) and the $^{235}U/^{238}U$ atom ratios indicate that only natural uranium is present. Figure 34 shows second semester 2011 ground water concentrations for HMX, total uranium activities, and uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratios.

3.2.5.2. Pit 9 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 9 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the Pit 9 Landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed of in the landfill.

The constituents of concern for the Pit 9 Landfill include VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

Concentrations and activities of VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride concentrations/activities in samples collected from the four $Tnsc_0$ HSU wells since monitoring began in 1987 have been either below reporting limits or within the range of background.

No contaminant releases have been identified from the Pit 9 Landfill. However, as discussed in Section 3.2.2.1.2 and shown on Figure 34, historic ground water elevation data indicate that the flow direction has ranged from northwest to northeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

During the five-year review period, LLNS Maintenance and Utilities Services Department staff annually inspected the Pit 9 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that may have lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled some animal burrows and cracks but otherwise, no significant issues (including subsidence) were reported during annual inspection of the landfill surface.

3.2.5.3. Building 845 Firing Table and Pit 9 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.2.5.4. Building 845 Firing Table and Pit 9 Landfill Risk Mitigation Remediation Progress

No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 845 Firing Table or the Pit 9 Landfill in the baseline human health and ecological risk assessments.

On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since no VOCs, including TCE and PCE, were detected above the reporting limit in the Building 845 Firing Table/Pit 9 Landfill ground water during the past five years, this risk was not reassessed. In addition, there is no evidence of new releases or contamination that warranted re-evaluation of risk.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 845 and Pit 9 Landfill. No information was identified during this review to question the ecological protectiveness of the remedy.

3.2.6. Building 845 Firing Table and Pit 9 Landfill Interviews and Site Inspection

DOE/NNSA and LLNL meets monthly with the U.S. EPA, RWQCB, and DTSC RPMs and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 9 Landfill cover and associated drainage ways are annually inspected by the LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes that are distributed following the meetings.

3.2.7. Building 845 Firing Table and Pit 9 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

3.2.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended. Monitoring indicates that constituents monitored in ground water remain below analytical reporting limits or within the range of background.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

3.2.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 845/Pit 9 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively, in IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, there are no VOCs, including TCE and PCE, currently detected in ground water at the Building 845/Pit 9 Landfill OU 8 release site. Therefore, the inhalation risk and hazard were not re-evaluated, and the protectiveness of the remedy is not affected.

The Site 300 Human Health Protection RAOs are not applicable to the remedy selected for the Building 845 Firing Table and Pit 9 Landfill because there is no ground water contamination and no unacceptable risks or hazards associated with contaminants in surface soil or subsurface soil/bedrock were identified for the Building 845 Firing Table or the Pit 9 Landfill in the baseline human health and ecological risk assessments. In the vicinity of the Building 845 Firing Table, HMX concentrations and uranium activities in soil samples were below applicable PRGs and

RSLs and Site 300 background levels. Ground water monitoring has revealed no impacts from these vadose zone COCs. In the vicinity of the Pit 9 Landfill, no contaminants have been detected in ground water since wells were installed in 1987 or in environmental media in the nearly 50 years since this landfill has been in existence.

3.2.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies are necessary to accelerate or achieve cleanup in a more cost-effective manner in the Building 845 and Pit 9 Landfill area, because: (1) no constituents are detected in ground water above reporting limits or background, (2) uranium activities and HMX concentrations in subsurface soil are below U.S. EPA's PRGs and RSLs for these constituents, and (3) there are no impacts to ground water from HMX and uranium in subsurface soil.

3.2.8. Building 845 Firing Table and Pit 9 Landfill Issues

No issues were identified during this evaluation. However, as discussed in Section 3.2.2.1.2 and shown on Figure 34, historic ground water elevation data indicate that the flow direction in the $Tnsc_0$ HSU has ranged from northwest to northeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

3.2.9. Building 845 Firing Table and Pit 9 Landfill Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the $Tnsc_0$ HSU in the vicinity of the Pit 9 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells east of the landfill and potentially one monitor well west of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

No other follow-up actions were identified related to this Five-Year Review.

3.2.10. Building 845 and Pit 9 Landfill Protectiveness Statement

The remedy for the Building 845 and Pit 9 Landfill currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) no constituents are detected in ground water above cleanup standards, analytical reporting limits, or background in the Building 845 and Pit 9 Landfill area, (2) no unacceptable risk or hazard to humans or threat to ground water were identified for COCs in subsurface soil (HMX and uranium) at the Building 845 Firing Table, (3) no COCs have been identified in surface soil or ground water in the vicinity of or beneath the Pit 9 Landfill and there is no evidence of releases from the Pit 9 Landfill, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of the Pit 9 Landfill will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions.

The cleanup standards for Site 300 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use and no constituents are detected in ground water above cleanup standards, analytical reporting limits, or background, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

3.3. Building 833

3.3.1. Building 833 Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 833:

1959–1982

- Building 833 was used to conduct thermal and mechanical tests on various mixtures of HE compounds.
- Environmental studies began in 1981 when LLNL initiated a survey of potential TCE spills to the ground at Site 300.

1985–1990

- DOE/LLNL performed active and passive soil vapor surveys, drilled boreholes and monitor wells, and collected and analyzed soil and ground water samples.
- LLNL Site 300 was placed on the National Priorities List in 1990.

1992

- A FFA was signed for Site 300.

1993

- Site 300 ERD sampling staff began occupancy of Building 833 for office use, equipment storage, and maintenance.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 833 release site.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified exposure control through risk and hazard management; and ground water monitoring as components of the remedy for the Building 833. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was submitted.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.3.2. Building 833 Background

3.3.2.1. Building 833 Physical Characteristics

3.3.2.1.1. Building 833 Site Description

Building 833 and the subject area covers approximately 4 acres of a hilltop located in the southeastern part of Site 300 (Figure 2). Building 833 was used from 1959 to 1982 to conduct thermal and mechanical tests on various mixtures of HE compounds. TCE served exclusively as the heat-transfer fluid for these tests. Surface discharge of waste fluids occurred through spills,

building wash down, and release of rinsewater from the test cell and settling basin to an adjacent lagoon.

Beginning in 1993, Building 833 was repurposed for storage and offices for ERD sampling personnel.

3.3.2.1.2. Building 833 Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 833 area, including the unsaturated zone, the two HSUs underlying the area and surface water present in the area. A conceptual hydrostratigraphic column for the southeast portion of Site 300, including the Building 833 area, is shown on Figure 28.

Building 833 Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and unsaturated Tertiary Pliocene sand and gravel sediments (Tpsg). When ground water is present in the ephemeral Tpsg HSU, the vadose zone is approximately 20 to 25 ft thick, but may be thicker when no ground water is present in the Tpsg HSU.

Building 833 Saturated Zone

Two HSUs units have been identified in the Building 833 area: the Tpsg HSU and $Tnbs_1$ HSU.

The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone contained within unconsolidated sand and gravel. During heavy rainfall events, this HSU may become saturated. However, ground water monitoring from 1993 to 2005 has shown little evidence of saturation. Since 2003, all wells screened in the Tpsg HSU at Building 833 were dry or only contained water within a sump below the screen. When present, depth to water is about 20 to 25 ft bgs, and the saturated thickness varies from 0 to 5 ft. Due to the lack of saturation in wells screened in the HSU, a ground water gradient and flow direction cannot be accurately determined. Recharge for this HSU occurs on hilltops via rainwater percolation.

The Tertiary Pliocene nonmarine sediments (Tps) claystone aquitard prevents downward movement of perched Tpsg ground water into the underlying Neroly bedrock. Approximately 300 ft of unsaturated Neroly Formation upper blue sandstone ($Tnbs_2$) and lower siltstone/claystone ($Tnsc_1$) are present beneath the Tps aquitard.

The $Tnbs_1$ HSU is comprised of Neroly Formation Lower blue sandstone stratigraphic unit ($Tnbs_1$). Depth to ground water in this HSU is over 325 ft below Building 833. Ground water within this HSU generally flows southeast with a moderate gradient.

Building 833 Surface Water

Natural surface water in the Building 833 area is the result of surface runoff from precipitation. Natural surface runoff is rarely present, and only occurs briefly during significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 833 area.

3.3.2.2. Building 833 Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7000-acre property-area is developed.

Building 833 is located in the southeastern part of Site 300 (Figures 1 and 2) and is approximately 1,800 feet west of the closest (eastern) site boundary. The Building 833 is currently used as storage and offices for the ERD sampling personnel.

There are no active onsite water-supply wells in the Building 833 area.

Annual grasslands surround Building 833. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, has been periodically mapped in the area around the facility. Building 833 also occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*) and the threatened California tiger salamander (*Ambystoma californiense*). Loggerhead shrikes (*Lanius ludovicianus*), a California Species of Special Concern, have been observed nearby. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 833. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.3.2.3. Building 833 History of Contamination

Spills, earthen disposal pits, and rinse water disposal at Building 833 resulted in minor VOC contamination of perched ground water in the Tpsg HSU. TCE was discharged to the ground surface at Building 833 and to a rinse water lagoon adjacent to Building 833, resulting in contamination of the vadose zone and ground water in the area. TCE has been identified in Tpsg sediments at a maximum concentration of 1.5 mg/kg in the immediate area of Building 833. The historic maximum TCE concentration in Tpsg ground water at Building 833 was 2,100 µg/L in 1992. Ground water is only occasionally present in small quantities in the Tpsg HSU beneath Building 833. There is no contamination in the $Tnbs_1$ HSU beneath Building 833.

No TCE or other VOCs were detected in surface soil samples collected in the vicinity of the former lagoon. TCE concentrations in shallow subsurface soil (less than 10 ft) ranged from 0.0031 mg/kg to 0.0085 mg/kg. The results of both active and passive soil vapor surveys in the vicinity of the lagoon also indicated that a significant VOC source was not present in surface or shallow subsurface soil. Because soil in the vicinity of the lagoon did not pose a risk to human or ecological receptors, or further threat to ground water, no cleanup was required.

3.3.2.4. Building 833 Initial Response

Environmental studies began in 1981 when LLNL initiated a survey of potential TCE spills to the ground at Site 300 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then 63 boreholes have been drilled at Building 833; nine of these boreholes have been completed as ground water monitor wells (Figure 36). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included active and passive soil vapor surveys.

3.3.2.5. Building 833 Contaminants of Concern

At Building 833, VOCs TCE and cis-1,2-DCE are the COCs in ground water. TCE is also a vadose zone COC. There are no COCs identified in surface water or surface soil at Building 833. TCE is present only in perched ground water in the Tpsg HSU (Figure 36). The distribution and concentration of contaminants in ground water is described in Section 3.3.5.1. Because this HSU is limited to the Building 833 area, there is no migration pathway for TCE from the Building 833 area to onsite or offsite water-supply wells. In addition, exposure, use, or ingestion of the contaminated ground water is highly unlikely because the perched water-bearing zone is naturally unsuitable for drinking water due to high dissolved solid concentrations and low sustainable yields. Samples have been collected from three wells in the Building 833 area for total dissolved solids (TDS) analysis. These results include:

- W-833-03: 1220 mg/L (December 1998).
- W-833-12: 900 mg/L (February 1993) and 740 mg/L (May 1998).
- W-833-30: 460 mg/L (June 1991) and 460 mg/L (December 1991).

TDS measurements have exceeded (three times) or nearly exceeded (two times) the 500 mg/L EPA MCL for TDS.

The baseline risk assessment for the Building 833 area estimated a cancer risk of 1×10^{-6} (one in one million) with an HI less than 1 for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. Engineering controls consisting of enhanced ventilation/positive pressure were in place to prevent infiltration and buildup of VOC vapors inside Building 833 that could result in an unacceptable exposure risk to workers in this building. No unacceptable hazard to ecological receptors was identified in the baseline risk assessment for Building 833.

Risk mitigation remediation progress is discussed in Section 3.3.5.3.

3.3.2.6. Building 833 Summary of Basis for Taking Action

Remedial actions were initiated at Building 833 to address unacceptable human health risks associated with onsite worker inhalation exposure to VOCs volatilizing from the subsurface soil to indoor air.

3.3.3. Building 833 Remedial Actions

3.3.3.1. Building 833 Remedy Selection

The remedy selected for the Building 833 is intended to achieve the following RAOs:

<u>For Human Health Protection:</u>

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.
- Prevent human inhalation of VOCs volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.

- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative HI greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.

There are no RAOs for the protection of ecological receptors as the baseline ecological risk assessment indicated that there was no risk or hazard to ecological receptors at Building 833.

The remedy for Building 833 was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for Building 833 consisted of:

1. Monitoring ground water to detect changes in VOC concentrations that could impact human health or the environment.
2. Risk and hazard management to prevent onsite worker exposure to VOCs volatilizing from subsurface soil into indoor air at Building 833 until risk is mitigated. Institutional/land use controls will continue to be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.

3.3.3.2. Building 833 Remedy Implementation

Land Use Controls have been implemented to prevent inhalation risk of VOCs volatilizing (see Section 3.3.3.4). The VOC inhalation risk at Building 833 is re-evaluated annually.

Ground water monitoring has been implemented and the results are reported in the semi-annual ERD Compliance Monitoring Report. Samples of ground water are collected for VOC analysis.

3.3.3.3. Building 833 Operation and Maintenance

The remedy for Building 833 is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place and monitoring procedures are consistent with established procedures and protocols.

Monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The budgeted and actual environmental restoration costs for Building 833 are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.3.3.4. Building 833 Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (U.S. EPA 2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as FFAs, that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers.

The land use controls and requirements described herein are only applicable to Building 833 and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for Building 833 are described in Table 5 which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and

(3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at Building 833. Figure 37 shows the specific areas of Building 833 where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at Building 833 by objective, and the status of the land use controls are summarized below.

3.3.3.4.1. Building 833 Land Use Control Objectives

Land use control objectives were established for Building 833 in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use controls identified for Building 833 include:

1. ***Risk Driver*** - VOC concentrations in ground water onsite exceed cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** - Potential exposure to VOCs at depth in subsurface soil.

   Land use control objective:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

3. ***Risk Driver*** - The baseline risk assessment identified a risk of 1×10^{-6} for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833.

   Land use control objective:

   - Prevent onsite site worker inhalation exposure to VOCs inside Building 833 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.

4. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

3.3.3.4.2. Building 833 Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for Building 833 that were established and are implemented to address the risk reduction objectives and their current status.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL has implemented multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Building 833 area until ground water cleanup standards are met. The land use controls include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well before a dig permit is issued. During this five-year review period, there were no dig permit applications to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Building 833 area.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, there were no proposals brought to the Work Induction Board to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Building 833 area.

Control Onsite Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work. During this

five-year review period, there were no dig permit applications for excavation in the Building 833 area.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Building 833 area.

Prevent Onsite Site Worker Inhalation Exposure to VOCs inside Building 833: Engineered Controls

DOE/LLNL has implemented engineered controls to prevent onsite site worker inhalation exposure to VOCs inside Building 833 until annual risk re-evaluation indicates that the risk is less than 10^{-6}. The engineered control consisted of:

- Evaluating and maintaining the heating, ventilating, and air-conditioning system for Building 833 to maintain a positive pressure to prevent VOC vapors from migrating into the building.

Engineering Controls Implementation Status

A pre-remediation risk of 1×10^{-6} was identified for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833. To prevent onsite site worker inhalation exposure to VOCs inside Building 833, engineering controls (heating, ventilating, and air-conditioning system for Building 833) were implemented to prevent onsite worker exposure to VOCs that could migrate from the subsurface into the building until the inhalation risk was mitigated through remediation.

The risk has been successfully reduced to less than 10^{-6} as of 2011 (see Section 3.3.5.3), therefore, this institutional/land use control is no longer needed.

Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

- Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD.

The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR

Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

Other Controls: Physical Barriers

The fences surrounding Site 300, signs, and security forces control and restrict access to Site 300; thereby preventing the inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300 to ensure they are intact. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review period. The physical barriers to control and restrict access are effective in preventing inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

3.3.3.4.3. Summary of the Status of Building 833 Land Use Controls

The review of the land use controls for Building 833 for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 833 for as long as necessary to keep the selected remedy protective of human health and the environment.

3.3.4. Building 833 Five-Year Review Process

3.3.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

3.3.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 833 at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.3.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 833 area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.3.5. Building 833 Data Review and Evaluation

This section is organized into three subsections: (1) analysis of contaminant distribution, concentration, and remediation progress (Section 3.3.5.1), (2) performance issues (Section 3.3.5.2), and (3) risk mitigation remediation progress (Section 3.3.5.3).

3.3.5.1. Building 833 Contaminant Distribution, Concentration, and Remediation Progress

At Building 833, the VOCs TCE and cis-1,2-DCE are the COCs present in perched ground water. TCE is also a COC in subsurface soil in the vadose zone in the Building 833 area. A list

of primary COCs and their historic maximum and 2011 maximum concentrations is detailed in Table 6. Figure 36 shows 2011 VOC concentrations in ground water.

The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone. During heavy rainfall events, this HSU may become saturated, but quarterly monitoring of the wells from 1993 to present has shown little evidence of saturation. When saturated, monitoring conducted from 1993 to present has shown a general decline in total VOC concentrations. VOCs detected in Tpsg HSU ground water are comprised entirely of TCE. TCE concentrations have decreased from a historic maximum concentration of 2,100 µg/L (W-833-03, 1992) to a five-year review period maximum TCE concentration of 180 µg/L (Tpsg HSU well W-833-28, in 2008). The most recent 2011 maximum TCE concentration was 150 µg/L (Tpsg HSU well W-833-33, February 2011). TCE has never been detected in deeper $Tnbs_1$ HSU well W-833-30.

Cis-1,2-DCE has been detected at a historic maximum concentration of 58 µg/L (Tpsg HSU well W-833-12, 1993). Cis-1,2-DCE has not been detected in well W-833-12 since 1993 and has never been detected in any other area wells including well W-833-30, screened in the deeper $Tnbs_1$ HSU.

During 2011, VOCs were not detected in ground water samples collected from the deep $Tnbs_1$ HSU monitor well W-833-30, indicating that VOC contamination continues to be limited to the shallow Tpsg perched water-bearing zone. Since its construction in 1991, VOCs have only been detected twice, both in 1992, in the deeper $Tnbs_1$ HSU monitor well W-833-30, in very small concentrations (0.8 and 1.6 µg/L of chloroform and PCE, respectively).

In summary, spills, earthen disposal pits and rinsewater disposal at Building 833 resulted in minor VOC contamination of perched ground water in the Tpsg HSU. The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone. After heavy rainfall events, this HSU may become saturated, but historic quarterly monitoring of the wells since 1993 has shown little evidence of saturation. VOCs have shown a general decreasing trend in the Tpsg HSU since monitoring began in 1988. No VOCs are present underlying $Tnbs_1$ regional aquifer.

3.3.5.2. Building 833 Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.3.5.3. Building 833 Risk Mitigation Remediation Progress

The baseline risk assessment for the Building 833 area estimated a cancer risk of 1×10^{-6} (one in one million) with an HI less than 1 for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. These risks have been re-evaluated and reported annually since 2003 as part of the Risk and Hazard Management Program.

The 2006 re-evaluation indicated that Building 833 indoor air levels are no longer of concern (less than 10^{-6}) (Dibley et al., 2007d). The risk was re-evaluated each year until 2011 and remained below 1×10^{-6}. Therefore, the risk is considered mitigated and risk re-evaluations will be discontinued.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). The updated cancer IUR for TCE is $4.0 \times 10^{-6} (\mu g/m^3)^{-1}$ and the non-cancer RfC for TCE is 2.0×10^3 mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor

inhalation pathway. As part of the 2011 Annual Compliance Monitoring Report, the inhalation risk for onsite workers breathing indoor air at Building 833 was re-evaluated using the new TCE toxicity values. The current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991) after the cancer IUR and the non-cancer RfC for TCE were updated. For TCE, the hazard quotient was 2.1×10^{-1} and the Incremental Risk (individual and cumulative excess cancer risk) was 7.0×10^{-7}, based on a TCE concentration of 150 µg/L in nearby well W-833-33 (Dibley et al., 2012). TCE is the only VOC currently detected in the Building 833 (OU 8) area. Therefore, no additional inhalation risk and hazard re-evaluations were necessary besides that conducted for TCE. Cis-1,2-DCE, the only other VOC COC at Building 833, has not been detected above the reporting limit in any Building 833 wells since 1993. No unacceptable risk or hazard was identified for the vapor inhalation pathway at Building 833. Therefore, the protectiveness of the remedy is not affected.

No unacceptable hazard to ecological receptors was identified in the baseline ecological risk assessment. A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 833. No information was identified during this review to question the ecological protectiveness of the remedy.

3.3.6. Building 833 Interviews and Site Inspection

DOE/NNSA and LLNL meets monthly with the U.S. EPA, RWQCB, and DTSC RPMs and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

3.3.7. Building 833 Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

3.3.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.

- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

3.3.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 833 remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. The updated cancer IUR for TCE is $4.0 \times 10^{-6} (\mu g/m^3)^{-1}$ and the non-cancer RfC for TCE is 2.0×10^3 mg/m^3. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.3.5.3, the Baseline Risk Assessment estimated a cancer risk of 1×10^{-6} for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. As part of the 2011 annual Compliance Monitoring Report, the inhalation risk for Building 833 was re-evaluated using the new TCE toxicity value. The current inhalation risk and hazard resulting from transport of TCE vapors from ground water to the building foundations and subsequently into indoor ambient air was estimated using the Johnson-Ettinger Model (Johnson and Ettinger, 1991) after the cancer IUR and the non-cancer RfC for TCE were updated. For TCE, the hazard quotient was 2.1×10^{-1} and the Incremental Risk (individual and cumulative excess cancer risk) was 7.0×10^{-7}, based on a TCE concentration of 150 µg/L in nearby well W-833-33 (Dibley et al., 2012). TCE is the only VOC currently detected in the Building 833 (OU 8) area. Therefore, no additional inhalation risk and hazard re-evaluations were necessary besides that conducted for TCE. Cis-1,2-DCE, the only other VOC COC at Building 833, has not been detected above the reporting limit in any Building 833 wells since 1993. Although EPA released updated toxicity values for PCE in February 2012, PCE has not been detected above the reporting limit in ground water

in any Building 833 well during the past five years. Therefore, although the toxicity criteria for PCE were updated within the five-year review period, the re-evaluation of risk and hazard for PCE was not warranted. No unacceptable risk or hazard was identified for the vapor inhalation pathway at Building 833. Therefore, the protectiveness of the remedy is not affected.

- The review found progress toward meeting the RAOs.

3.3.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 833 Landfill area.

3.3.8. Building 833 Landfill Issues

No issues were identified during this evaluation.

3.3.9. Building 833 Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Remove cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells including well W-833-30, screened in the deeper $Tnbs_1$ HSU.

However, ground water samples from Building 833 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports.

3.3.10. Building 833 Protectiveness Statement

The remedy at Building 833 currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) VOCs in ground water are decreasing towards cleanup standards, (2) engineering controls prevented exposure of onsite workers that

could inhale VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833 until the risk was mitigated in 2011, and (3) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Building 833 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

3.4. Building 851 Firing Table

3.4.1. Building 851 Site Chronology

The following is a chronological listing of significant environmental restoration events at Building 851:

1962–Present

- Building 851 Firing Table began operating in 1962.

1988

- Building 851 Firing Table gravels were removed in 1988.

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A FFA was signed for Site 300.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 851.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs and uranium in soil and bedrock and for RDX and metals in surface soil as well as monitoring as components of the remedy for the Building 851 area. The Interim Site-Wide ROD did not contain ground water cleanup standards.

- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was issued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.4.2. Building 851 Firing Table Background

3.4.2.1. Building 851 Firing Table Physical Characteristics

3.4.2.1.1. Building 851 Firing Table Site Description

Building 851 complex area covers 5 acres and is located in the northwestern part of Site 300 (Figure 2). The Building 851 complex consists of Buildings 851A (bunker), Building 851B (machine shop), and the Building 851 Firing Table. The firing table has been used since 1962 to conduct experimental high explosives research. Firing table gravels were removed in 1988 and are still replaced periodically to prevent: (1) compaction of gravel that could reduce shock dampening and, (2) the accumulation of contaminants in firing table gravels that could be released to the environment. Gravels from Building 851 Firing Table were formerly disposed of in the Pit 3 Landfill (open 1958 to 1967), Pit 4 Landfill (open 1968 to 1974), Pit 5 Landfill (open 1968 to 1978), and the Pit 7 Landfill (open 1978 to 1988). Since the Pit 7 Landfill was closed in 1988, gravel removed from the Building 851 Firing Table has been transported to the Nevada Test Site for disposal.

3.4.2.1.2. Building 851 Firing Table Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 851 area, including the unsaturated zone, one HSU underlying the area, and surface water in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 851 area is shown on Figure 28.

Building 851 Firing Table Vadose (Unsaturated) Zone

The vadose zone consists of approximately 100 to 150 ft of unconsolidated Quaternary alluvial and colluvial deposits (Qal), Quaternary landslide deposits (Qls), and underlying unsaturated Neroly Formation $Tnbs_1$lower blue sandstone and $Tnsc_0$ siltstone/claystone bedrock.

Building 851 Firing Table Saturated Zone

The Tmss HSU consists of one stratigraphic unit: the Cierbo Formation (Tmss) that is comprised of sandstone, claystone, pebble conglomerate, and shale. Tmss strata beneath the Building 851 area are saturated; ground water is under confined conditions. Depth to water varies from 100 to 150 ft below ground surface, and the saturated thickness varies from 5 to 10 ft. Since monitoring of the existing well network began in 1988, the ground water gradient in the Tmss HSU in the vicinity of Building 851 has remained nearly flat (Figure 38).

Building 851 Firing Table Surface Water

Natural surface water in the Building 851 area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 851 area.

3.4.2.2. Building 851 Firing Table Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7000-acre property-area is developed.

The Building 851 Firing Table is located in the northwestern part of Site 300 (Figure 2) and is approximately 3,300 feet east of the closest (western) site boundary. The Building 851 complex continues to be used for high explosive testing.

There are no active onsite water-supply wells in the Building 851 area.

Annual grasslands surround the Building 851 complex, with a small amount of native perennial grasslands and coastal sage scrub located to the north of the facility. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's (CNPS) List 1B, is routinely mapped around the perimeter of the facility. The diamond-petal poppy (*Eschscholzia rhombipetela*), also a CNPS List 1B plant, occurs on a hillside to the west of the facility. In addition, the round-leaved filaree (*California macrophylla*, formerly known as *Erodium macrophyllum*), another CNPS List 1B plant, occurs along the fire trials directly behind (west) of the facility. The Building 851 complex is located within the critical habitat for the federally threatened Alameda whipsnake (*Masticophis lateralis euryxanthus*). The Building 851 complex also occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed nearby. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from the Building 851 complex. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.4.2.3. Building 851 Firing Table History of Contamination

High explosives testing has been conducted at the Building 851 Firing Table since 1962. Firing table gravels were removed in 1988 and are still replaced periodically to prevent accumulation of contaminants in gravels that could be released to the environment. Former explosives experiments resulted in the release of uranium-238, the HE compound HMX, and metals to the surrounding surface soil; VOCs and uranium-238 to subsurface soil; and uranium-238 to ground water.

3.4.2.4. Building 851 Firing Table Initial Response

Investigations at the Building 851 complex began in 1988 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then,

12 boreholes have been drilled at Building 851; four of these boreholes have been completed as ground water monitor wells (Figure 38). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Five of the boreholes were drilled within the firing table to characterize the extent of any contamination in firing table gravels and underlying vadose zone. Firing table gravels and some contaminated soil were removed in 1988 and disposed in Pit 7. Ground water monitoring has been conducted to evaluate uranium activities in ground water.

3.4.2.5. Building 851 Firing Table Contaminants of Concern

Uranium-238 has been identified as a COC in Tmss HSU ground water in the Building 851 area. However, the maximum total uranium activities in ground water continue to be a fraction of the 20 pCi/L MCL cleanup standard and are at similar levels to those at which uranium naturally occurs in ground water in this area. VOCs (cis-1,2-DCE and TCE) and uranium-238 are COCs in subsurface soil and rock. The HE compound, RDX, uranium-238, and the metals cadmium, copper, and zinc were identified as COCs in surface soil. The distribution and concentration of contaminants in soil and ground water is described in detail in Section 3.4.5.1.

No risk or hazard associated with surface soil, subsurface soil/bedrock, or ground water were identified for the Building 851 Firing Table in the baseline risk assessment (Ferry et al., 1999).

Modeling conducted in the Site-Wide Feasibility Study indicated that COCs in surface soil and subsurface soil/rock do not pose a significant threat to ground water. The water-bearing zone (Tmss HSU) affected by contamination is not used for drinking water.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 851 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil. Cadmium surface soil sampling was conducted in November 2011; three samples were collected and all samples contained less than 0.5 mg/kg of cadmium (reporting limit) (Figure 40, Table 8, and Section 3.1.5.3).

3.4.2.6. Building 851 Summary of Basis for Taking Action

The baseline risk assessment did not identify any human health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. However, site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. Therefore, no active remediation was required.

3.4.3. Building 851 Firing Table Remedial Actions

3.4.3.1. Building 851 Firing Table Remedy Selection

The remedy selected for the Building 851 Firing Table is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

The remedy for the Building 851 Firing Table was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 851 Firing Table consisted of:

1. No further action for VOCs and uranium in subsurface soil/bedrock and for RDX and metals in surface soil.
2. Monitor ground water to detect changes in contaminant concentrations that could impact human health or the environment.
3. Land Use Controls will continue to be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.

3.4.3.2. Building 851 Firing Table Remedy Implementation

Ground water monitoring has been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. The four monitor wells at the Building 851 complex are sampled and analyzed for uranium isotopes and VOCs. Water elevations are also measured quarterly.

3.4.3.3. Building 851 Operation and Maintenance

The remedy for the Building 851 Firing Table is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place and monitoring procedures are consistent with established procedures and protocols.

Monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The budgeted and actual environmental restoration costs for the Building 851 Firing Table are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.4.3.4. Building 851 Firing Table Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (U.S. EPA 2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as FFAs, that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers. The land use controls and requirements described

herein are only applicable to the Building 851 Firing Table and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 851 Firing Table are described in Table 5 which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 851 Firing Table. Figure 39 shows the specific areas of the Building 851 Firing Table where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 851 Firing Table by objective, and the status of the land use controls are summarized below.

3.4.3.4.1. Building 851 Firing Table Land Use Control Objectives

Land use control objectives were established for the Building 851 Firing Table in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 851 Firing Table include:

1. ***Risk Driver*** - Potential exposure to depleted uranium and VOCs at depth in subsurface soil.

   Land use control objectives:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers. (Note: Risk for onsite worker exposure to uranium and VOCs at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

2. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

The only COC in ground water (uranium) is below the cleanup standard (see Section 3.4.5.1), there is no contamination offsite associated with the Building 851 Firing Table, and no unacceptable risk or hazard to human or ecological receptors was identified for the Building 851 Firing Table in the baseline risk assessment.

3.4.3.4.2. Building 851 Firing Table Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 851 Firing Table that were established and are implemented to address the risk reduction objectives and their current status.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work. During this five-year review period, there were no dig permit applications for excavation in areas of subsurface soil contamination at the Building 851 Firing Table.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Building 851 Firing Table. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities within area of subsurface soil contamination were proposed in the Building 851 Firing Table area.

Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

- Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD.

The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

Other Controls: Physical Barriers

The fences surrounding Site 300, signs, and security forces control and restrict access to Site 300; thereby preventing the inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300 to ensure they are intact. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review. The physical barriers to control and restrict access are effective in preventing inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

3.4.3.4.3. Summary of the Status of Building 851 Firing Table Land Use Controls

The review of the land use controls for the Building 851 Firing Table for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the

Building 851 Firing Table for as long as necessary to keep the selected remedy protective of human health and the environment.

3.4.4. Building 851 Firing Table Five-Year Review Process

3.4.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

3.4.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 851 Firing Table at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.4.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 851 Firing Table area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.4.5. Building 851 Firing Table Data Review and Evaluation

This section is organized into three subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.4.5.1), (2) performance issues (Section 3.4.5.2), and (3) risk mitigation remediation progress (Section 3.4.5.3).

3.4.5.1. Building 851 Firing Table Contaminant Distribution, Concentrations, and Remediation Progress

Uranium-238 is the only ground water COC at the Building 851 Complex. The historic maximum, the 2011 maximum concentration, and cleanup standard for this ground water COC for the Building 851 Firing Table are detailed in Table 6. Figure 38 shows second semester 2011 ground water activities for total uranium and the 2011 $^{235}U/^{238}U$ atom ratios.

TCE, cis-1,2-DCE, and uranium-238 are vadose zone (subsurface soil) COCs. These vadose zone COCs, their historic maximum concentration detected in subsurface soil at Building 851, and applicable PRGs and RSLs are presented in Table 7.

The HE compound, RDX, uranium-238, and the metals cadmium, copper, and zinc are surface soil COCs. These surface soil COCs, their historic maximum concentration detected in surface soil at Building 851, and applicable PRGs and RSLs are presented in Table 7.

The 2011 maximum total uranium activity detected in ground water samples from wells in the Building 851 complex area was 0.962 pCi/L (W-851-08, November), far below the 20 pCi/L MCL cleanup standard and well within natural background levels. The historic maximum uranium activity was 3.2 pCi/L (W-851-07, October 1991) and the five-year review period maximum activity was 1.4 pCi/L (W-851-08, November 2009). From 1994 to 2011, the $^{235}U/^{238}U$ atom ratio in samples from wells W-851-06 and W-851-08 have indicated the addition of some depleted uranium to the total uranium in the ground water with a slight trend over time toward a higher percentage of natural uranium ($^{235}U/^{238}U$ atom ratio trending upward and closer to 0.0072). Over the same time period, samples from wells W-851-05 and W-851-07 exhibited some added depleted uranium with a more pronounced trend toward natural uranium in more recent samples. During 2011, the samples from these wells contained only natural uranium. Overall, 2011 uranium activities in ground water have been similar to previous years and remain far below the 20 pCi/L cleanup standard and within the range of natural background levels.

In summary, a small amount of depleted uranium was added to pre-existing natural uranium in ground water in the Tmss HSU at Building 851. The total uranium in ground water has trended toward natural uranium over time. Total uranium activities have always been well below the MCL cleanup standard of 20 pCi/L.

COCs in the vadose zone are TCE, cis-1,2-DCE, and uranium-238. These vadose zone COCs, their historic maximum concentration in subsurface soil, and applicable RSLs and PRG are detailed in Table 7. The historic maximum TCE concentration measured in soil was 0.0003 mg/kg (1990), well below its Industrial RSL (6.4 mg/kg). The historic maximum cis-1,2-DCE concentration measured in soil was 0.012 mg/kg (1990) well below its Industrial RSL (2,000 mg/kg).

Since monitoring of Building 851 wells began in 1990, TCE has never been detected in ground water above its cleanup standard of 5 µg/L and cis-1,2-DCE has never been detected above its reporting limit (typically <0.5 µg/L). VOCs were only reported in three historic ground water samples collected at Building 851 with a maximum of 2.7 µg/L of total VOCs; the last detection was from a sample collected in 1992. Ground water has not been impacted by vadose zone VOCs.

While the historic maximum uranium-238 activity measured in subsurface soil in the Building 851 area (11 pCi/g in 1990) exceeds the Industrial PRG, no risk or hazard was identified associated with this COC in subsurface soil. Overall, uranium activities in ground water have been well below the 20 pCi/L cleanup standard and within the range of background levels, indicating that ground water has not been significantly affected by vadose zone uranium-238.

COCs in surface soil are RDX, cadmium, copper, zinc, and uranium-238. These surface soil COCs, their historic maximum concentrations in surface soil, and applicable PRGs and RSLs are presented in Table 7. The historic maximum RDX concentration measured in surface soil is 0.031 mg/kg (1990), well below its Industrial RSL (24 mg/kg). The historic maximum cadmium concentration measured in surface soil is 9 mg/kg (1990), well below its Industrial RSL (800 mg/kg). The historic maximum copper concentration measured in surface soil is 79 mg/kg (1990), well below its Industrial RSL (41,000 mg/kg). The historic maximum zinc concentration measured in surface soil is 360 mg/kg (1990), well below its Industrial RSL (310,000 mg/kg). While the historic maximum uranium-238 activity measured in surface soil (14.1 pCi/g in 1990), no risk or hazard associated with uranium-238 in surface soil was identified in the baseline risk assessment.

Surface soil and vadose zone COCs have not been detected in ground water above cleanup standards. Although some depleted uranium has been detected in ground water, its activities have been well below cleanup standards and $^{235}U/^{238}U$ atom ratios in wells where depleted uranium was detected have been trending to natural uranium during the five-year review period. The other vadose zone COCs have not been detected in ground water in excess of background concentrations.

Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) concluded that contaminants in subsurface soil and the vadose zone do not pose a threat to ground water. Results of ground water monitoring support this conclusion.

3.4.5.2. Building 851 Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.4.5.3. Building 851 Risk Mitigation Remediation Progress

No unacceptable human health risk or hazard associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 851 area in the baseline risk assessment (Ferry et al., 1999).

On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively, in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since no VOCs, including TCE and PCE, were

detected above the reporting limit in the Building 851 area ground water during the past five years, the re-evaluation of risk and hazard were not warranted. In addition, there is no evidence of new releases or contamination that warrants re-evaluation of risk. Total uranium activities in ground water have always been well below the 20 pCi/L MCL and at similar levels to those at which uranium naturally occurs in ground water in this area. Ground water data do not indicate any new sources, releases, or contaminants in the Building 851 area.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 851 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil.

Cadmium surface soil sampling was performed in November 2011 by an LLNL ecologist (Dibley, et al., 2012). A map of historical sampling locations including the November 2011 is depicted on Figure 40 and Table 8 provides a historical summary of cadmium analytical results used to calculate the 95% UCL, including the November 2011 samples. The 95% UCL was below the Site 300 background for cadmium (1.9 mg/kg). It would appear that cadmium does not pose an ecological risk in the Building 851 area, however, additional sampling behind Building 851 is needed to definitively remove this risk. The additional sampling will be scheduled.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 851. No information was identified during this review to question the ecological protectiveness of the remedy.

3.4.6. Building 851 Firing Table Interviews and Site Inspection

DOE/NNSA and LLNL meets monthly with the U.S. EPA, RWQCB, and DTSC RPMs and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

3.4.7. Building 851 Firing Table Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.

3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

3.4.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

3.4.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 851 remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively, in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.4.5.3, the Baseline Risk Assessment did not identify any human health risks at Building 851. Since no VOCs, including TCE and PCE, were detected above the reporting limit in the Building 851 area ground water during the past five years, this risk was not reassessed and the protectiveness of the remedy is not affected.
- The review found progress toward meeting the RAOs.
- A small amount of depleted uranium contamination trending over time toward natural exists in ground water in the Tmss HSU at activities well below the cleanup standard of 20 pCi/L. Metal and RDX concentrations in surface soil and VOC concentrations in

subsurface soil are below applicable RSLs. Ground water has not been impacted by uranium, metals, or RDX in surface soil or VOCs and uranium in subsurface soil.

3.4.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 851 area.

3.4.8. Building 851 Firing Table Issues

No issues were identified during this evaluation. However, as discussed in Section 3.4.2.1.2 and shown on Figure 38, historic ground water elevation data indicate that the ground water gradient in the Tmss HSU has remained nearly flat in the vicinity of Building 851. Therefore, DOE/NNSA recommends installing additional Tmss HSU monitor wells in the vicinity of Building 851 to ensure full monitoring capability under the observed nearly flat ground water gradient.

3.4.9. Building 851 Firing Table Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the Tmss HSU in the vicinity of Building 851 to ensure full monitoring capability under the nearly flat ground water gradient. Up to two monitor wells located southwest and northwest of Building 851 are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

3.4.10. Building 851 Firing Table Protectiveness Statement

The remedy at the Building 851 Firing Table currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) concentrations of ground water COCs below MCL cleanup standards and are within the range of background levels, (2) no unacceptable

human health risk or hazard associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified in the baseline risk assessment, (3) metal and RDX concentrations in surface soil and VOCs in subsurface soil are below applicable RSLs, and (4) ground water has not been impacted by uranium, metals or RDX in surface soil or VOCs and uranium in subsurface soil. Exposure pathways that could result in unacceptable risk to onsite workers (i.e., excavation of subsurface soil) are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of Building 851 will add an additional layer of protection by increasing the monitoring capability under a nearly flat ground water gradient.

The cleanup standards for Building 851 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

3.5. Pit 2 Landfill

3.5.1. Pit 2 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Pit 2 Landfill:

1956–1960

- Debris from the Buildings 801 and 802 firing tables was deposited in the Pit 2 Landfill.
- In 1960, an earthen cover was installed on the landfill.

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A FFA was signed for Site 300.

1996

- Potable water was continuously discharged to maintain a wetland habitat for red-legged frogs (a federally listed endangered species) within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Pit 2 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified ground water monitoring to detect any potential future contaminant releases as the remedy for the Pit 2 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was submitted.

2005

- The potable water discharge to maintain a wetland habitat for red-legged frogs within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill was discontinued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.5.2. Pit 2 Landfill Background

3.5.2.1. Pit 2 Landfill Physical Characteristics

3.5.2.1.1. Pit 2 Landfill Site Description

The Pit 2 Landfill is an unlined landfill that was constructed in 1956. The Pit 2 Landfill covers approximately 1.5 acres and is located in the north-central part of Site 300 south of Building 865 (Figure 2). The Pit 2 Landfill was used until 1960 to dispose of firing table debris from the firing tables at Buildings 801 and 802.

3.5.2.1.2. Pit 2 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Pit 2 Landfill area, including the unsaturated zone, three HSUs, and surface water present in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Pit 2 Landfill area is shown on Figure 28.

Pit 2 Landfill Vadose (Unsaturated) Zone

The vadose zone in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam that are unsaturated to a depth of approximately 5 to 50 ft bgs.

Pit 2 Landfill Saturated Zones

Three HSUs are present in the Pit 2 Landfill area: the Qal/WBR HSU, the $Tnbs_1/Tnbs_0$ HSU, and the Tmss HSUs. The Qal/WBR HSU in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and underlying weathered bedrock in the Elk Ravine drainage channels. This HSU is generally unconfined and unsaturated in Elk Ravine except for short periods following winter storms. Until 2005, potable water from Building 865 was discharged to Elk Ravine to maintain a wetland habitat for red-legged frogs, a federally listed endangered species (U.S. DOE, 2011). While this discharge occurred, the Qal/WBR was likely perennially saturated in Elk Ravine in the area south of Building 865 and around the northern and eastern boundaries of the Pit 2 Landfill. In 2005, the frogs were relocated to a constructed wetland habitat, and the discharge of water from Building 865 was discontinued. Depth to water in the Qal/WBR HSU varies from 0 to 25 ft bgs. Ground water flow follows the topography/ground elevation contours and is parallel to stream channel axes (Figure 41).

The $Tnbs_1/Tnbs_0$ HSU in the Pit 2 Landfill area is comprised of the Neroly Formation Lower Blue Sandstone ($Tnbs_1$) and the Basal Blue Sandstone ($Tnbs_0$). Ground water in this HSU is unconfined to confined. The HSU is saturated beneath Elk Ravine, where depth to water is approximately 50 to 65 ft bgs. The saturated thickness of the HSU may be from 25 to 100 ft. As suggested by the potentiometric surface contours shown on Figure 42, the southwestern branch of the Elk Ravine Fault may locally either be a conduit or a barrier to ground water flow in this HSU.

The Tmss HSU is comprised of sandstone of the Cierbo Formation (Tmss). The saturated thickness of this HSU may be over 40 ft beneath Elk Ravine.

Pit 2 Landfill Surface Water

Surface water in the vicinity of the Pit 2 Landfill is the result of either surface runoff from precipitation or from spring discharge upstream of the landfill area. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms. During severe storms, surface water may flow within Doall Ravine or Elk Ravine for short distances before infiltrating into the ground. As discussed previously, perennial surface water was present south of Building 865 around the northern and eastern boundaries of the Pit 2 Landfill until the discharge from Building 865 was discontinued in 2005.

3.5.2.2. Pit 2 Landfill Land and Resource Use

The Pit 2 Landfill is located in the north-central portion of Site 300, approximately 6,300 feet south of the closest site (northern) boundary. Use of the Pit 2 Landfill was discontinued and a cover installed in 1960. The Pit 2 Landfill area has not been used for site activities since that time.

There are no active onsite water-supply wells in the Pit 2 Landfill area.

Site 300 has unique environmental qualities, largely because it has not been grazed for over 50 years and contains several habitat types and numerous special status species (e.g., threatened and endangered species, migratory birds, and rare plants). Pit 2 Landfill is covered by annual

grassland, although a large area of native perennial grassland occurs to the south of the pit. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the CNPS List 1B, is periodically mapped within the vicinity of the pit. Pit 2 Landfill occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*) and the threatened California tiger salamander (*Ambystoma californiense*). The Sharp Pool, to the northwest of Pit 2, also provides non-breeding aquatic habitat for the red-legged frog. Loggerhead shrikes (*Lanius ludovicianus*), burrowing owls (*Athene cunicularia*), and a San Joaquin coachwhip (*Masticophis flagellum ruddocki*), all California Species of Special Concern, have all been observed nearby. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from the Pit 2 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.5.2.3. Pit 2 Landfill History of Contamination

Debris from the Buildings 801 and 802 firing tables were disposed in the Pit 2 Landfill.

No COCs were identified in surface soil, subsurface soil, or surface water in the Pit 2 Landfill area. While uranium was not originally identified as a contaminant in ground water, the increases in uranium activities in the Pit 2 monitor wells between 1996 and 2005 may have been the result of the discharge of potable water that was used to maintain a wetland habitat for red-legged frogs within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill. This discharge occurred between 1996 and 2005. Since the discharge was discontinued in 2005, total uranium activities detected in Pit 2 Landfill detection monitor wells, especially in well W-PIT2-1934, have decreased and are within background levels for total uranium. There have been no other releases from the Pit 2 Landfill.

3.5.2.4. Pit 2 Landfill Initial Response

Investigations began at the Pit 2 Landfill in 1982 to identify contaminant sources and the distribution of contaminants in soil, bedrock, and ground water. Since then, ten boreholes have been drilled; all of these boreholes have been completed as ground water monitor wells (Figures 41 and 42). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 2 Landfill.

3.5.2.5. Pit 2 Landfill Contaminants of Concern

No COCs were identified in surface soil, subsurface soil and rock, or surface water at the Pit 2 Landfill. Nitrate was identified as a COC for ground water. The distribution and concentration of contaminants in ground water is described in detail in Section 3.5.5.1 of this review. No unacceptable risk or hazard to human or ecological receptors was identified for the Pit 2 Landfill in the baseline risk assessment.

3.5.2.6. Pit 2 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human or ecological health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards and the landfill remains in place.

3.5.3. Pit 2 Landfill Remedial Actions

3.5.3.1. Pit 2 Landfill Remedy Selection

The remedy selected for the Pit 2 Landfill is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.

The remedy for the Pit 2 Landfill was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Pit 2 Landfill consists of:

1. Monitoring ground water to detect any future releases from the Pit 2 Landfill or changes in contaminant concentrations that could impact human health or the environment.
2. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
3. Inspecting the Pit 2 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.5.3.2. Pit 2 Landfill Remedy Implementation

Monitoring of ground water at the Pit 2 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 2 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. The detection monitoring and results for the Pit 8 Landfill is discussed in Section 3.5.5.2.

As part of the remedial action monitoring program, ground water samples are collected from downgradient wells and analyzed for ground water COCs to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, to meet remedial

action objectives, and verify the attainment of cleanup standards. The remedial action monitoring results are discussed in Section 3.5.5.1.

Land Use Controls have been implemented to prevent damage to the landfill cap (see Section 3.5.3.4).

The results of the detection and remedial action monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.5.3.3. Pit 2 Landfill System Operations/Operation and Maintenance

The remedy for the Pit 2 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cap maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 2 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cover to detect differential settling or other earth movement.
- Annual inspection of the pit cover by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cover are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the Pit 2 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.5.3.4. Pit 2 Landfill Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (U.S. EPA 2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as FFAs, that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term "land use controls" is used to encompass institutional controls, engineered controls, and physical barriers. The land use controls and requirements described herein are only applicable to the Pit 2 Landfill and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Pit 2 Landfill are described in Table 5 which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Pit 2 Landfill. Figure 43 shows the specific areas of the Pit 2 Landfill where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the Pit 2 Landfill by objective, and the status of the land use controls are summarized below.

3.5.3.4.1. Pit 2 Landfill Land Use Control Objectives

Land use control objectives were established for the Pit 2 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Pit 2 Landfill include:

1. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
   - Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

2. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs were identified in surface soil, subsurface soil and rock, or surface water, the only COC in ground water (nitrate) is below the cleanup standard (see Section 3.5.5.1), there is no contamination offsite associated with the Pit 2 Landfill, and no unacceptable risk or hazard to human or ecological receptors was identified for the Pit 2 Landfill in the baseline risk assessment.

3.5.3.4.2. Pit 2 Landfill Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the Pit 2 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill covers and ground water monitoring systems. Landfill cap maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to maintain the integrity of the Pit 2 Landfill cover: Dig Permit and Work Induction Board processes.

Dig Permit Process: The Dig Permit process reviews all onsite excavation. Any proposed excavation would be approved by the LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 2 Landfill cover. During this five-year review period, there were no dig permit applications for excavation at the Pit 2 Landfill.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 2 Landfill cover. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, no excavation or construction activities were proposed in the Pit 2 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Governmental Institutional Controls:
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 2 Landfill area.

Prevent Inadvertent Exposure of Onsite Workers and Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers and unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Fences.
  - Security Force.
  - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300.

The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers are routinely inspected. These inspections are documented in the Annual Compliance Monitoring Report land use control checklist. There were no incidents of unauthorized access during the Five-Year Review period. The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

- Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD.

The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a

portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

3.5.3.4.3. Summary of the Status of Pit 2 Landfill Land Use Controls

The review of the land use controls for the Pit 2 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Pit 2 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.5.4. Pit 2 Landfill Five-Year Review Process

3.5.4.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

The draft, draft final and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment for review.

3.5.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Pit 2 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.5.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).

- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Pit 2 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).
- Pit 1 Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (U.S. DOE 2011).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.5.5. Pit 2 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.5.5.1), (2) Pit 2 Landfill detection monitoring and results (Section 3.5.5.2), (3) performance issues (Section 3.5.5.3), and (4) risk mitigation remediation progress (Section 3.5.5.4).

3.5.5.1. Pit 2 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

Nitrate is the only COC identified in ground water in the Pit 2 Landfill area. Historic maximum and 2011 maximum concentrations for this COC at the Pit 2 Landfill are included in Table 6. No COCs have been identified in surface water, surface soil, or the vadose zone at the Pit 2 Landfill. Detection monitoring results for the landfill are discussed in Section 3.5.5.2.

While nitrate has been detected in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs, nitrate has only been detected at concentrations above the 45 mg/L MCL cleanup standard in the $Tnbs_1/Tnbs_0$ HSU. Nitrate has not been detected in the Tmss HSU ground water at concentrations above background levels. Therefore, nitrate in this HSU is not discussed further.

Second semester 2011 ground water concentrations for nitrate and activities for tritium, total uranium and $^{235}U/^{238}U$ atom ratios, are shown on (1) Figure 41 for the Qal/WBR HSU and (2) Figure 42 for the $Tnbs_1/Tnbs_0$ HSU.

Nitrate concentrations in ground water in the vicinity of the Pit 2 Landfill have been relatively stable over time.

The Qal/WBR HSU is generally unsaturated except for short periods following winter storms. When present, the depth to ground water in the Qal/WBR HSU is 15 to 20 ft bgs. For wells screened within the Qal/WBR HSU, the 2011 maximum nitrate concentration of 29 mg/L (NC2-14S, May 2011) was below its 45 mg/L cleanup standard. The historic maximum nitrate concentration of 42 mg/L (NC2-14S, 2003) and the five-year review period maximum nitrate concentration of 37 mg/L (W-PIT2-2304, 2008) are both below the 45 mg/L cleanup standard. The 2008 Final Site-Wide ROD cited a historic maximum nitrate concentration of 186 mg/L (in 1993, from well K2-04S screened in the Qal/WBR HSU) (U.S. DOE, 2008). This well was not included as part of this Five-Year Review because it: (1) is located approximately 800 feet upgradient of the Pit 2 Landfill (farther east of NC2-14S) and (2) is likely impacted by historic nitrate releases from Building 850 and not from Pit 2.

Depth to ground water within the $Tnbs_1/Tnbs_0$ HSU is currently over 50 ft to over 70 ft beneath the Pit 2 Landfill. For wells screened within the $Tnbs_1/Tnbs_0$ HSU, the 2011 maximum nitrate concentration in the Pit 2 Landfill area of 38 mg/L (W-PIT2-1935, May 2011) was below the 45 mg/L cleanup standard. The historic maximum nitrate concentration was 106 mg/L (K2-01C, 1993). Other than a 1998 nitrate detection of 48 mg/L in the same well, nitrate levels above the cleanup level have not been detected in this or any other well screened in the $Tnbs_1/Tnbs_0$ HSU since monitoring began in 1993. The five-year review period maximum nitrate concentration is 42 mg/L (W-PIT2-1934, May 2007). Figure 44 presents time-series plots of nitrate detections in the $Tnbs_1/Tnbs_0$ HSU since monitoring began in 1993.

3.5.5.2. Pit 2 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 2 Landfill is conducted annually to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the Pit 2 Landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill.

The constituents of concern for the Pit 2 Landfill include VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

Concentrations and activities of VOCs, nitrate, HE compounds, Title 26 metals, lithium, and fluoride concentrations/activities in samples collected since monitoring began in 1982 have been either below reporting limits or within the range of background.

Concentrations/activities of tritium, perchlorate, and uranium in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water in the vicinity of the Pit 2 Landfill are discussed below.

Tritium

Tritium was not detected Qal/WBR HSU well W-PIT2-2301, located downgradient of the Pit 2 Landfill, at activities above the 100 pCi/L reporting limit during the five-year review period. The maximum tritium activity in the Qal/WBR HSU ground water during the five-year review period was detected at an activity of 4,620 pCi/L (June 2007) in well NC2-14S, located upgradient of the landfill. Tritium detected in this well has migrated in Qal/WBR ground water from the Building 850 area.

During the five-year review period, the maximum tritium activities in wells located downgradient from Pit 2 were detected in well K2-01C. Tritium activities in this well decreased from 6,120 pCi/L in October 2007 to 4,070 pCi/L in November 2011. During the five-year review period, tritium activities in $Tnbs_1/Tnbs_0$ HSU well NC2-08, located cross-/downgradient of the landfill, decreased from 7,820 pCi/L in March 2007 to 4,460 ± 885 pCi/L in November

2011. A ground water sample collected on February 15, 2006 from well NC2-08 yielded a reported tritium activity of 26,500 pCi/L (analyzed by General Engineering Laboratory, Charleston SC); another laboratory (formerly Thermo Nutech, now Eberline Laboratory, Richmond CA) detected 9,460 pCi/L for tritium in a duplicate sample. The higher activity measured is likely spurious as it is conspicuously inconsistent with the other tritium data from this well (shown on the time-series plots on Figure 45). These data indicate that tritium activities in $Tnbs_1/Tnbs_0$ HSU ground water are decreasing (especially in wells immediately downgradient of the landfill) and are currently a fraction of the historic maximum. Figure 45 shows tritium time-series plots for Pit 2 wells screened in the $Tnbs_1/Tnbs_0$ HSU and illustrates the historical upward then downward trend in tritium apparently affected by the discharge of potable water from 1996 to 2005. The overall distribution of tritium activities in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 2 Landfill area appears to include a large component resulting from migration of the Building 850 tritium plume into the Pit 2 Landfill area. While some tritium may have been released to ground water from the Pit 2 Landfill, the data indicate that tritium activities in ground water immediately downgradient of the landfill are decreasing and are currently a fraction of the historic maxima and cleanup standard.

Perchlorate

Within the Qal/WBR HSU, perchlorate has only been detected once at or above its 6 µg/L MCL cleanup standard in well NC2-14S (2004). Well NC 2-14S is located upgradient of the landfill. Within the deeper $Tnbs_1/Tnbs_0$ HSU, perchlorate has only been detected three times at or above its cleanup standard in well K2-03 (11.3 µg/L, November 2010) and in well NC2-08 (6 µg/L, May 2003 and May 2004). Both K2-03 and NC2-08 are located upgradient of the landfill. During 2011, perchlorate was not detected above its cleanup standard in any Pit 2 area ground water samples representative of both HSUs.

Uranium

Uranium activities detected in Qal/WBR HSU wells W-PIT2-2301 and W-PIT2-2302, located downgradient of the Pit 2 Landfill, were all within the range of background levels during the five-year review period (0.1 to 1.3 pCi/L). The maximum uranium activity in the Qal/WBR HSU ground water during the five-year review period was detected at an activity of 4,620 pCi/L (June 2007) in well NC2-14S, located upgradient of the landfill. $^{235}U/^{238}U$ atom ratio data from Qal/WBR HSU ground water reveal a slightly depleted uranium signature.

Uranium isotope data from ground water sampled in Pit 2 wells screened in the $Tnbs_1/Tnbs_0$ HSU have also been very low. The historic and five-year review period maximum uranium activities were 27.4 pCi/L and 10.7 pCi/L, respectively, both measured in downgradient well K2-01C (June 1994 and April 2008, respectively). The 2011 maximum activity was 8.4 pCi/L detected in well K2-03 (May 2011), located upgradient from the landfill. In 2011, wells located downgradient of Pit 2 Landfill had even lower uranium activities. Figure 46 presents time-series plots of uranium activities in $Tnbs_1/Tnbs_0$ HSU ground water. The plots show downward trends in uranium activity since the discharge of potable water stopped in 2005 and that uranium activities have remained below the 20 pCi/L cleanup standard since 1994. $^{235}U/^{238}U$ atom ratio data from $Tnbs_1/Tnbs_0$ HSU ground water have also revealed a depleted uranium signature. Time-series plots of these data are depicted on Figure 47 and show a slight trend toward natural uranium since the discharge of potable water was discontinued in 2005.

The detection of depleted uranium in ground water indicates that low activities of depleted uranium have been added to the naturally occurring uranium in the ground water by the Pit 2 Landfill. The release likely resulted from the continuous discharge of potable water from 1996 to 2005 to maintain a wetland habitat for red-legged frogs (a federally listed endangered species) within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill. Since this discharge stopped, Qal/WBR HSU wells located immediately downgradient of Pit 2 have generally been dry. Ground water sampled from downgradient $Tnbs_1/Tnbs_0$ HSU wells W-PIT2-1934 and W-PIT2-1935, both located along the northern and eastern margin of the Pit 2 Landfill, have exhibited a decrease in total uranium activities as demonstrated by the uranium atom ratio activity time-series plots depicted on Figure 46. The 2011 samples collected from downgradient wells W-PIT2-1934 and W-PIT2-1935 and analyzed by mass spectrometry contained only natural uranium at 4.5 and 1.8 pCi/L, respectively (May 2011). Samples collected from these wells and analyzed by alpha spectrometry contained 4.6 and 1.7 pCi/L of uranium, respectively.

No contaminant releases have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005.

LLNS Maintenance and Utilities Services Department staff annually inspect the Pit 2 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that could lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled animal burrows but no significant issues (including subsidence) were reported during annual inspection.

3.5.5.3. Pit 2 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.5.5.4. Pit 2 Landfill Risk Mitigation Remediation Progress

No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Pit 2 Landfill in the baseline risk assessment.

On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively, in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since no VOCs, including TCE and PCE, have been detected above the reporting limit in the Pit 2 Landfill area ground water, the re-evaluation of risk and hazard were not warranted.

Although there was evidence of a possible new release of depleted uranium from the landfill prior to 2005 when clean water was discharged in the surface water drainage adjacent to the Pit 2 Landfill, re-evaluation of risk does not appear to be warranted at this time because total uranium activities are below its cleanup standard, there is no threat of impacts to water-supply wells, and uranium activities decreased following discontinuation of the water discharge.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Pit 2 Landfill area. No information was identified during this review to question the ecological protectiveness of the remedy.

3.5.6. Pit 2 Landfill Interviews and Site Inspection

DOE/NNSA and LLNL meets monthly with the U.S. EPA, RWQCB, and DTSC RPMs and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 2 Landfill cap and associated drainage ways are annually inspected by the LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes that are distributed following the meetings.

3.5.7. Pit 2 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

3.5.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

3.5.7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.

- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, no there are no discharges to ground surface or NPDES permit required as part of the Pit 2 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011 and February 2012, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE and PCE, respectively, in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.5.5.4, the Baseline Risk Assessment did not identify any human health risks in the Pit 2 Landfill area. Since no VOCs, including TCE and PCE, have been detected above the reporting limit in the Building 851 area ground water, this risk was not reassessed and the protectiveness of the remedy is not affected.
- The review found progress toward meeting the RAOs.

3.5.7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Pit 2 Landfill area.

3.5.8. Pit 2 Landfill Issues

No issues were identified during this evaluation.

3.5.9. Pit 2 Landfill Recommendations and Follow-Up Actions

No recommendations or follow-up actions were identified related to this Five-Year Review.

3.5.10. Pit 2 Landfill Protectiveness Statement

The remedy at the Pit 2 Landfill currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that

could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards.

The remedy protects human health because: (1) nitrate concentrations in ground water have decreased to below the MCL cleanup standard, (2) no unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Pit 2 Landfill in the baseline risk assessment, (3) no new contaminant releases have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Pit 2 Landfill ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

4. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2018).

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6. Acronyms and Abbreviations

1,1,1-TCA	1,1,1-Trichloroethane
ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFF	Contained Firing Facility
CMP/CP	Compliance Monitoring Plan/Contingency Plan
CNPS	California Native Plant Society
COC	Contaminant of concern
DCA	Dichloroethane
DCE	Dichloroethene or Dichloroethylene
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
ERD	Environmental Restoration Department
FFA	Federal Facilities Agreement
ft	Feet
gpm	Gallons per minute
GSA	General Services Area
HE	High explosives
HI	Hazard Index
HMX	High-Melting Explosive
HSU	Hydrostratigraphic unit
ICs	Institutional Controls
IRIS	Integrated Risk Information System
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security
LUCs	Land Use Controls
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
NNSA	National Nuclear Security Administration
NPDES	National Pollution Discharge Elimination System
OU	Operable unit
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene or Tetrachloroethylene
pCi/g	PicoCuries per gram

pCi/L	PicoCuries per liter
PHG	Public Health Goal
PRG	Preliminary Remediation Goal
Qal	Quaternary alluvium
Qls	Quaternary landslide deposits
Qt	Quaternary alluvial terrace
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDX	Research Department explosive
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPMs	Remedial Project Managers
RSL	Regional Screening Level
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendment Reauthorization Act
SVRA	Carnegie State Vehicular Recreation Area
TBOS/TKEBS	Tetrabutyl orthosilicate/ Tetrakis (2-ethylbutyl) silane
TCA	Trichloroethane
TCE	Trichloroethylene
THMs	Total trihalomethanes
TMSRA	Technical Memorandum in Support of a Record of Decision Amendment
Tmss	Miocene Cierbo Formation—lower siltstone/claystone member
$Tnbs_0$	Neroly silty Sandstone
$Tnbs_1$	Tertiary Neroly Lower Blue Sandstone
$Tnbs_2$	Tertiary Neroly Upper Blue Sandstone
$Tnsc_0$	Tertiary Neroly Formation—lower siltstone/claystone member
$Tnsc_1$	Tertiary Neroly Lower Siltstone/Claystone
Tps	Tertiary Pliocene nonmarine sediments
Tpsg	Tertiary Pliocene sand and gravel
Tts	Tesla Formations
$^{235}U/^{238}U$	Uranium-235/uranium-238 (atom ratio)
UCL	Upper Confidence Limit
U.S.	United States
VOCs	Volatile organic compounds
yd^3	Cubic yards
µg/L	Micrograms per liter

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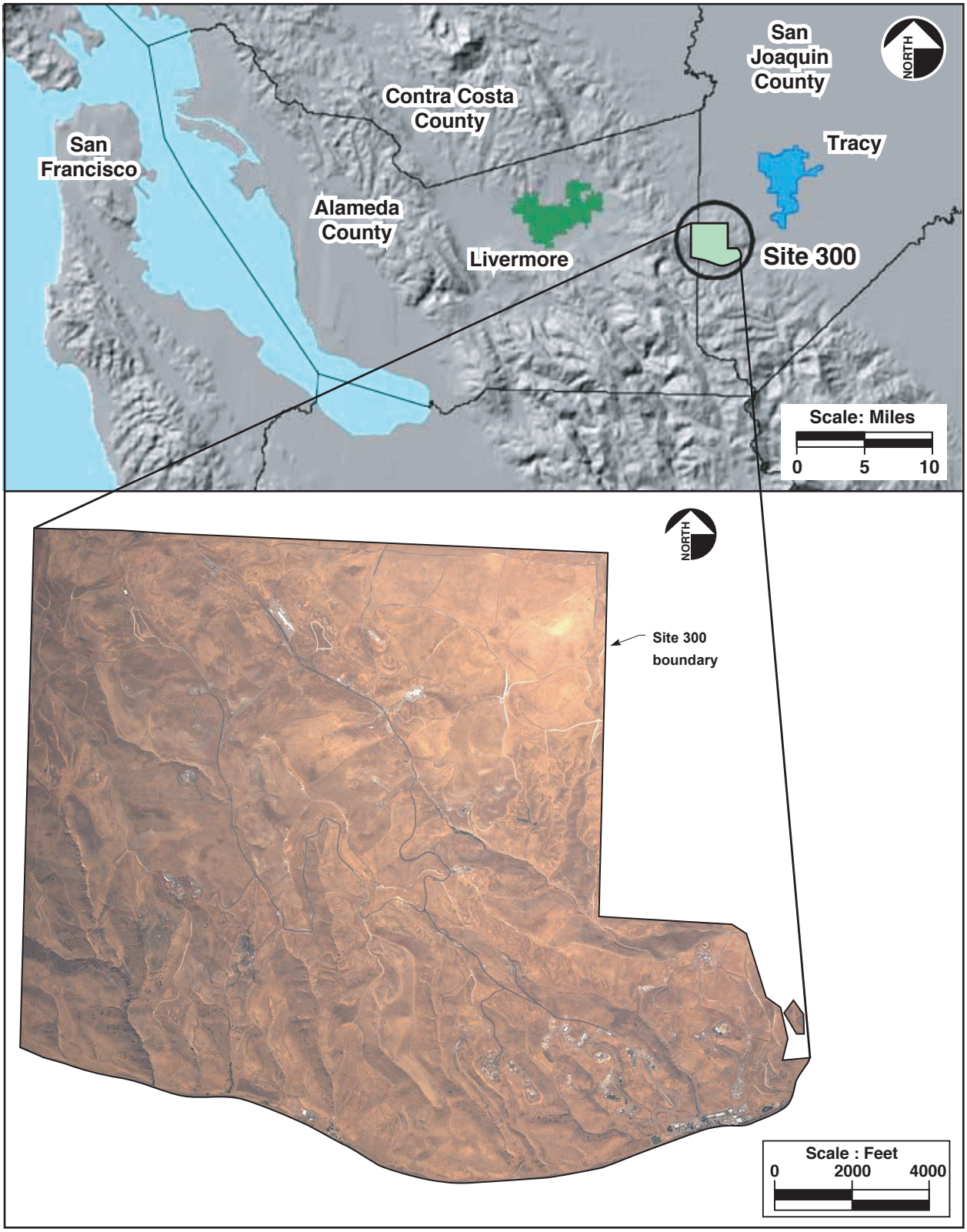

ERD-S3R-12-0039

Figure 1. Location of LLNL Site 300.

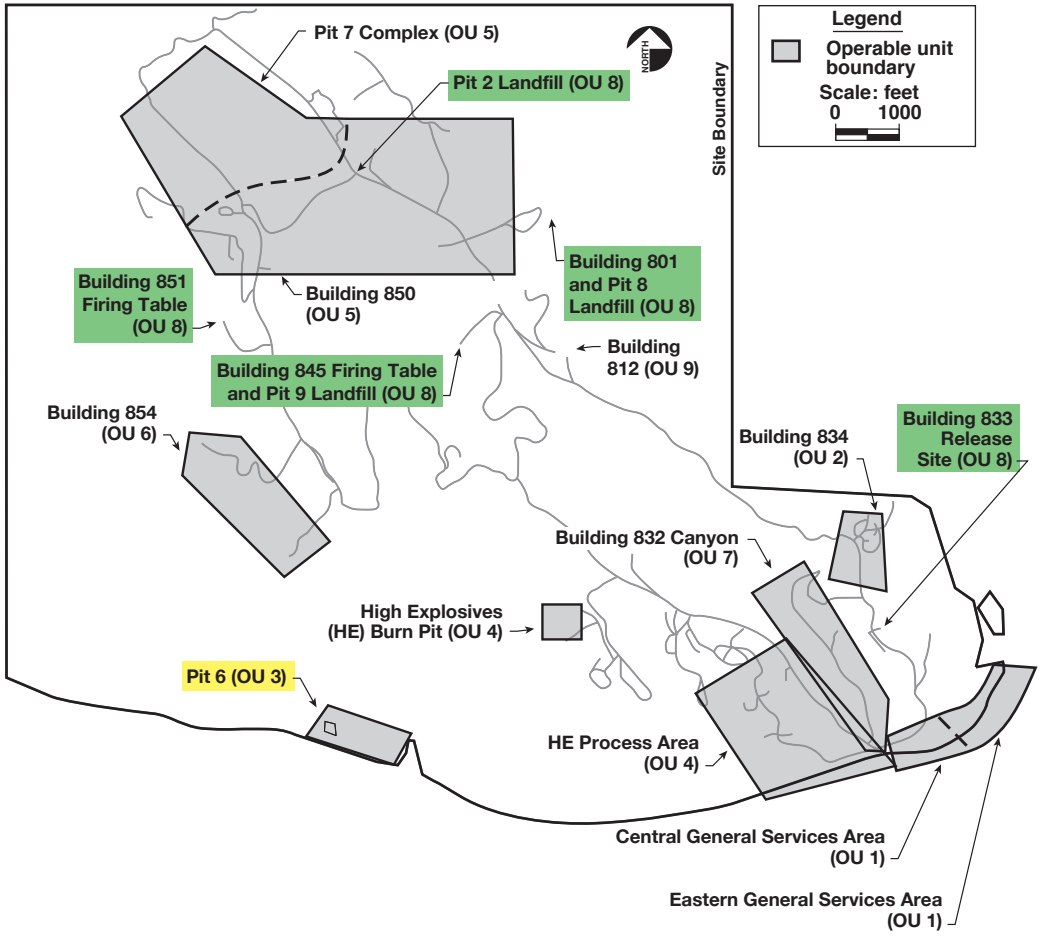

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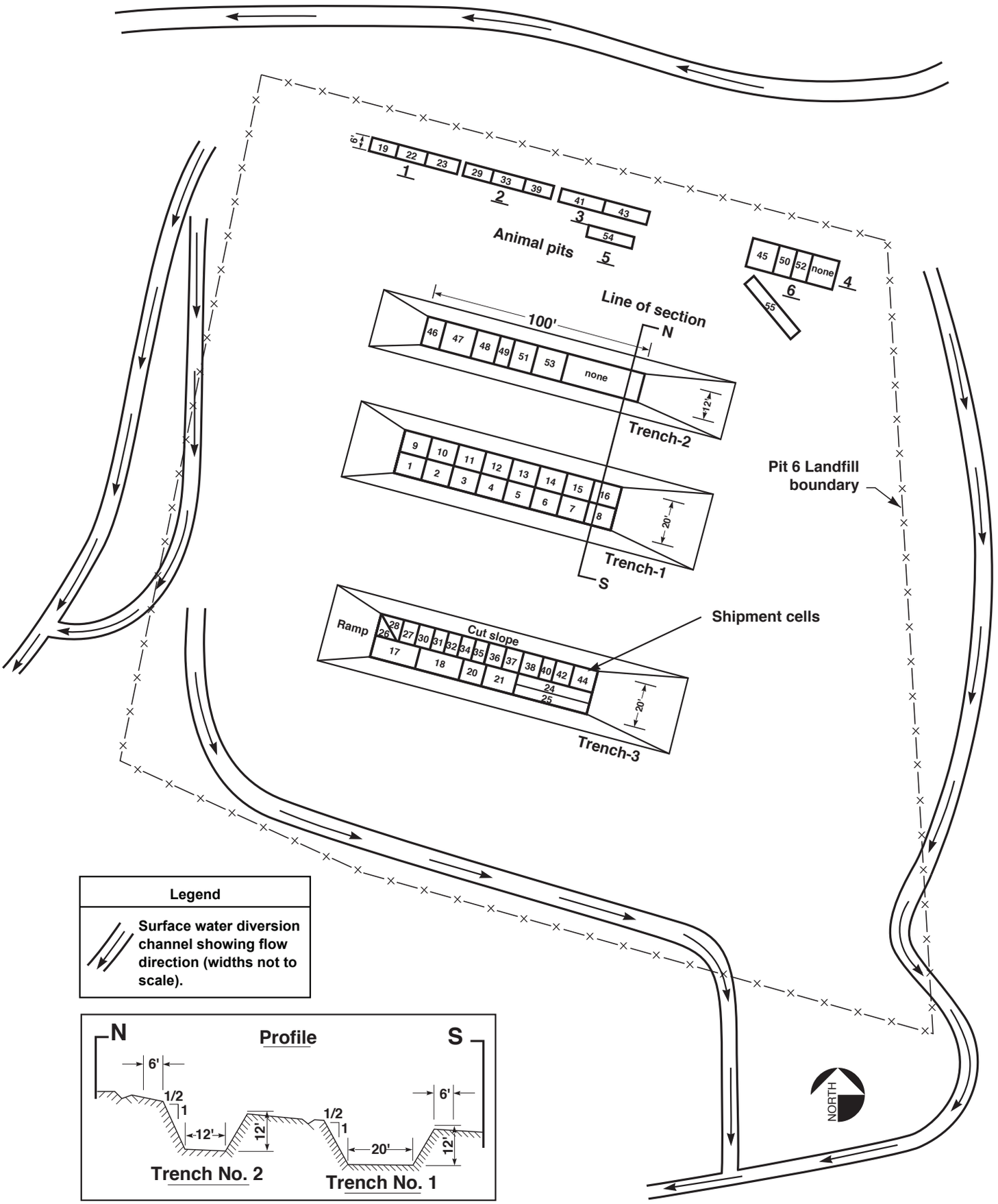
Figure 2. Site 300 map showing Operable Unit locations.

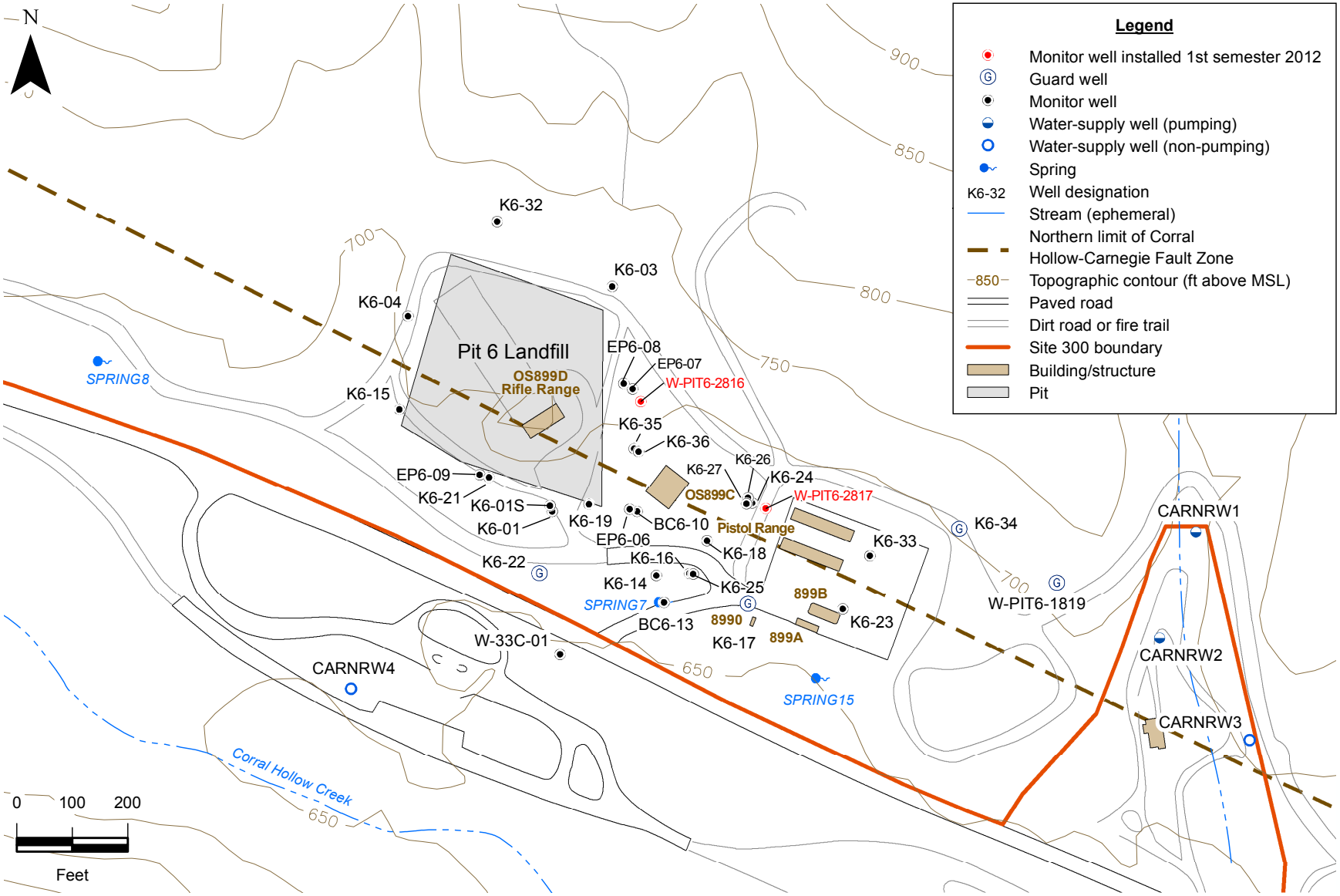


ERD-S3R-13-0019

Scale: feet
0 35 70

Figure 3. Pit 6 Landfill trench and animal pit locations.

All locations are approximate.



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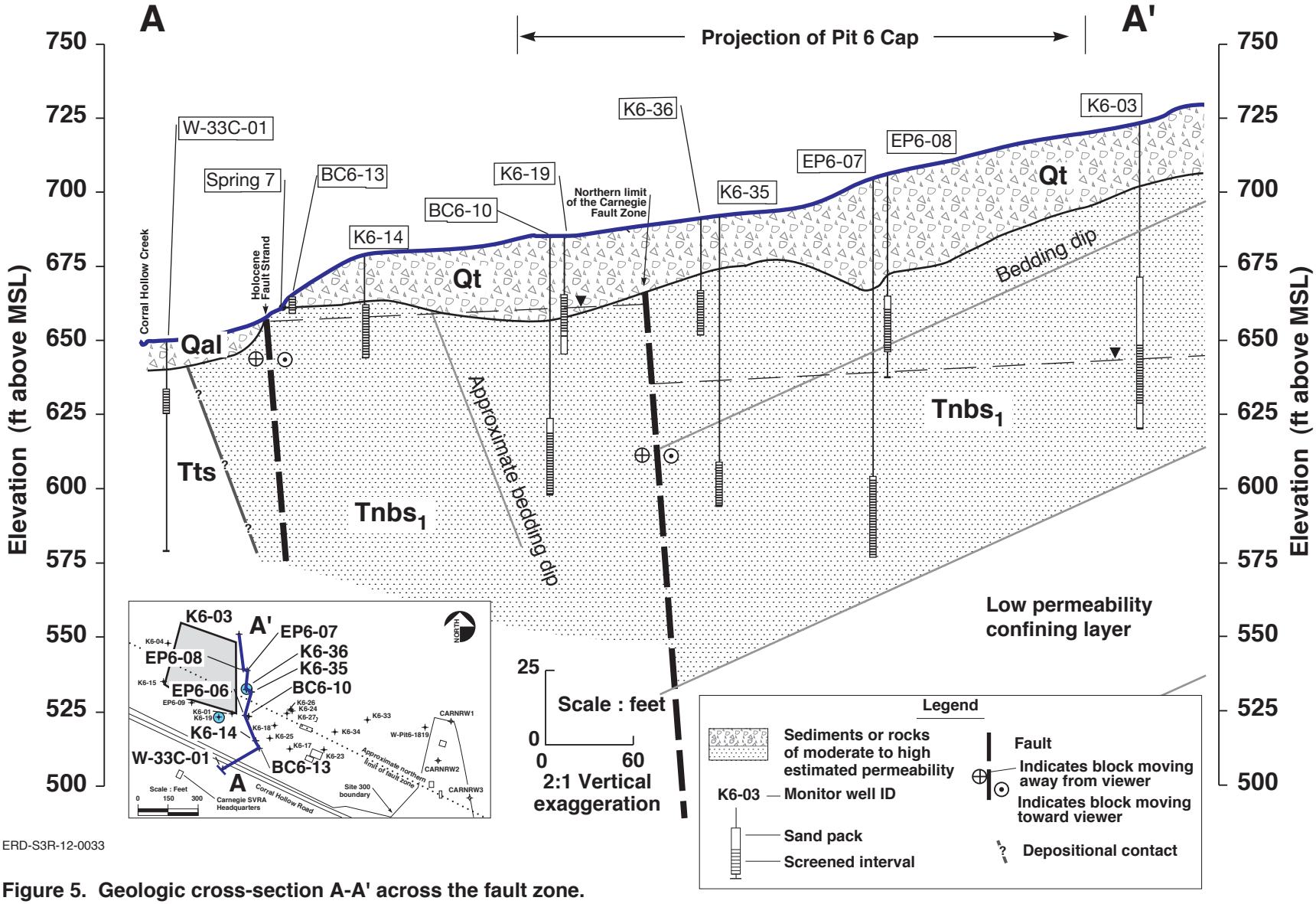

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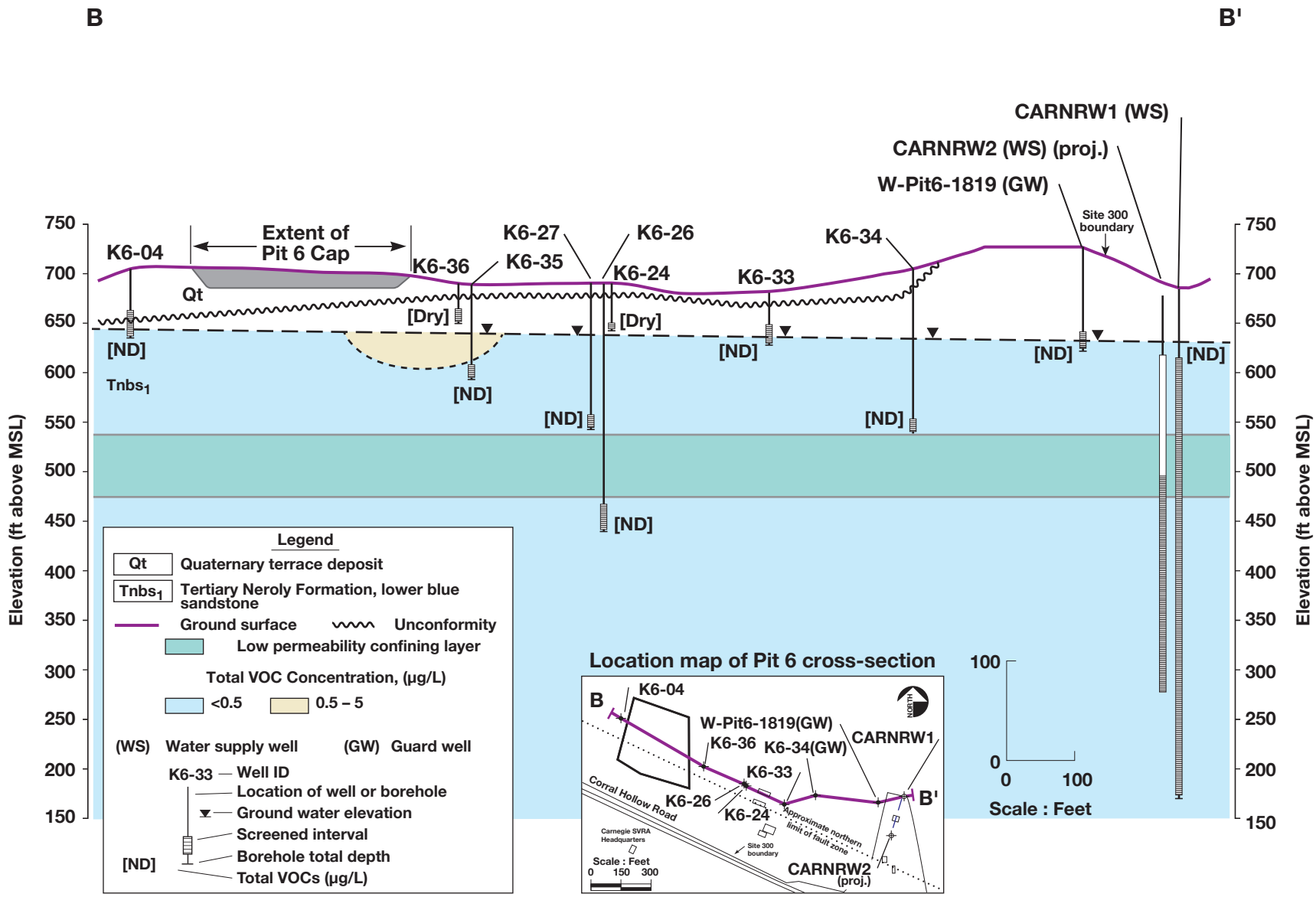

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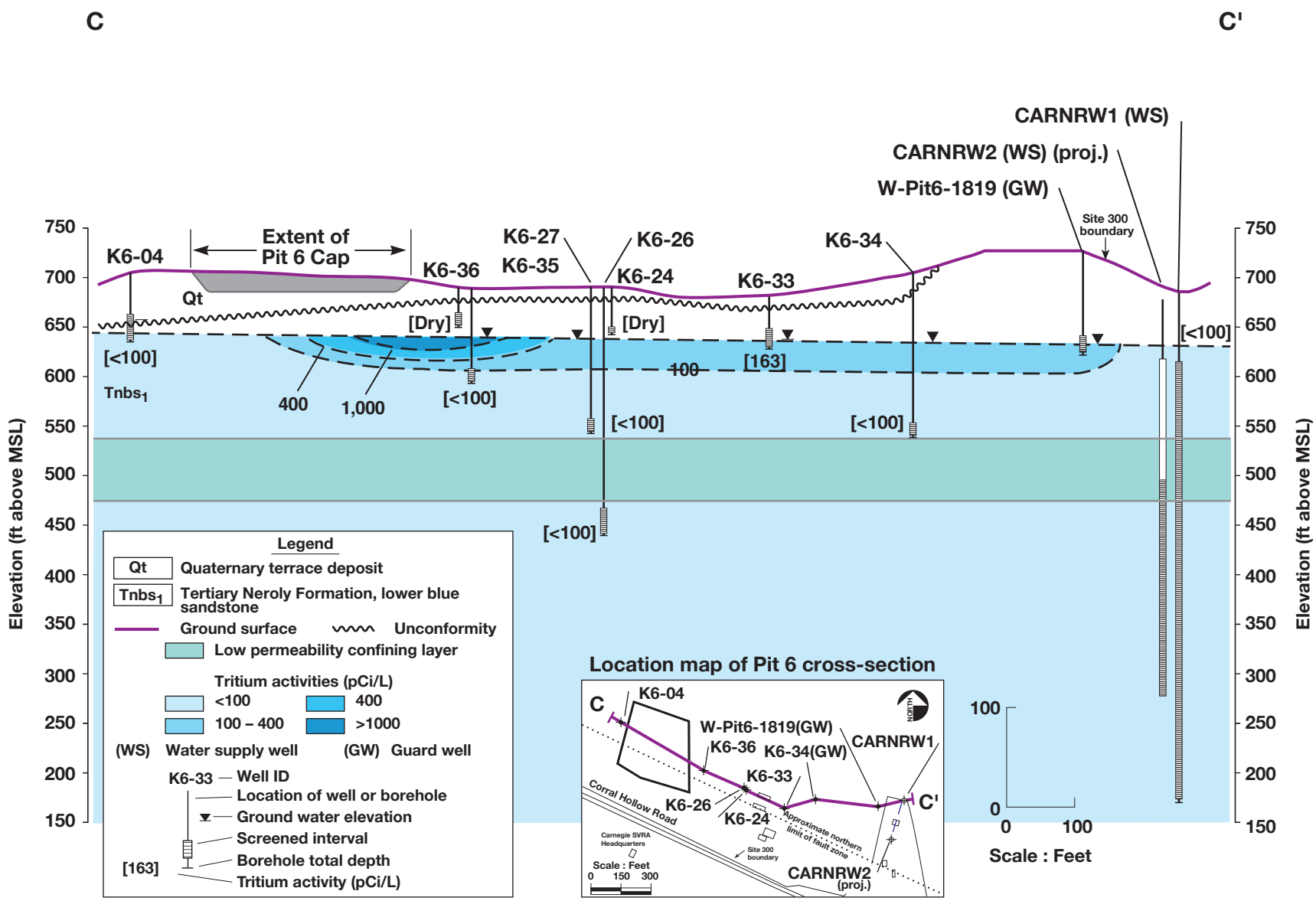
Figure 6. Hydrogeologic cross-section B-B', showing total volatile organic compound concentrations north of the fault zone.



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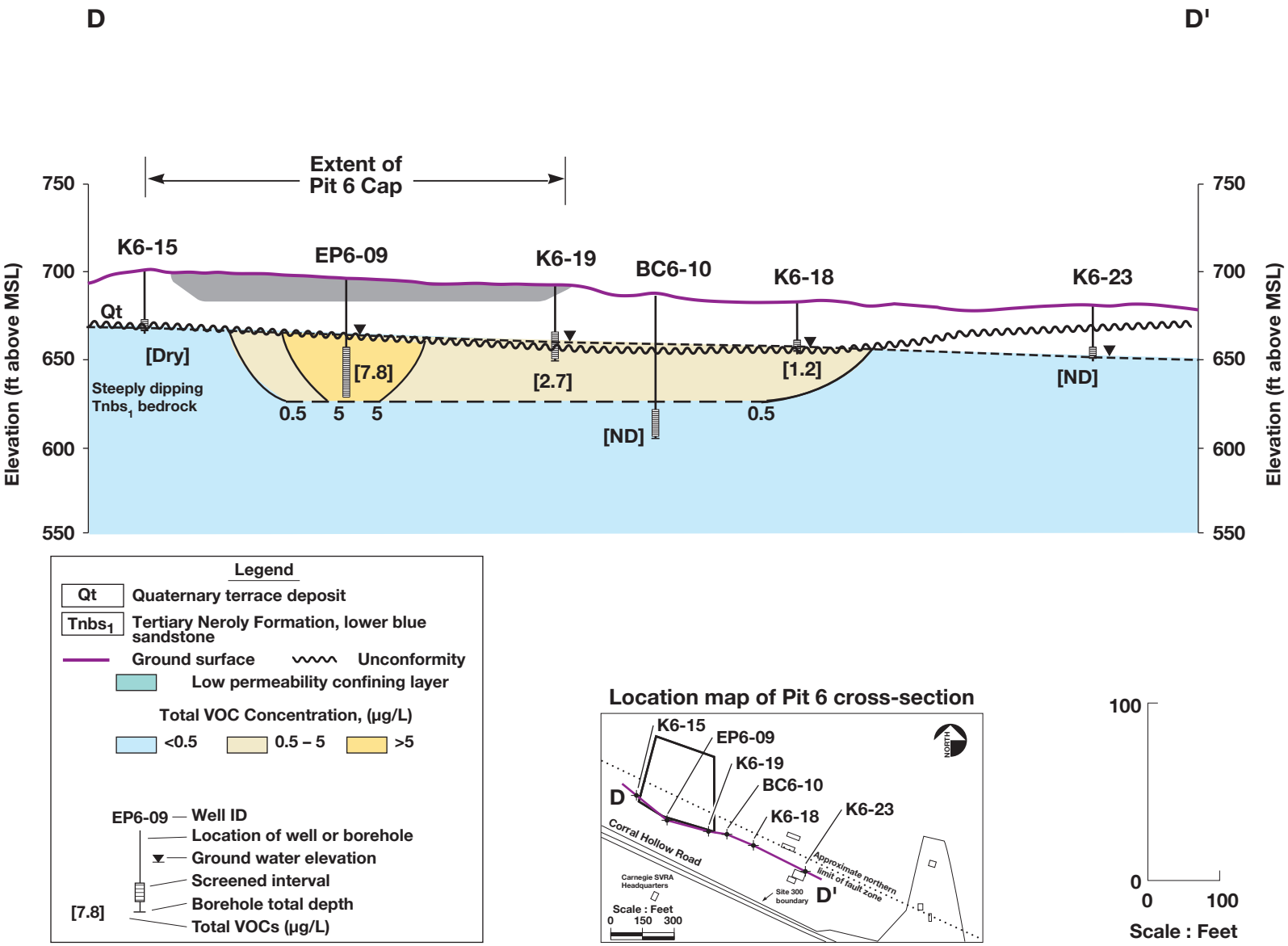

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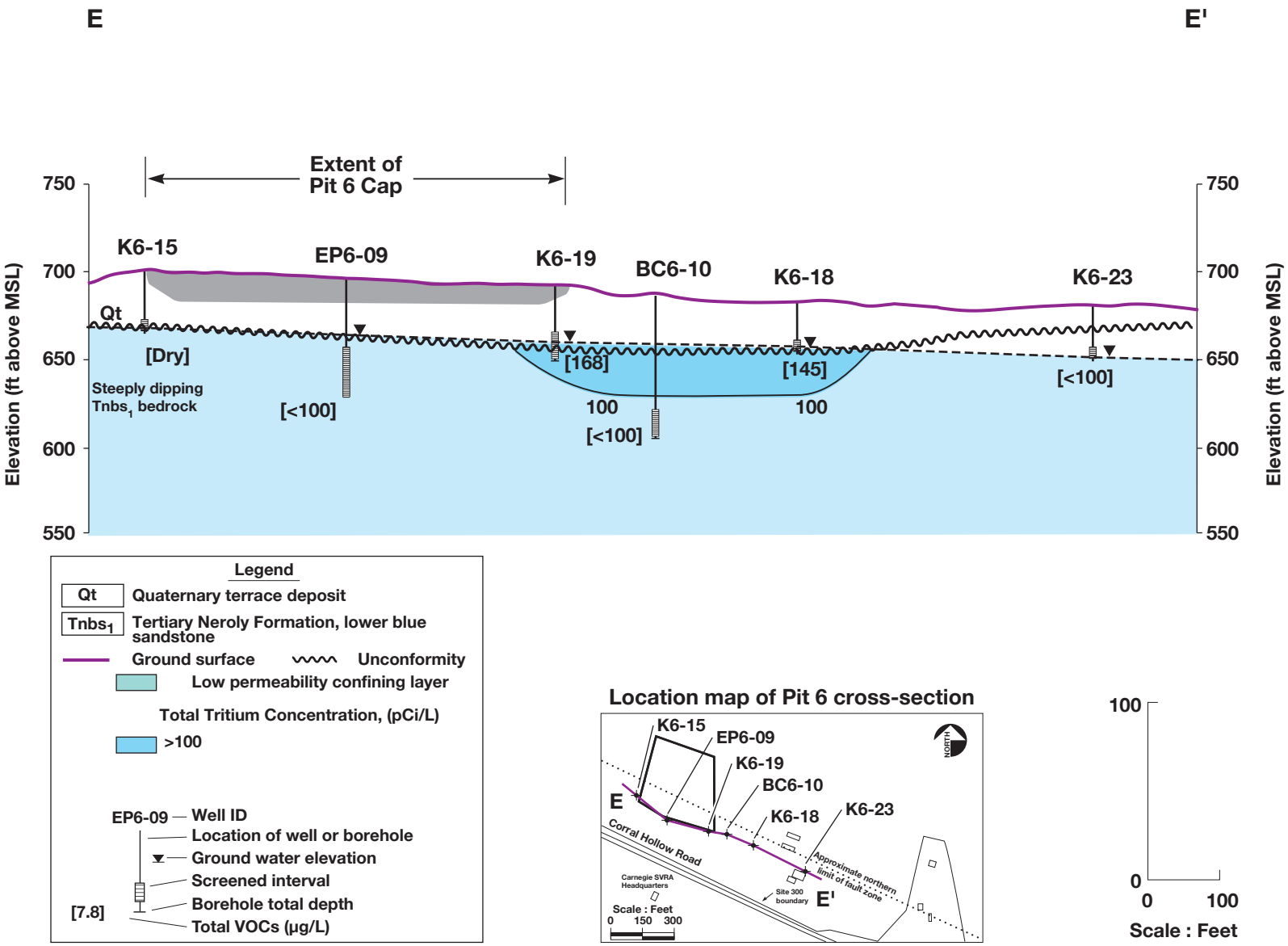

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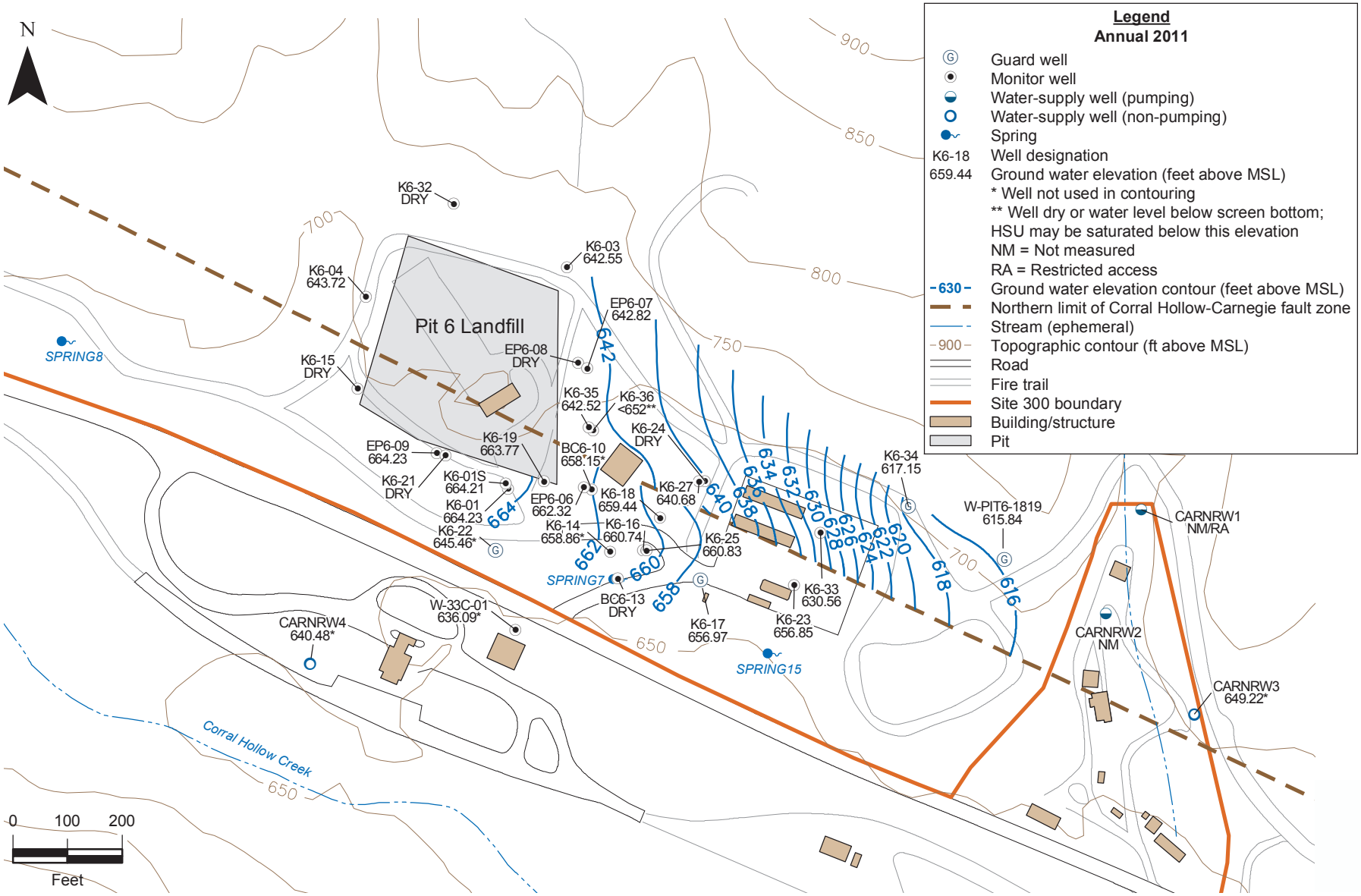
Figure 9. Hydrogeologic cross-section E-E', showing tritium activities within the fault zone.



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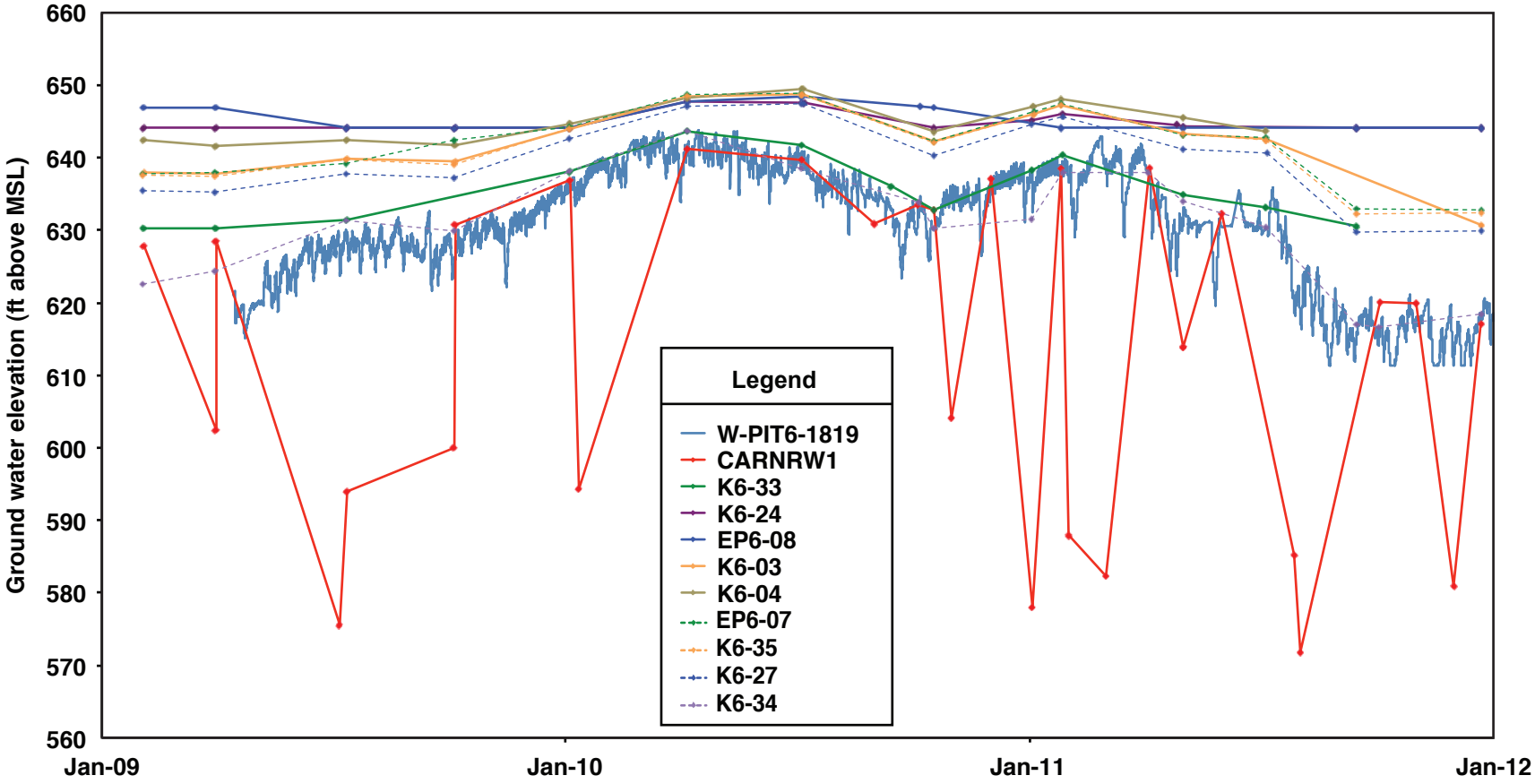

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Figure 11. Hydrographs of Qt-Tnbs$_1$ North wells showing influence of CARNRW1 well pumping on water levels from 2009 through 2011.

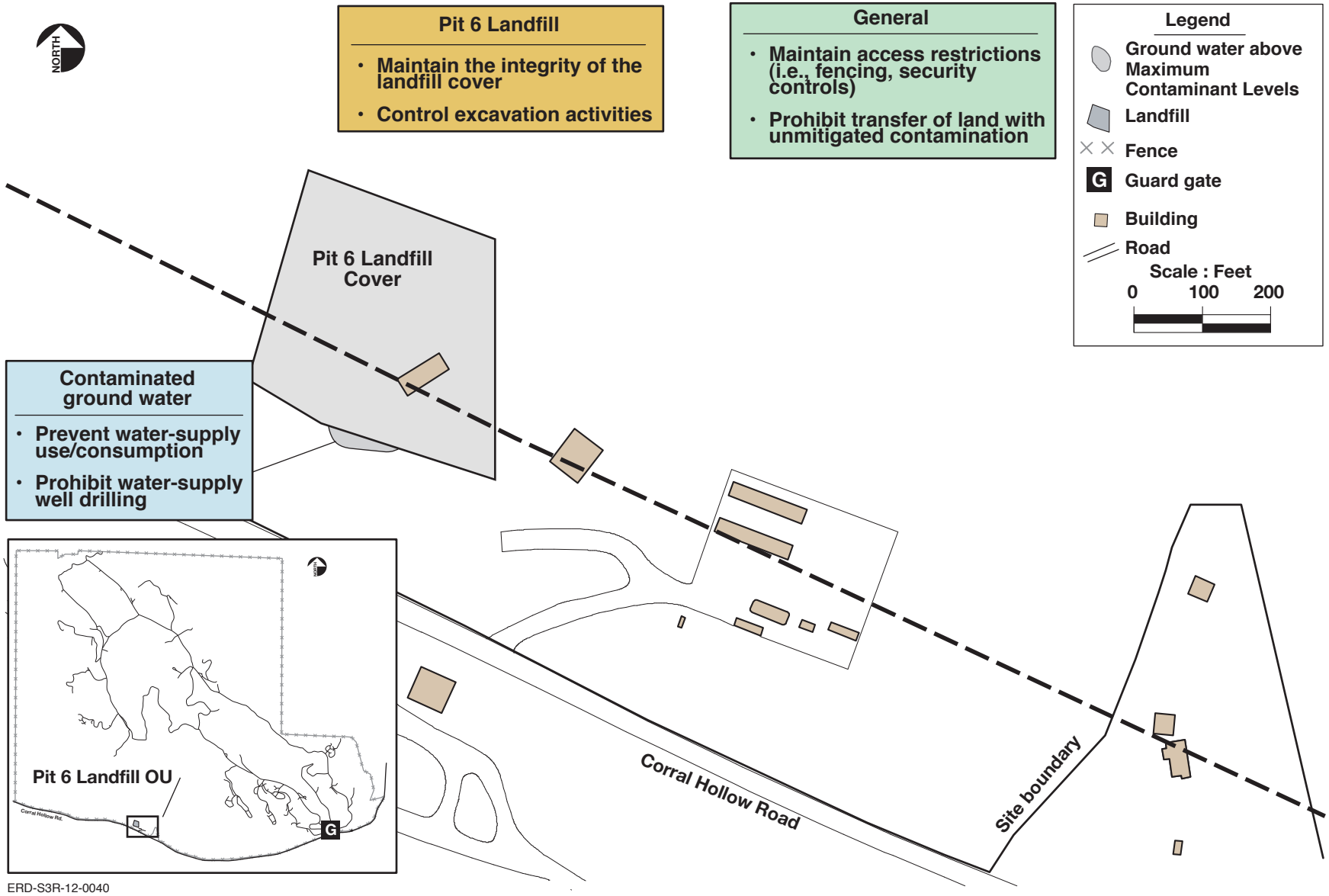
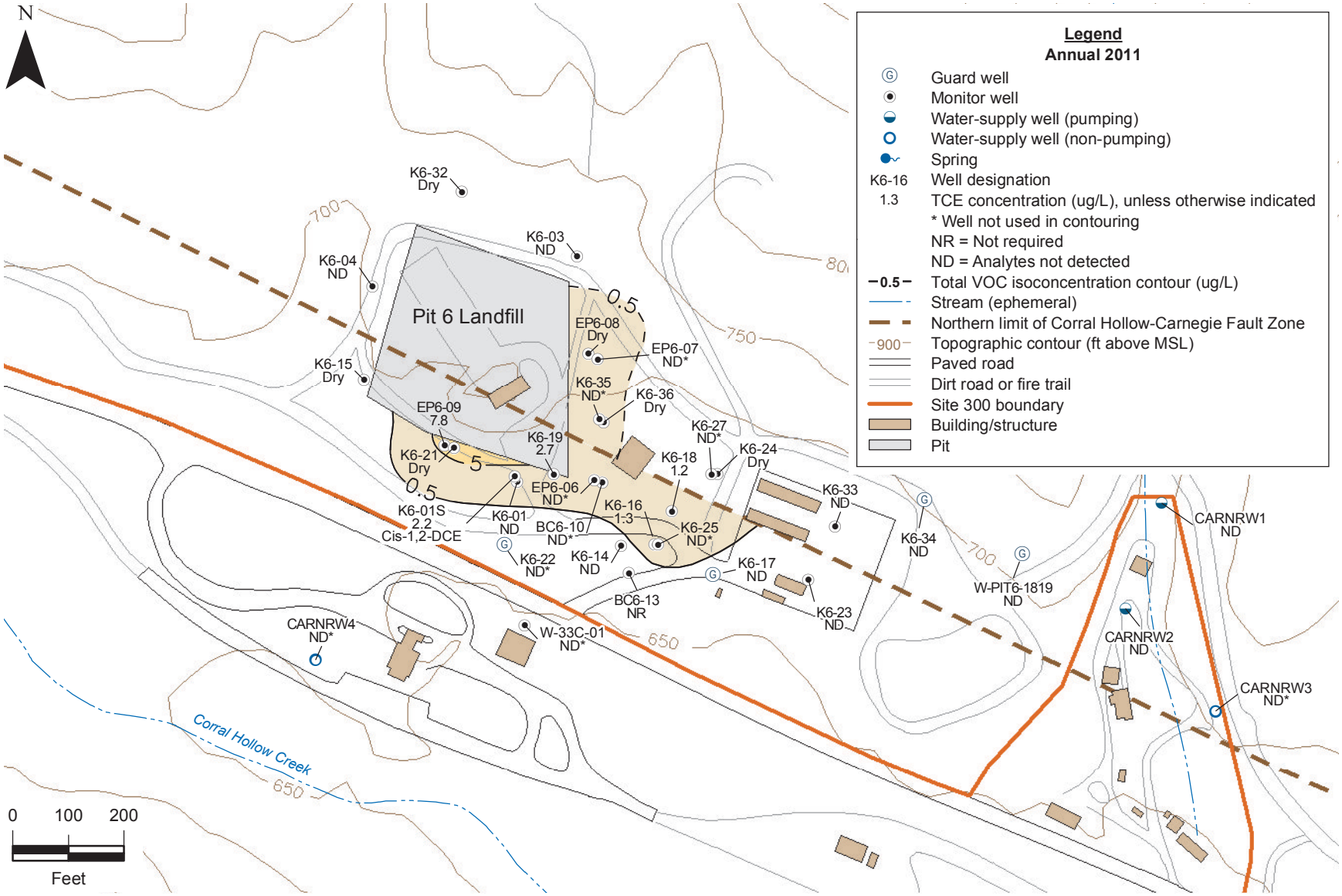


Figure 12. Pit 6 Landfill Operable Unit land use controls.



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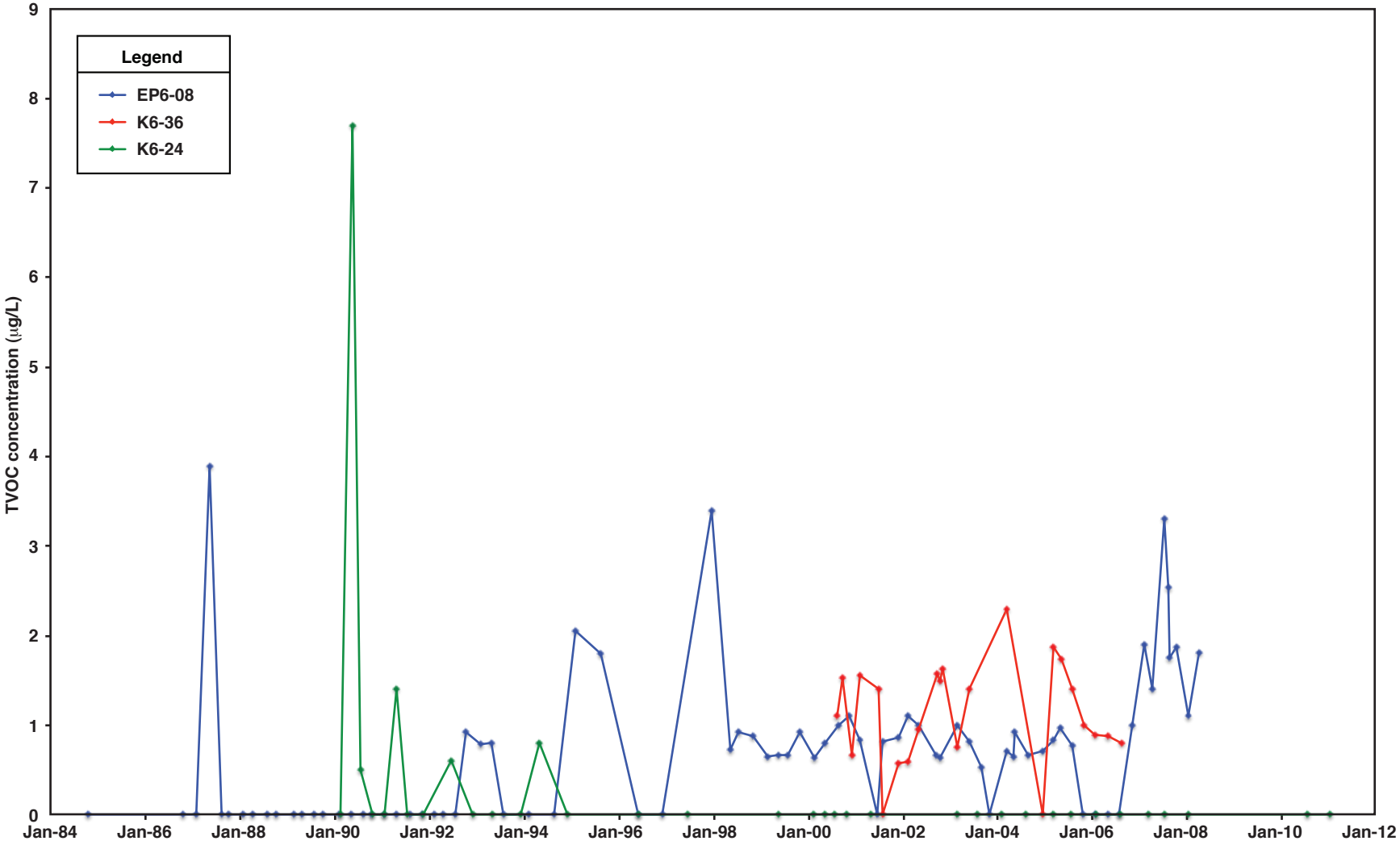

ERD-S3R-12-0044

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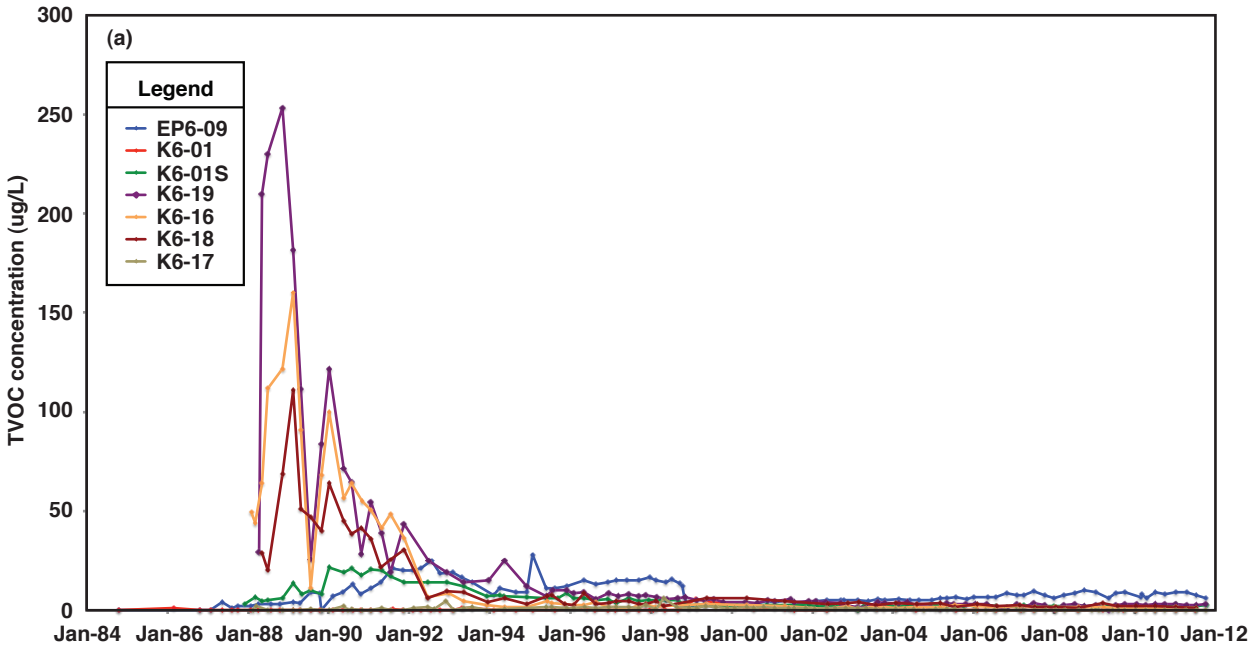

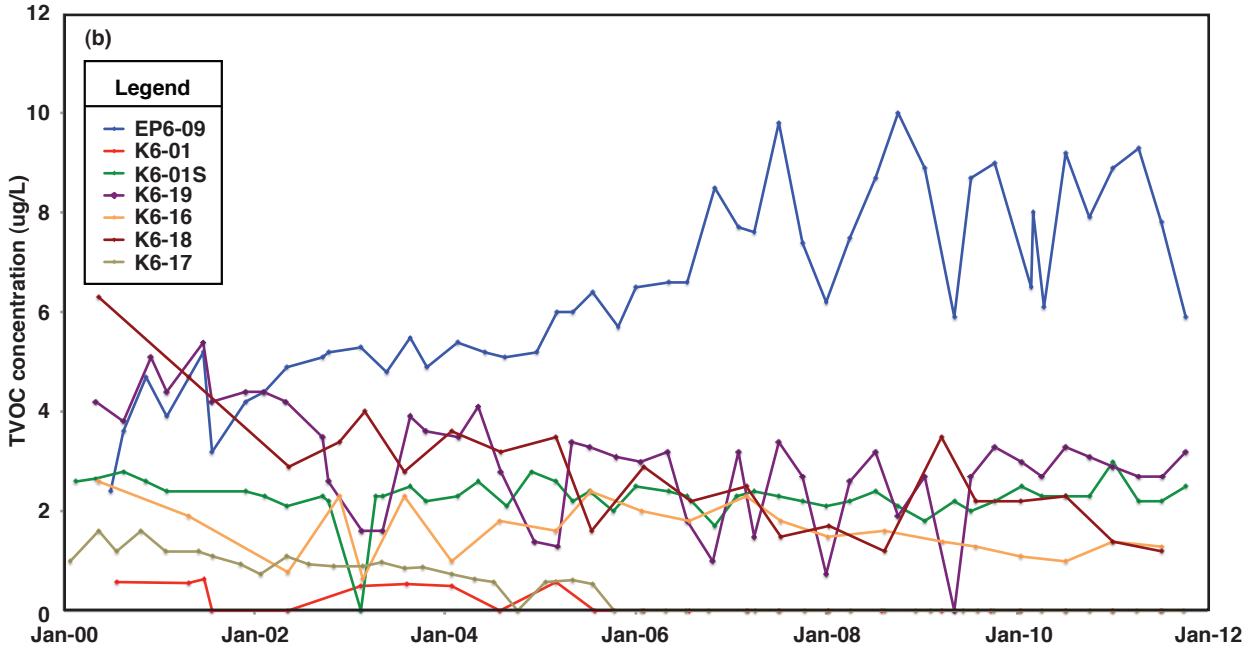

ERD-S3R-12-0045

Figure 15. Time-series plots of total volatile organic compounds in ground water for Qt-Tnbs$_1$ hydrostratigraphic unit wells within the fault zone (Qt-Tnbs$_1$ South HSU) from (a) 1984 through 2011 and (b) 2000 through 2011.

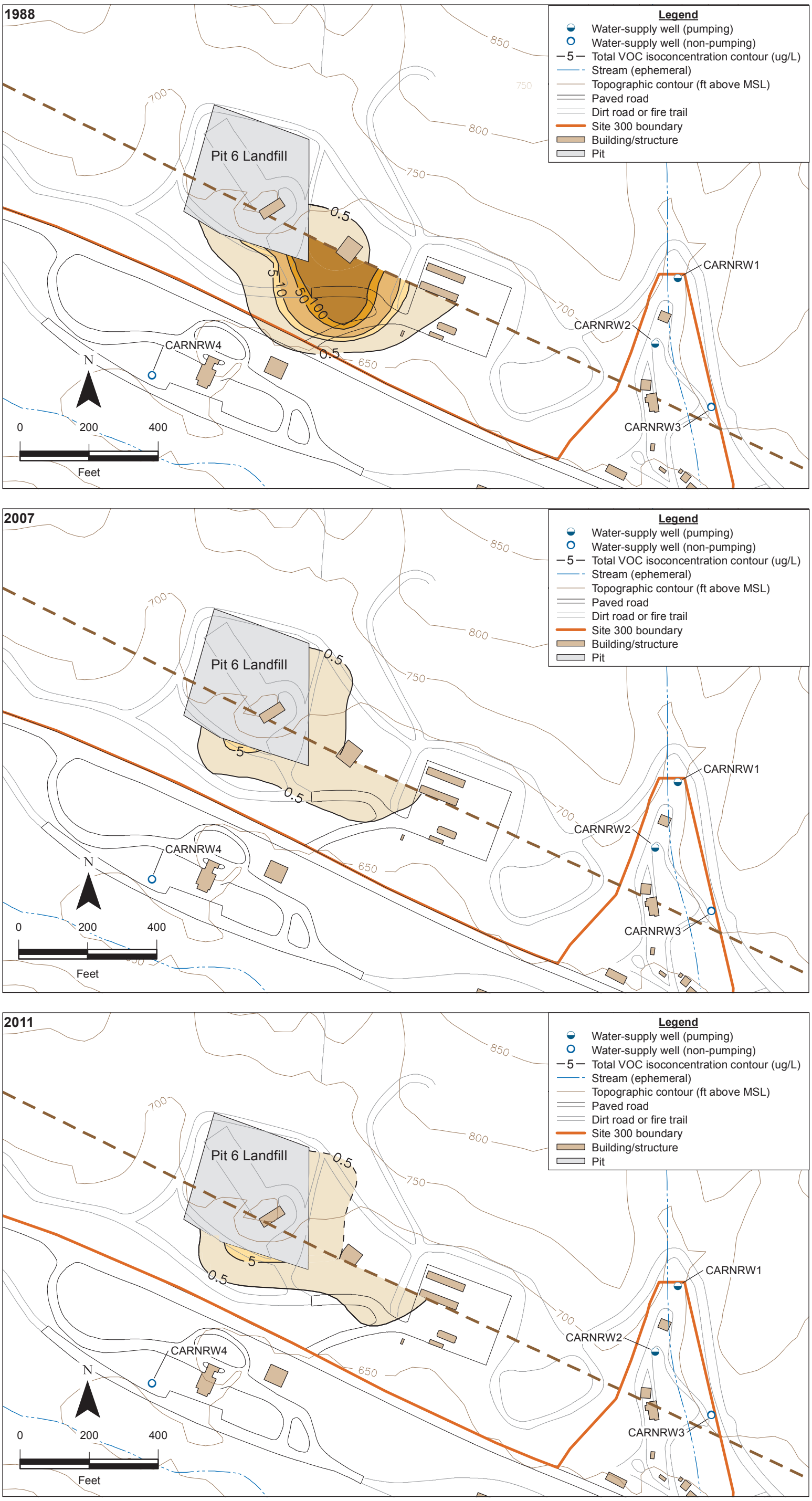

Figure 16. Comparison of the distribution of total volatile organic compounds in the Qt-Tnbs$_1$ hydrostratigraphic unit in 1988, 2007, and 2011.

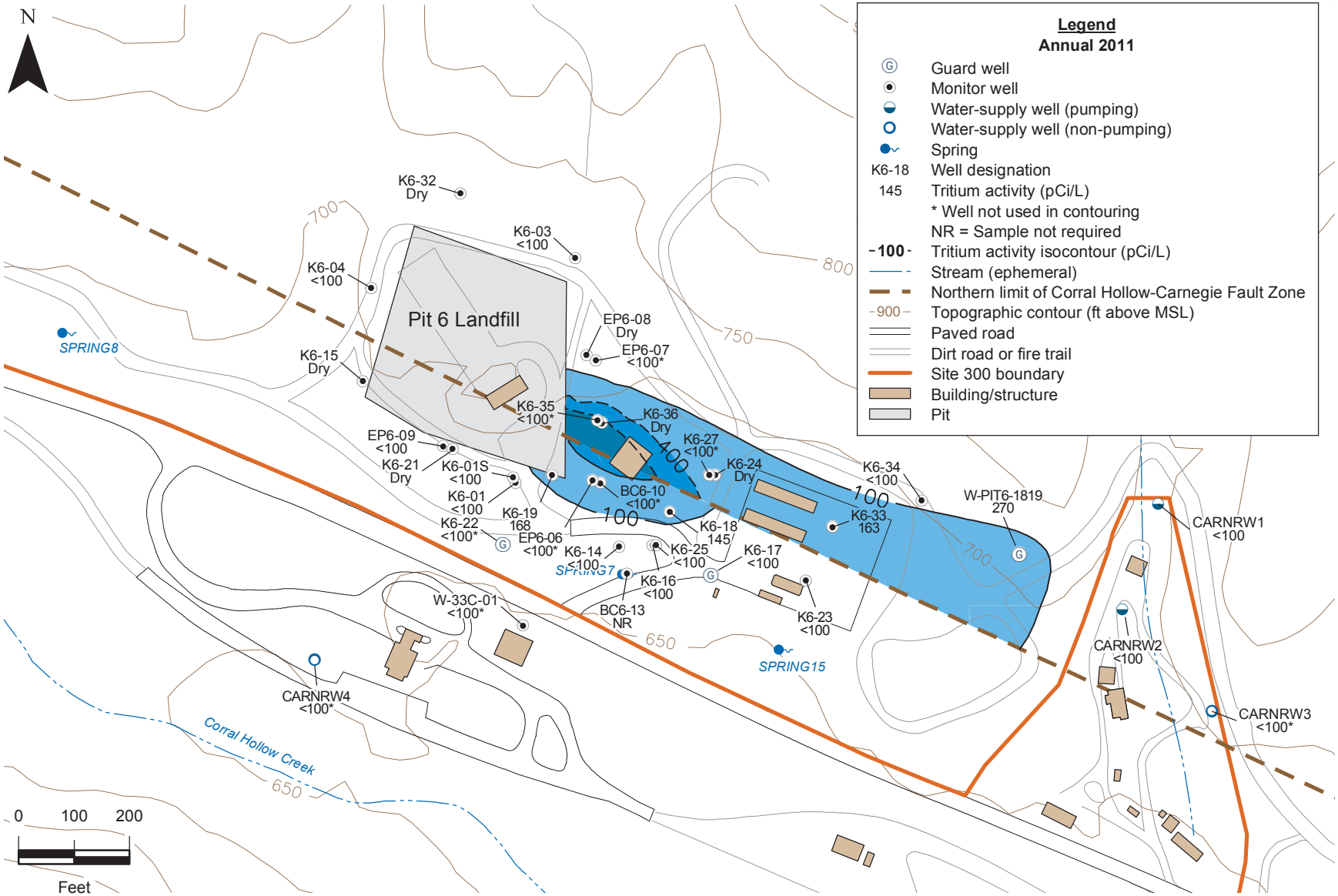

Figure 17. Map showing tritium activity contours for the Qt-Tnbs$_1$ hydrostratigraphic unit.

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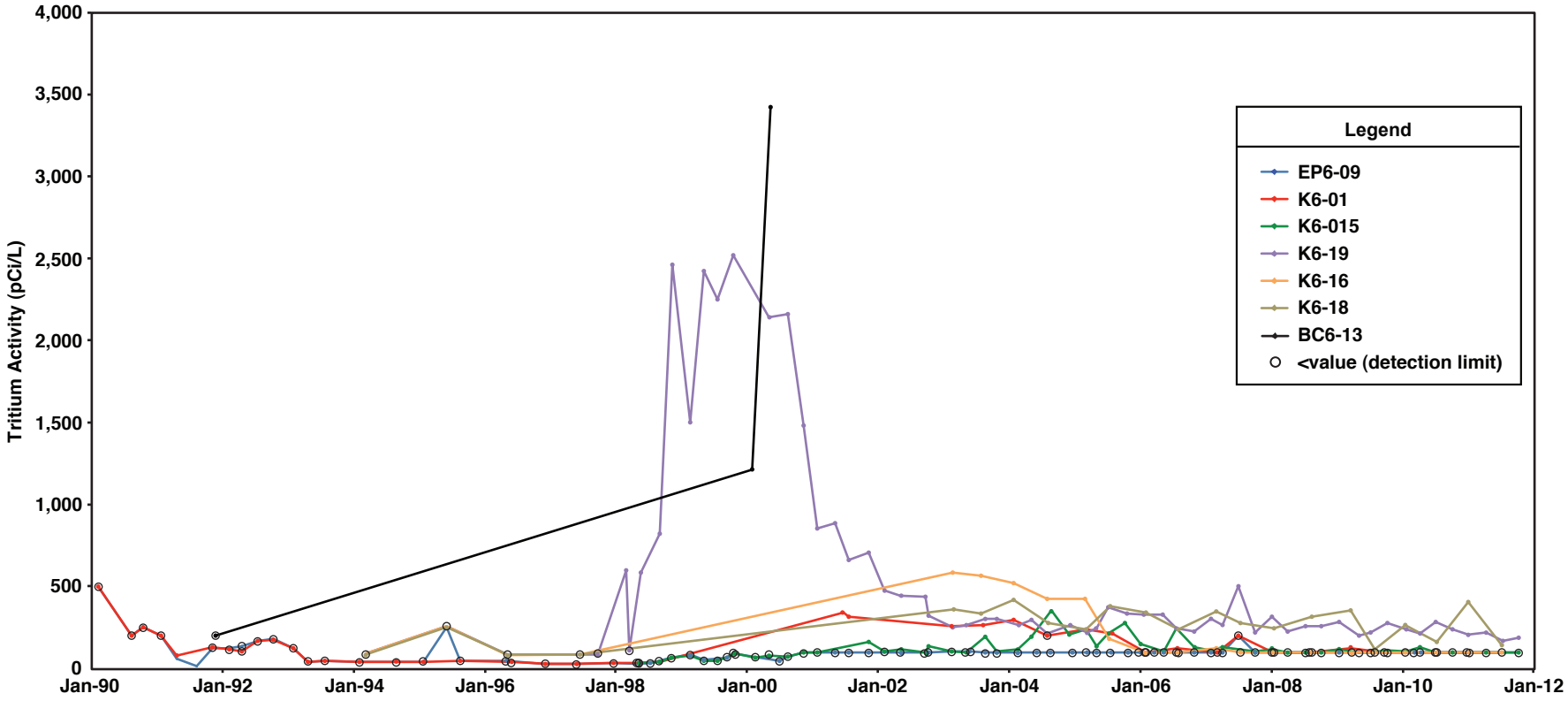
Figure 18. Time-series plots of tritium in ground water for Qt-Tnbs$_1$ hydrostratigraphic unit wells north of the fault zone (Qt-Tnbs$_1$ North HSU).



ERD-S3R-13-0020

Figure 19. Tritium activities in Qt-Tnbs$_1$ hydrostratigraphic unit wells within the fault zone.

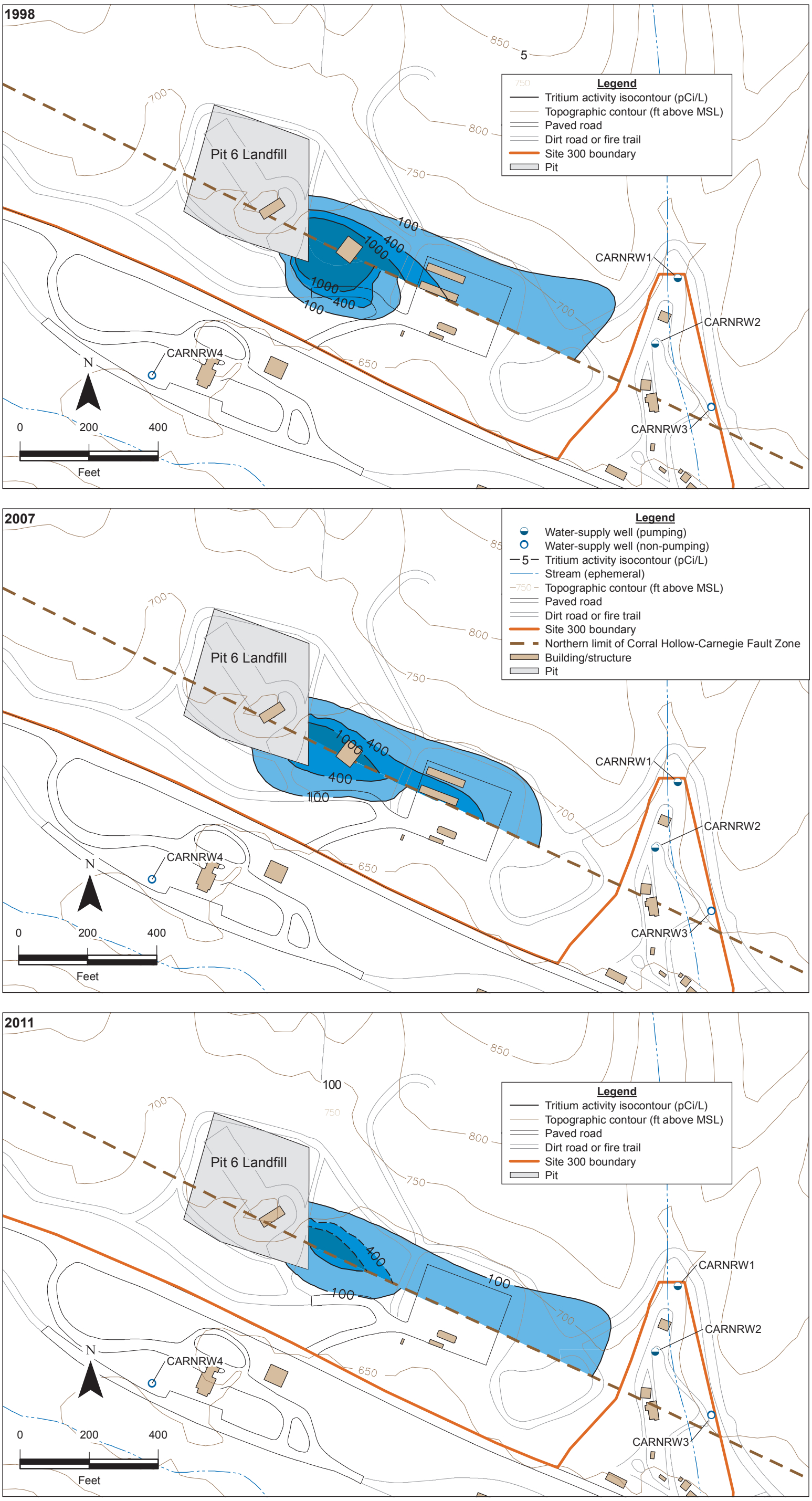


Figure 20. Comparison of the distribution of tritium in the Qt-Tnbs$_1$ hydrostratigraphic unit in 1998, 2007, and 2011.

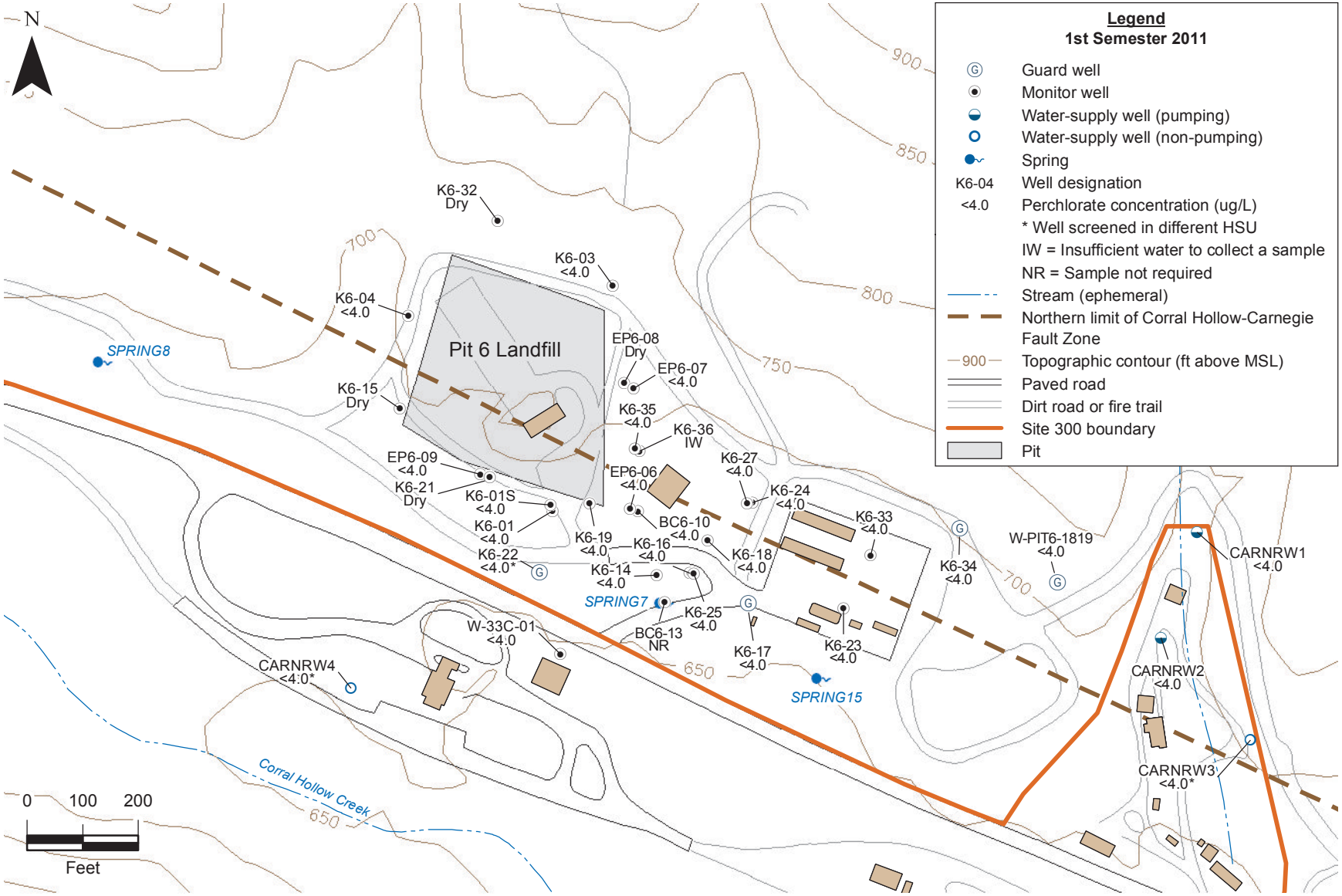


Figure 21. Map showing perchlorate concentrations for the Qt-Tnbs$_1$ hydrostratigraphic unit.

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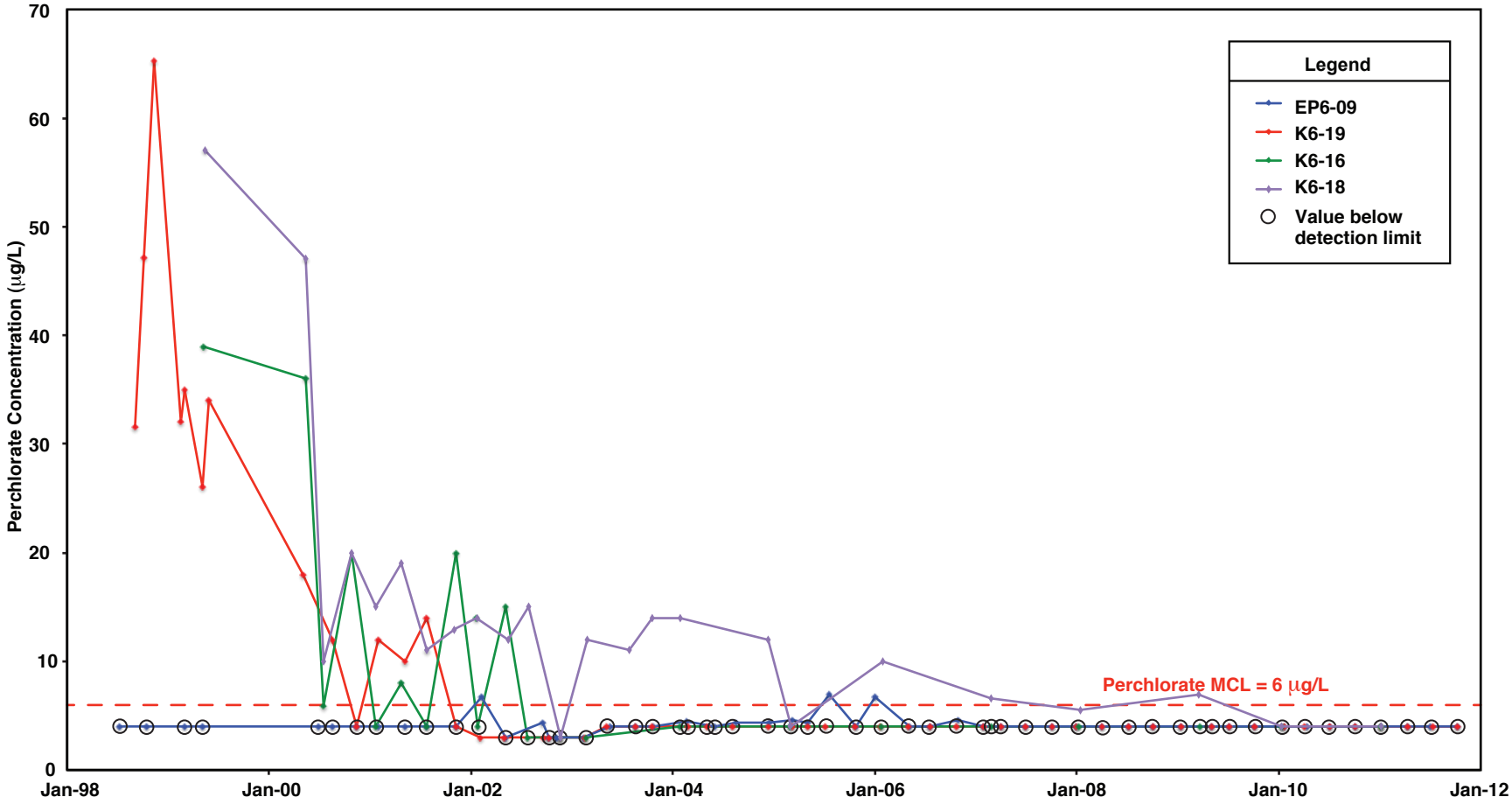

Figure 23. Time-series plots of perchlorate in ground water for Qt-Tnbs$_1$ hyrdrostratigraphic unit wells within the fault zone (Qt-Tnbs$_1$, South HSU).

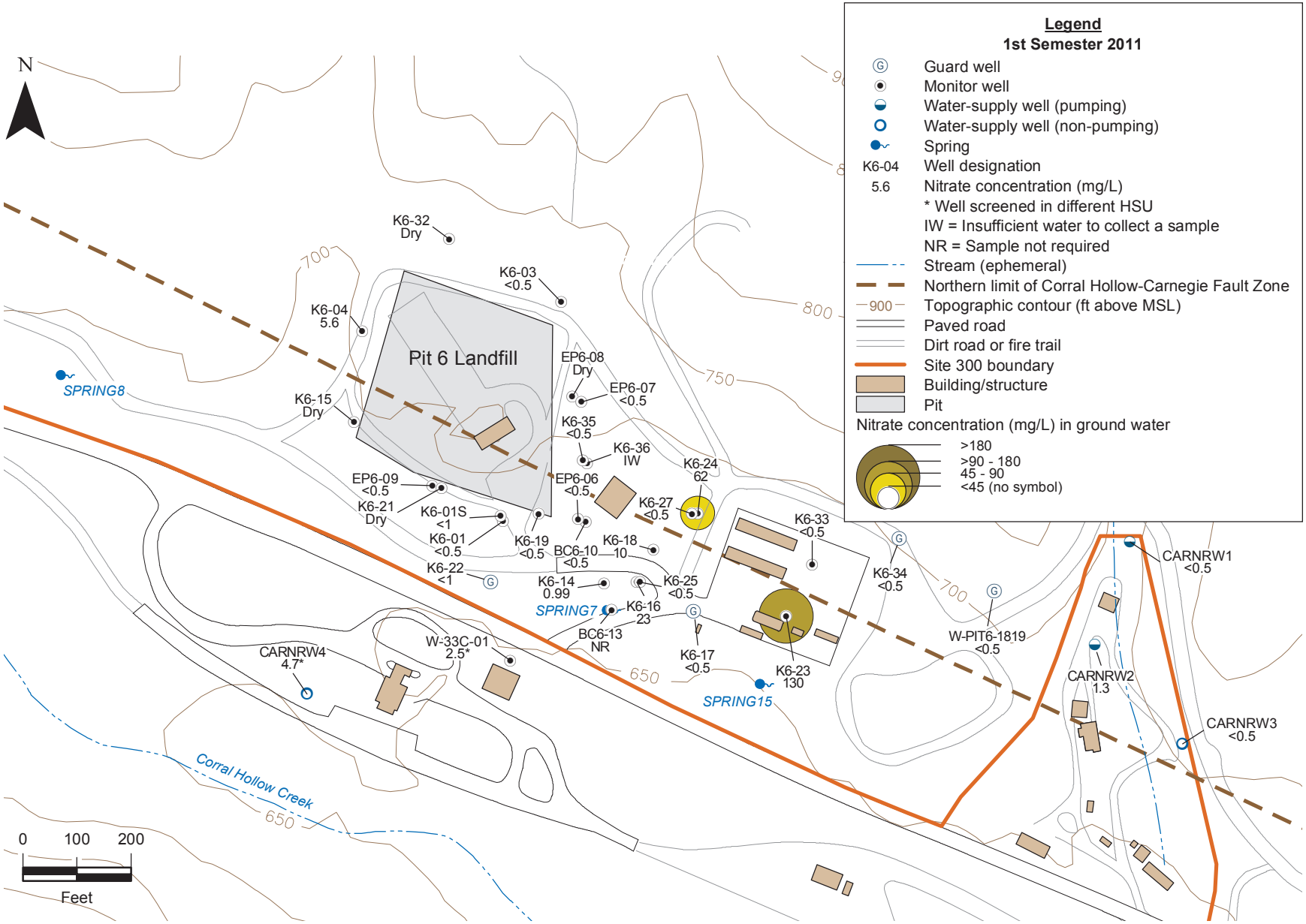

Figure 24. Map showing nitrate concentrations for the Qt-Tnbs$_1$ hydrostratigraphic unit.

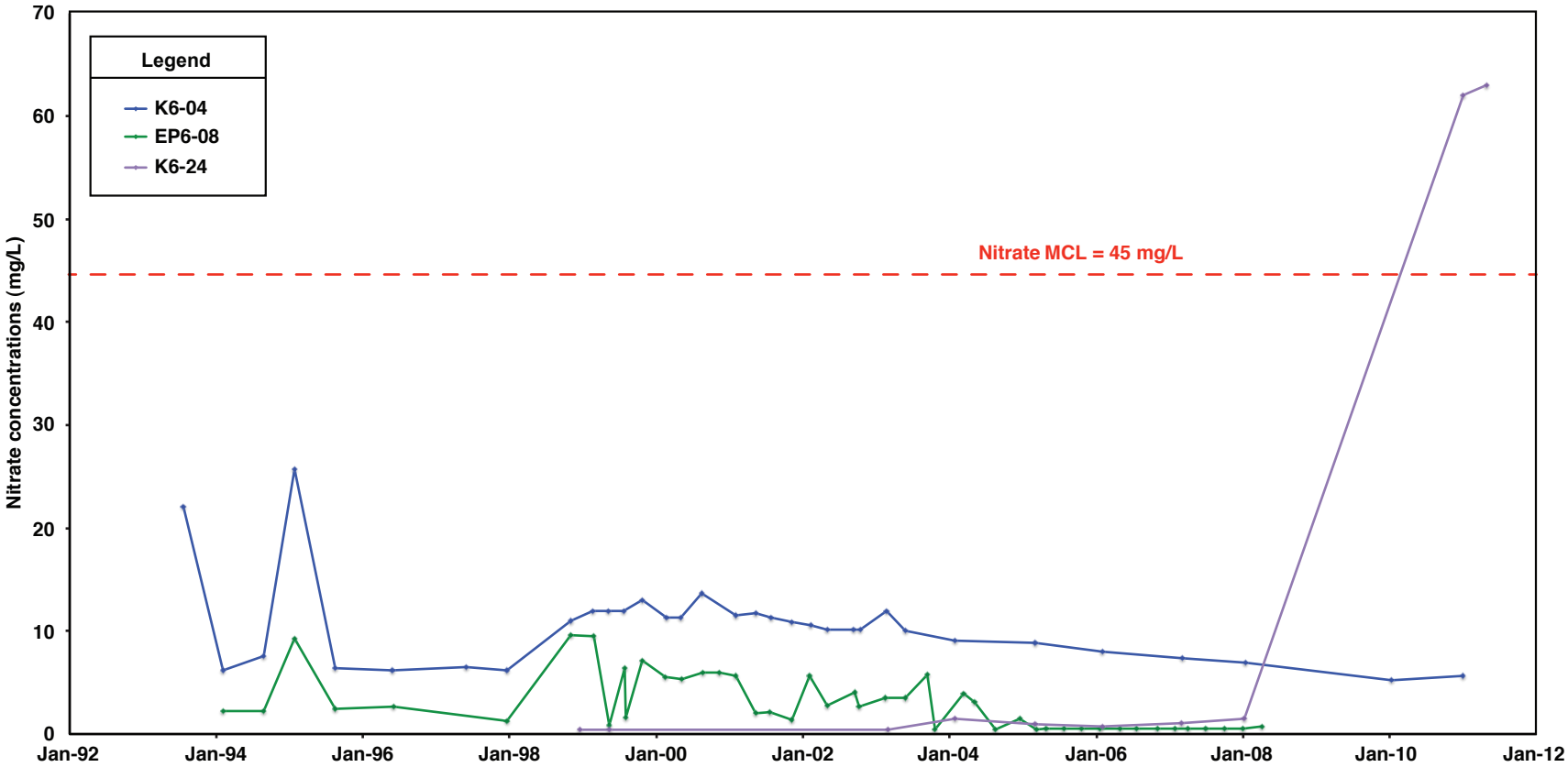

Figure 25. Time-series plots of nitrate in ground water for Qt-Tnbs$_1$ hydrostratigraphic unit wells north of the fault zone (Qt-Tnbs$_1$ North HSU).

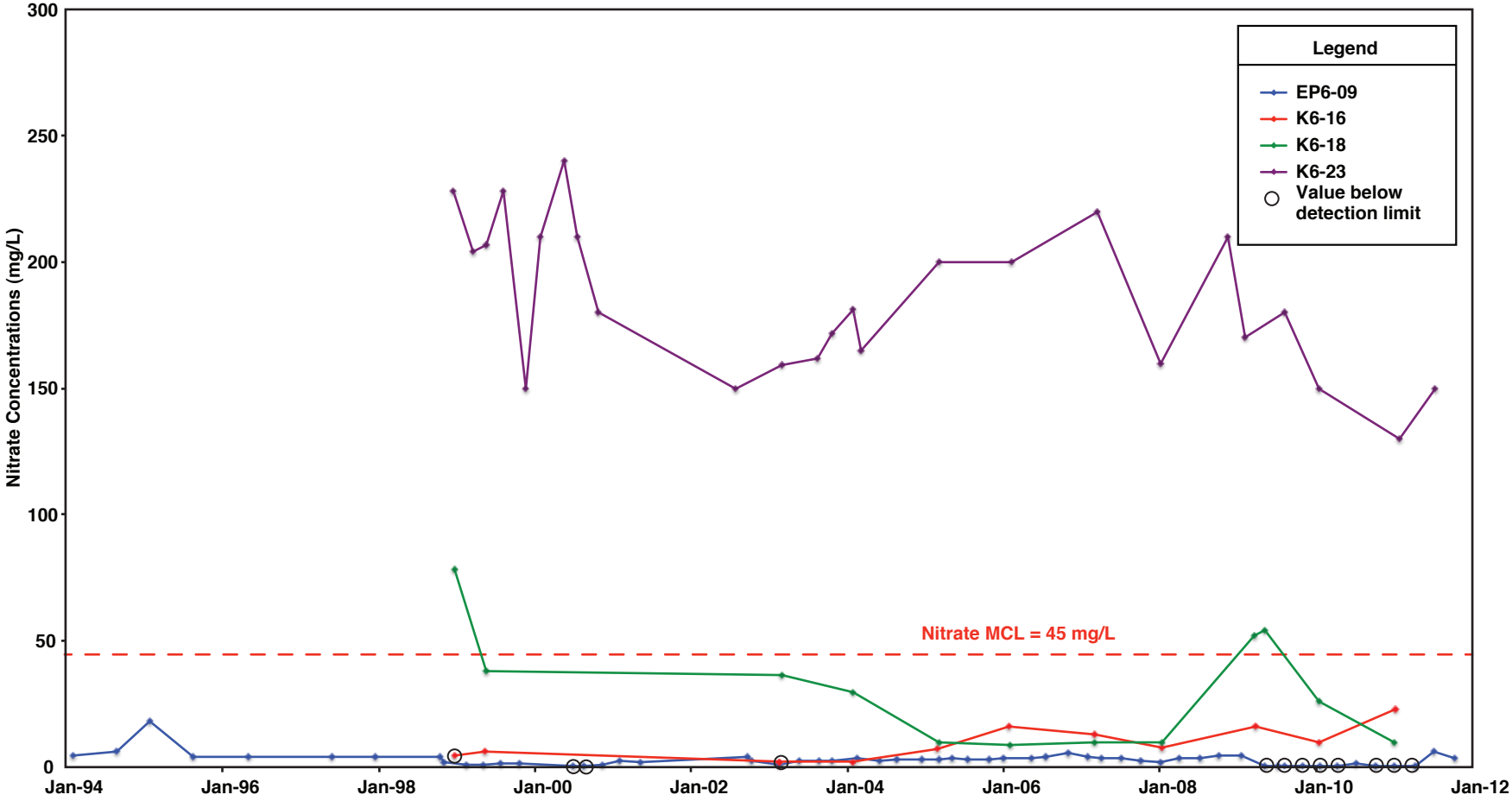

Figure 26. Time-series plots of nitrate in ground water for Qt-Tnbs$_1$ hydrostratigraphic unit wells within the fault zone (Qt-Tnbs$_1$ South HSU).

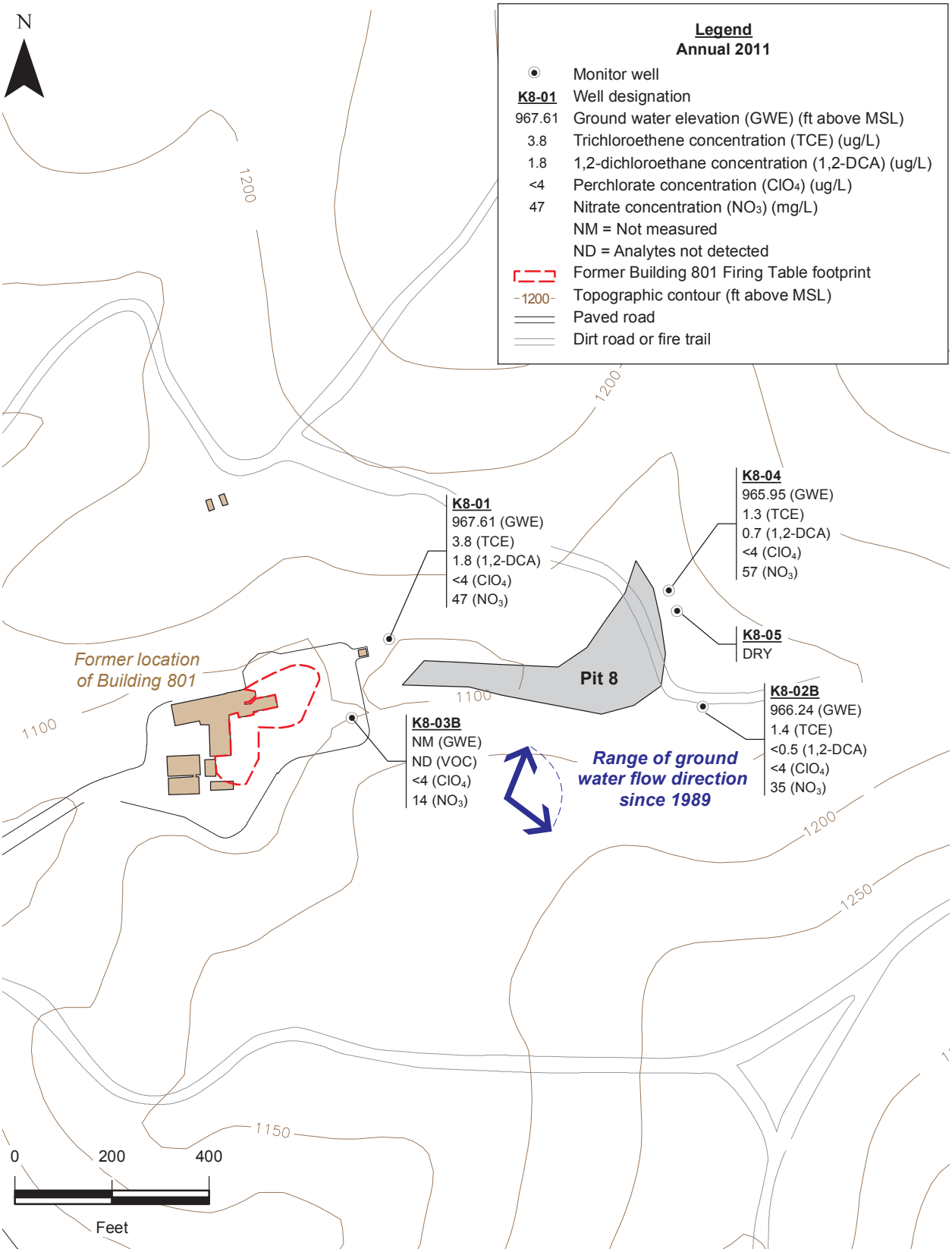

Figure 27. Site map of Building 801 and Pit 8 Landfill showing monitor well locations, ground water elevations and generalized flow direction, and volatile organic compounds, perchlorate, and nitrate concentrations in the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

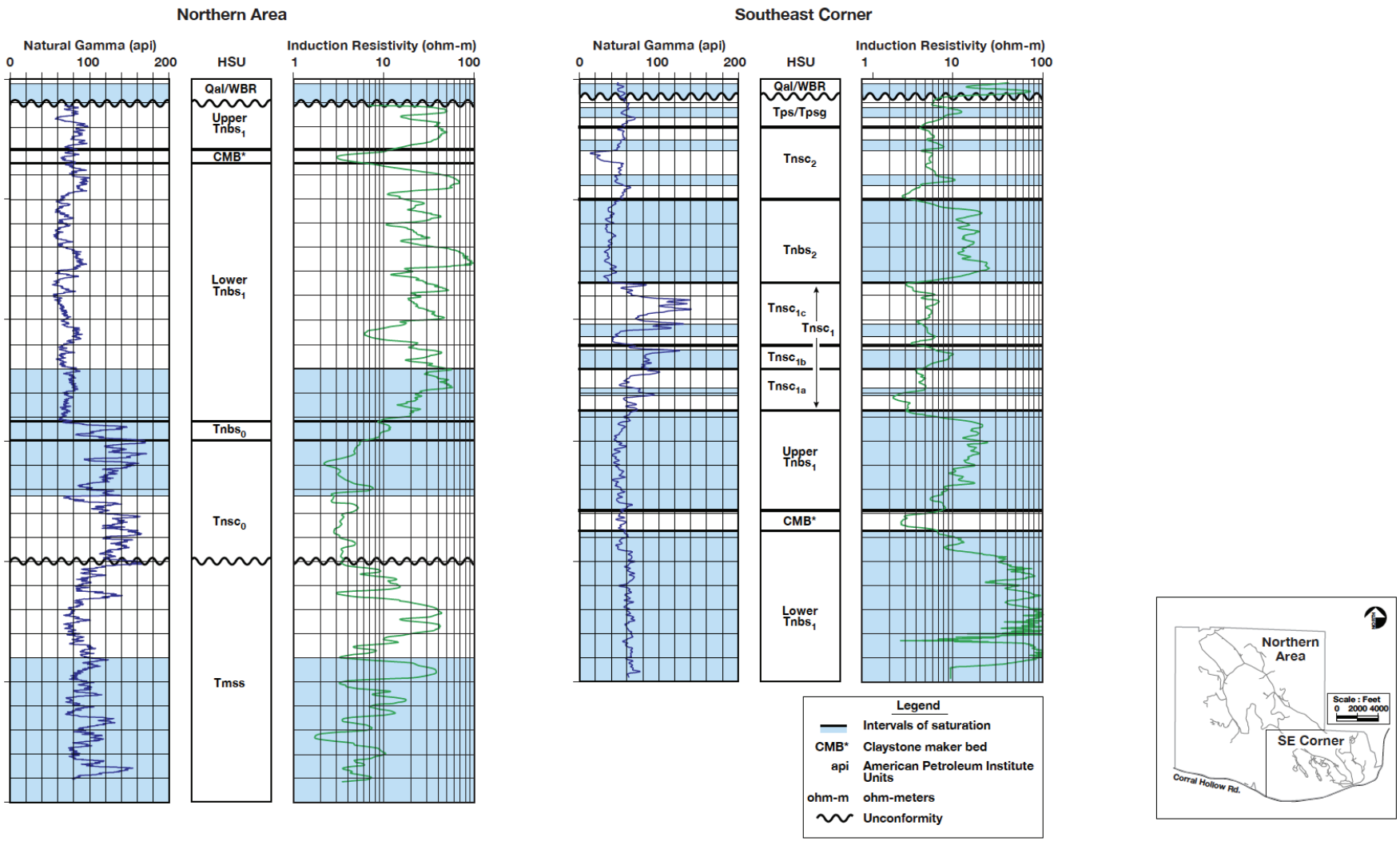

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Figure 28. Composite hydrostratigraphic columns for Site 300 showing saturated HSUs.

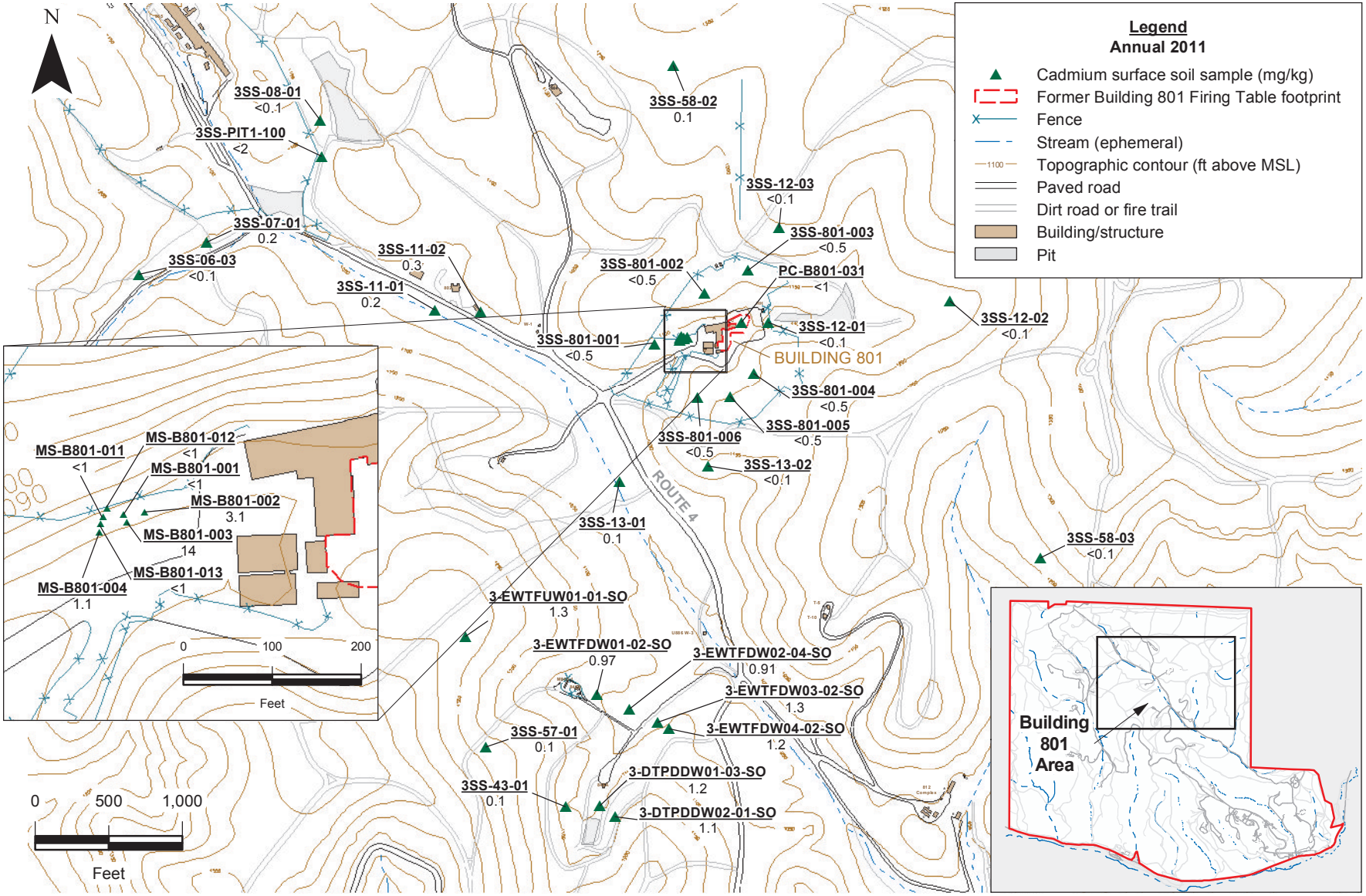

Figure 29. Surface soil cadmium concentrations in milligrams per kilogram (mg/kg) in the vicinity of Building 801 used to calculate a 95% upper confidence limit of the mean to evaluate potential ecological hazard.

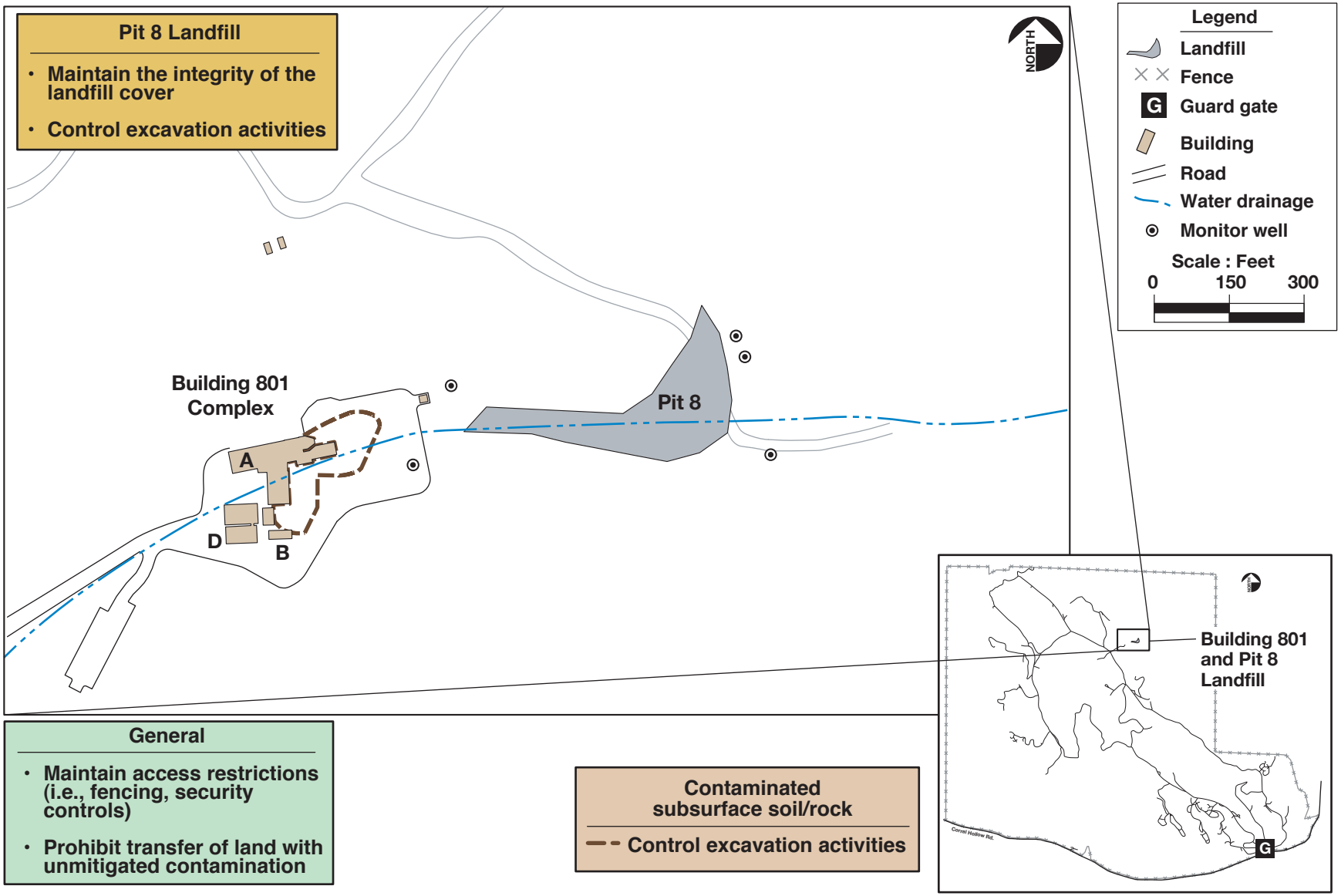

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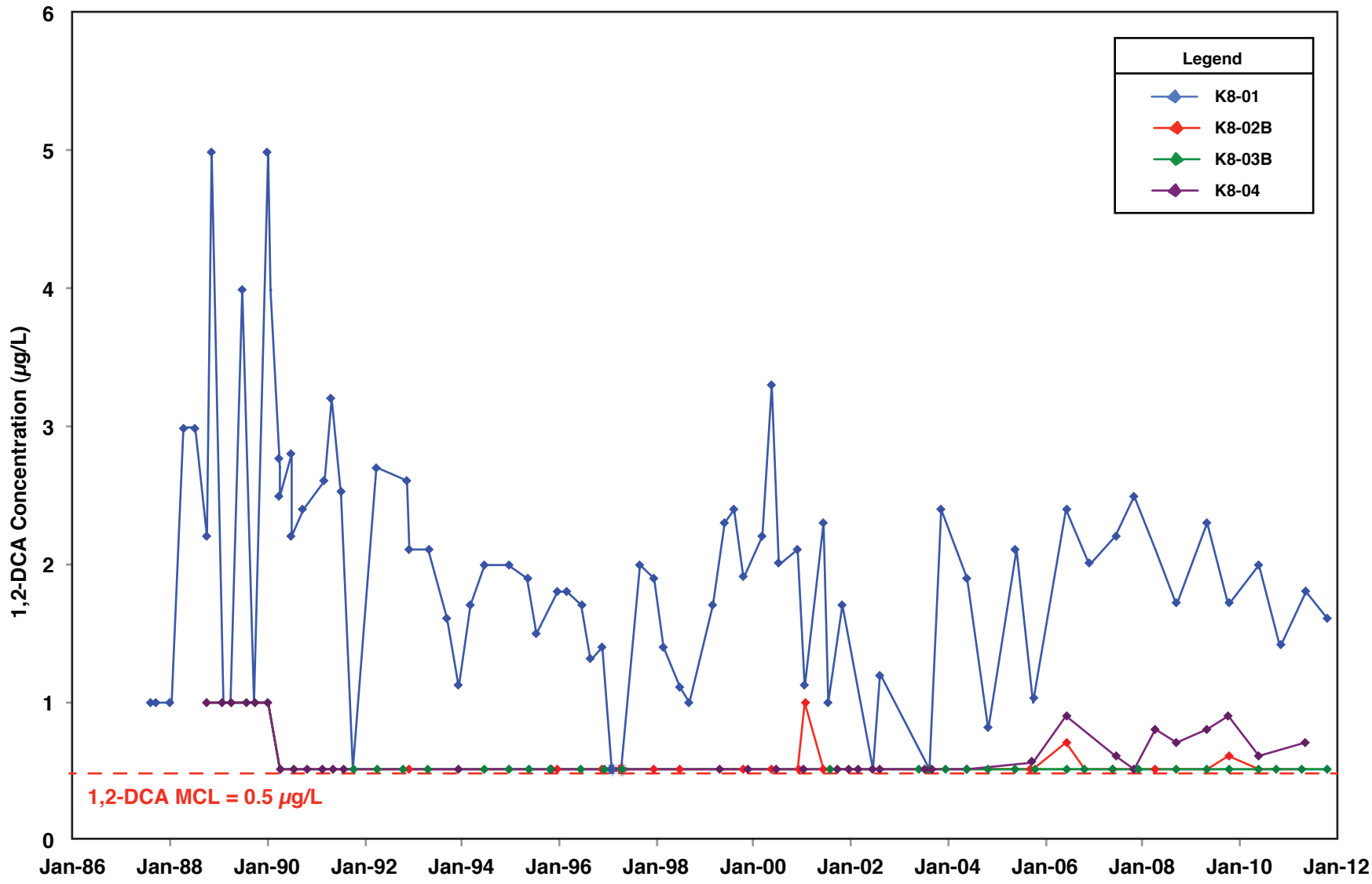
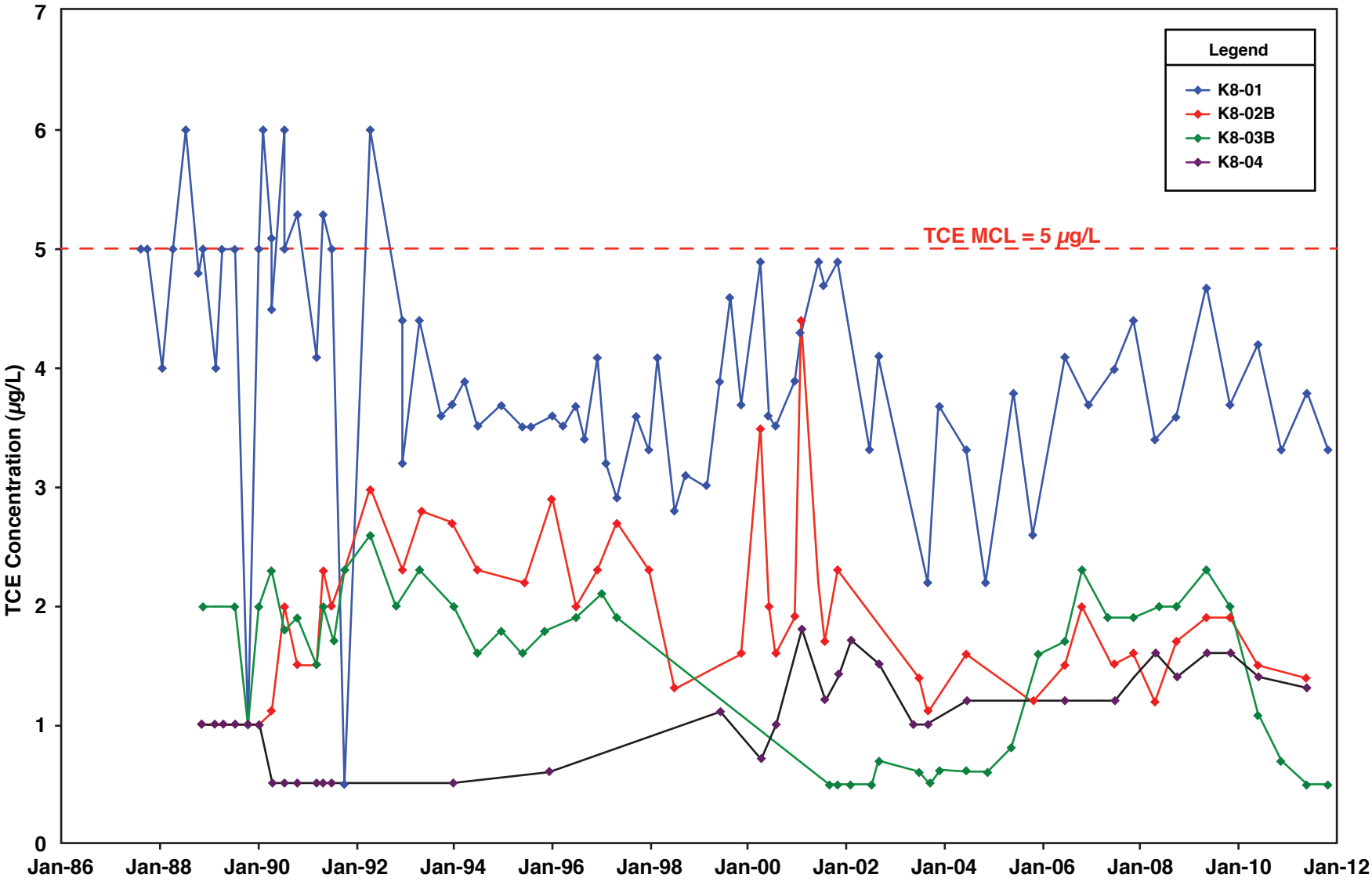
Figure 30. Building 801 and Pit 8 Landfill land use controls.



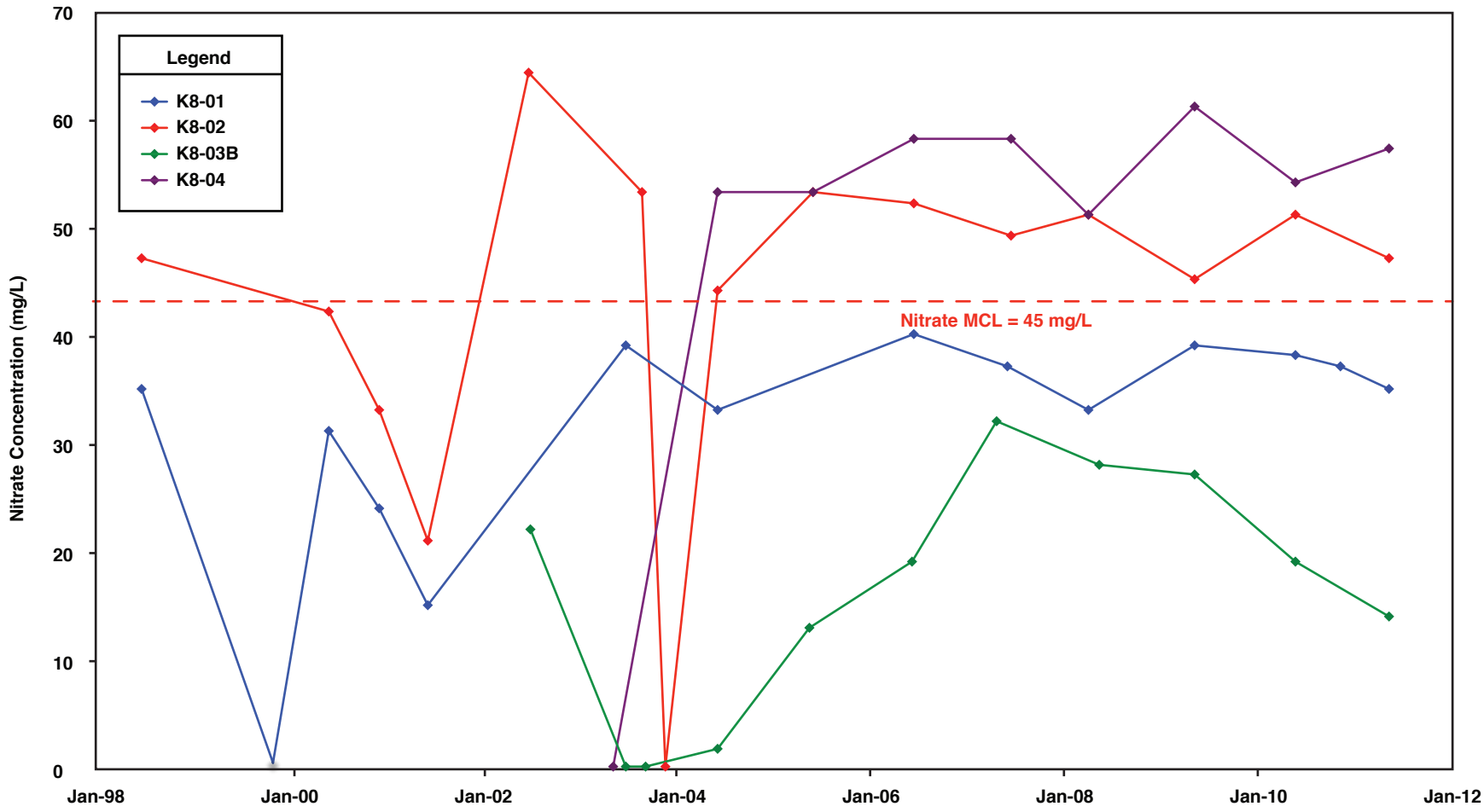
ERD-S3R-12-0053

Figure 31. Time-series plots of 1,2-dichloroethane (1,2-DCA) in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Building 801 and Pit 8 Landfill area.



ERD-S3R-12-0042

Figure 32. Time-series plots of trichloroethene (TCE) in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Building 801 and Pit 8 Landfill area.



ERD-S3R-12-0044

Figure 33. Time-series plots of nitrate in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Building 801 and Pit 8 Landfill area.

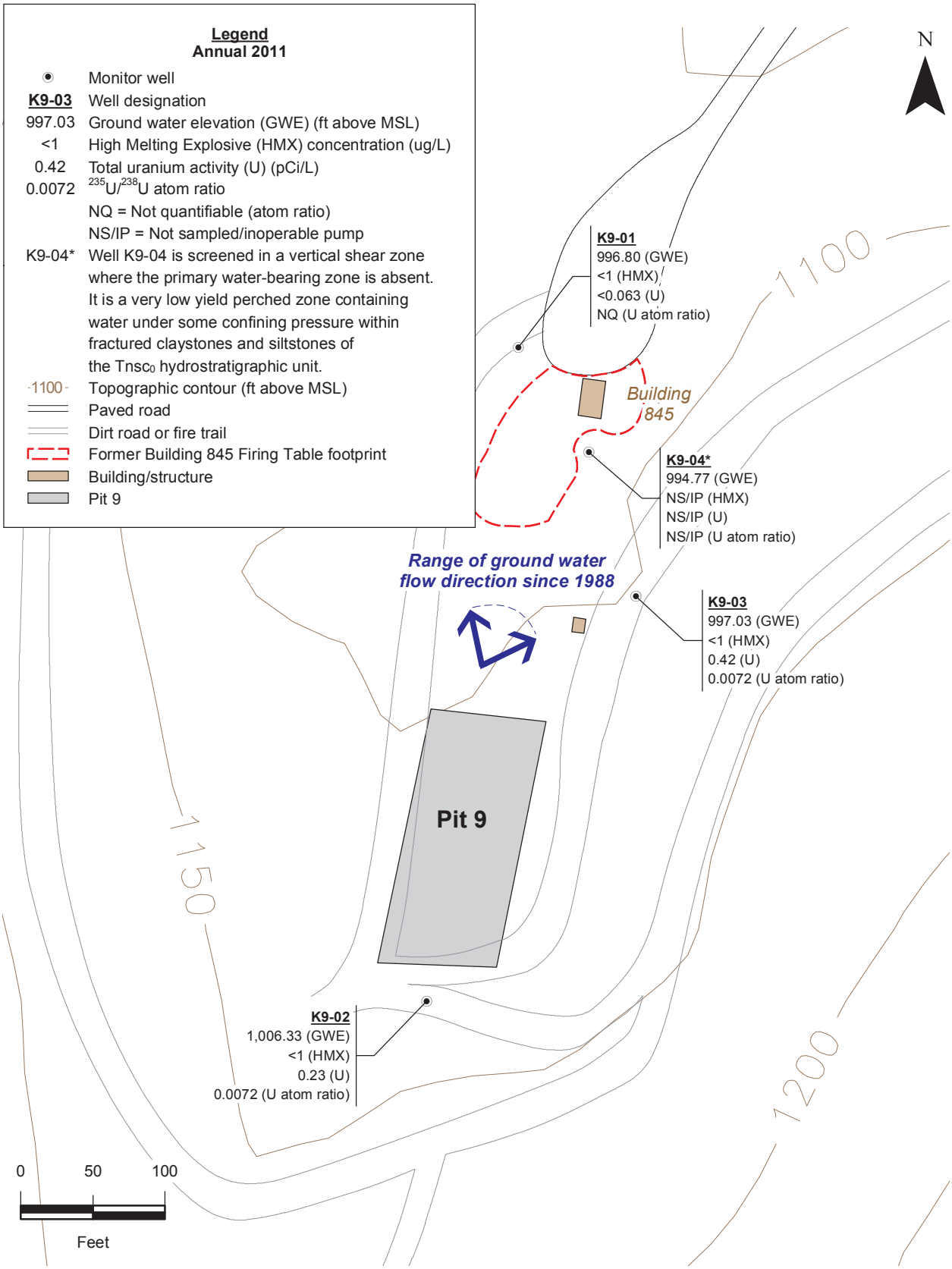
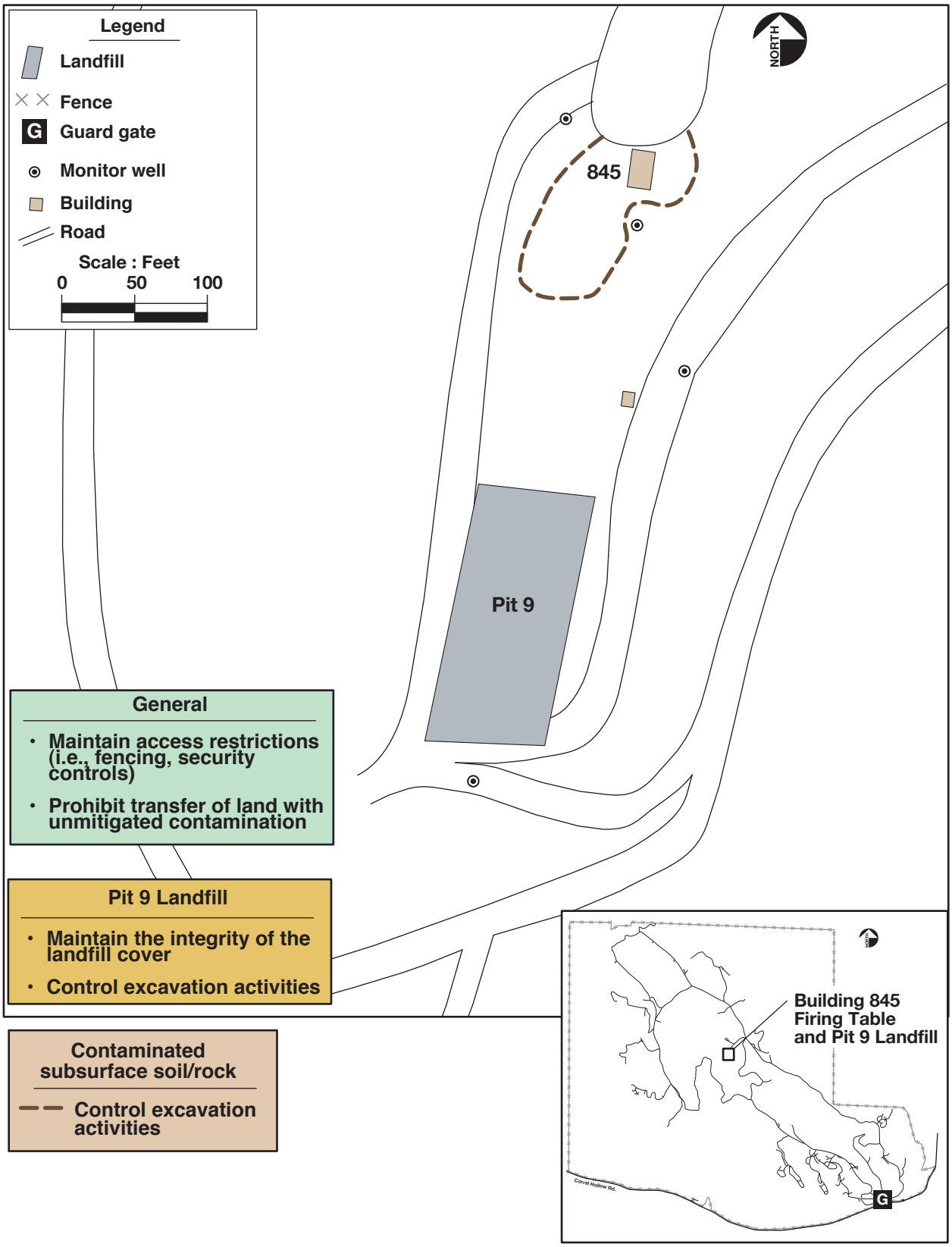


Figure 34. Site map of Building 845 Firing Table and Pit 9 Landfill area showing monitor well locations, ground water elevations and generalized flow direction, High Melting Explosive concentrations, uranium activities, and $^{235}U/^{238}U$ atom ratios in the $Tnsc_0$ hydrostratigraphic unit.



ERD-S3R-12-0054

Figure 35. Building 845 Firing table and Pit 9 Landfill area land use controls.

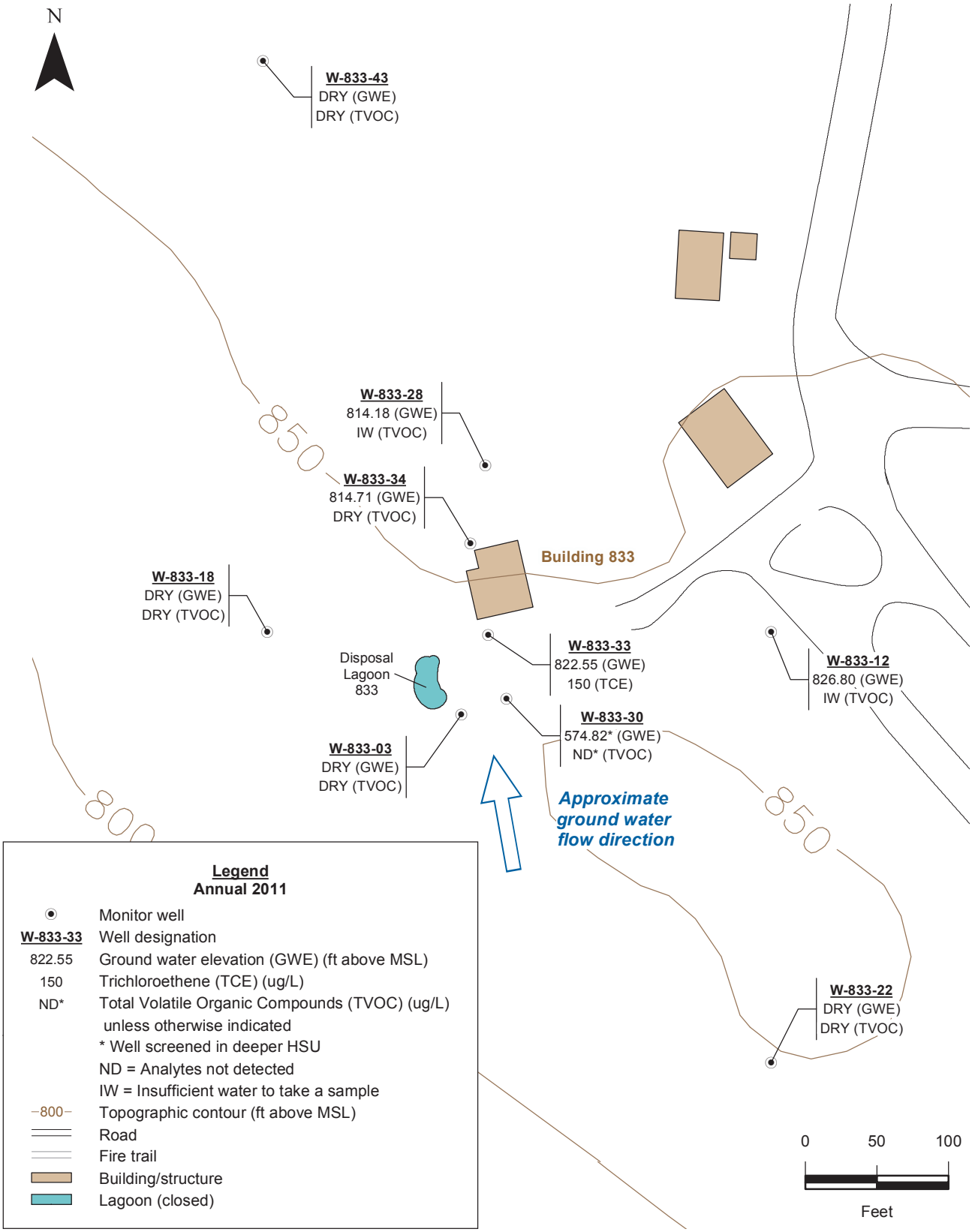
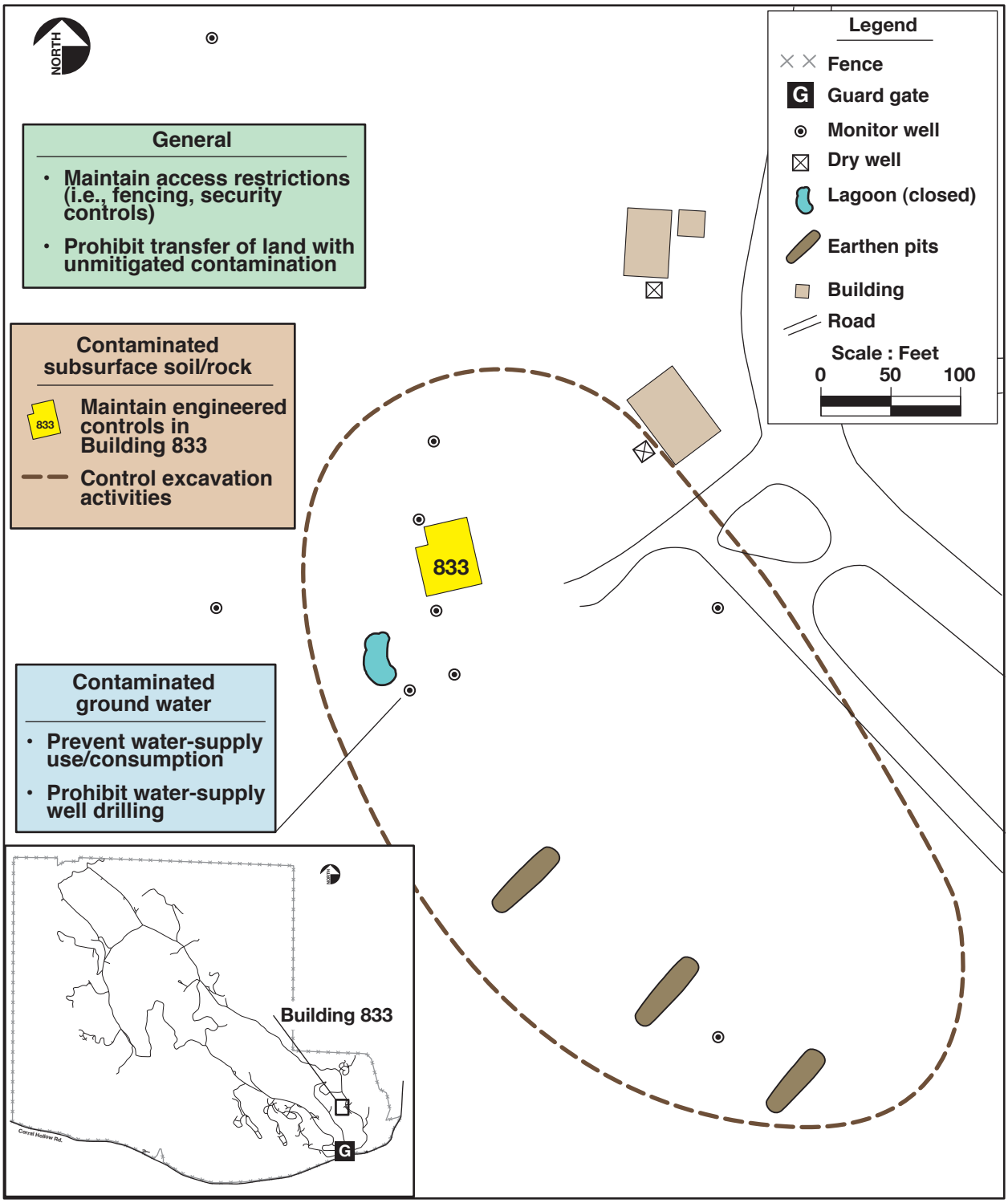


Figure 36. Site map of Building 833 showing monitor well locations, ground water elevations and generalized flow direction, and total volatile organic compound concentrations in the Tpsg hydrostratigraphic unit.



ERD-S3R-12-0036

Figure 37. Building 833 area land use controls.

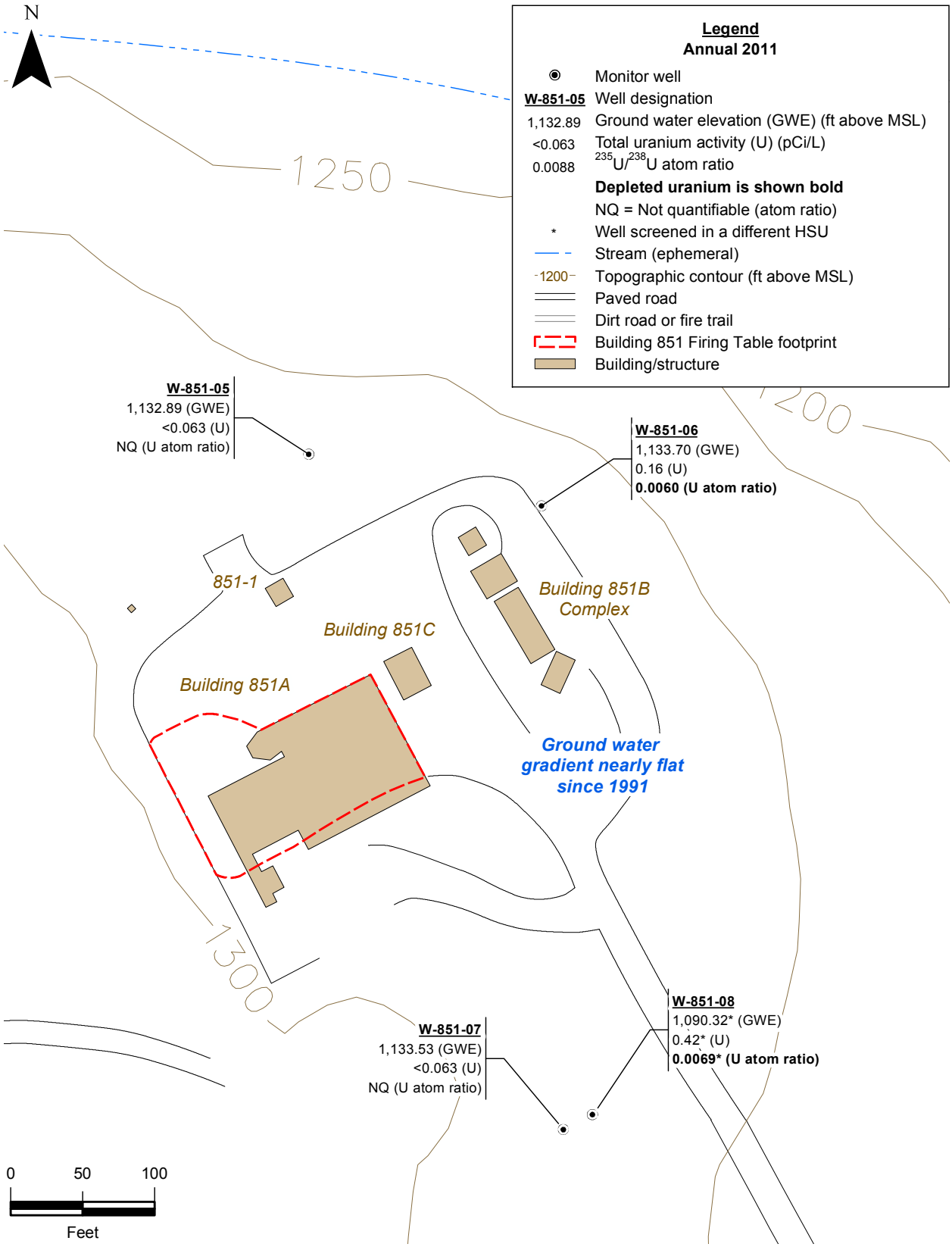
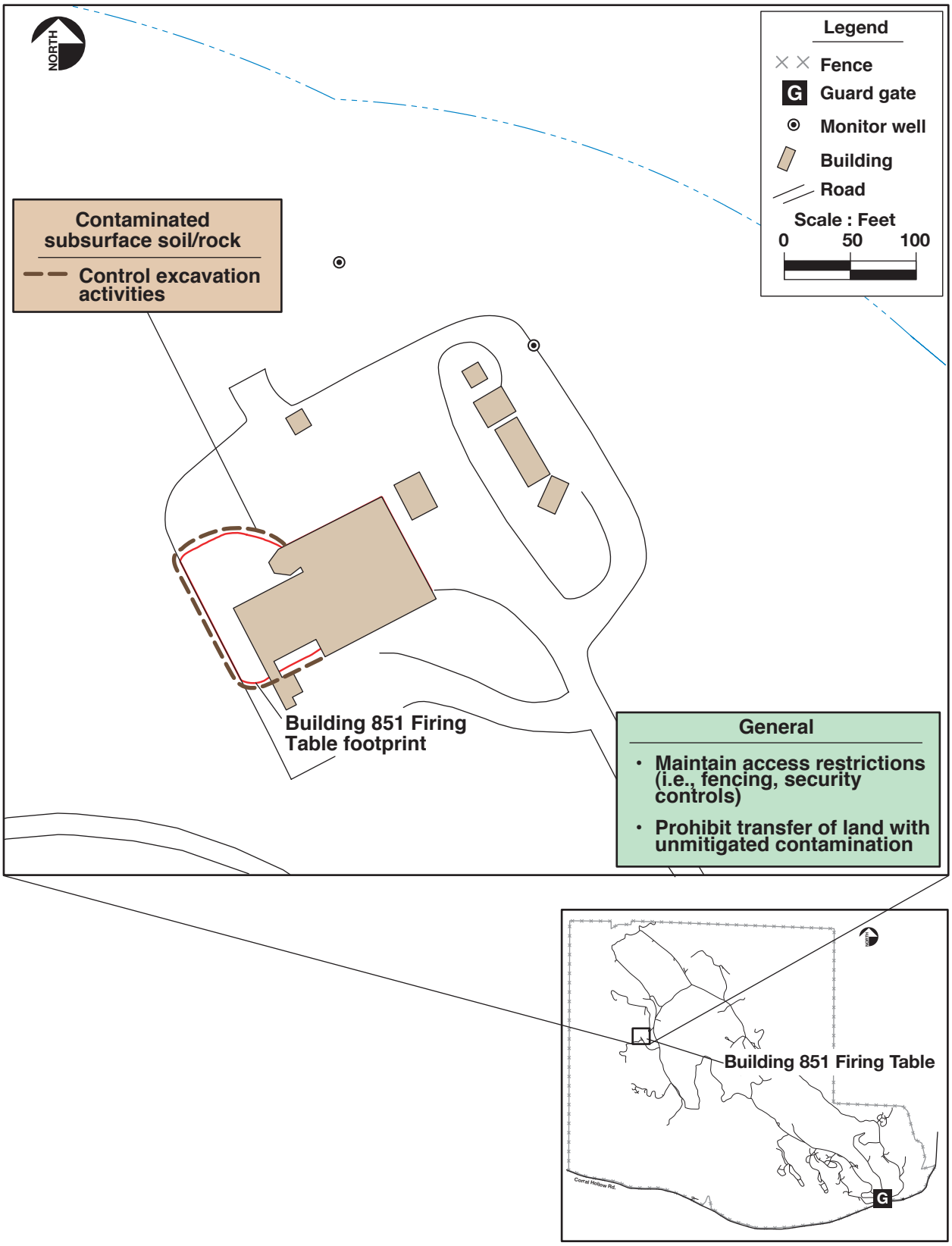


Figure 38. Site map of the Building 851 Firing Table area showing monitor well locations, ground water elevations and generalized flow direction, uranium activities, and $^{235}U/^{238}U$ atom ratios in the Tmss hydrostratigraphic unit.



ERD-S3R-12-0056

Figure 39. Building 851 Firing Table land use controls.

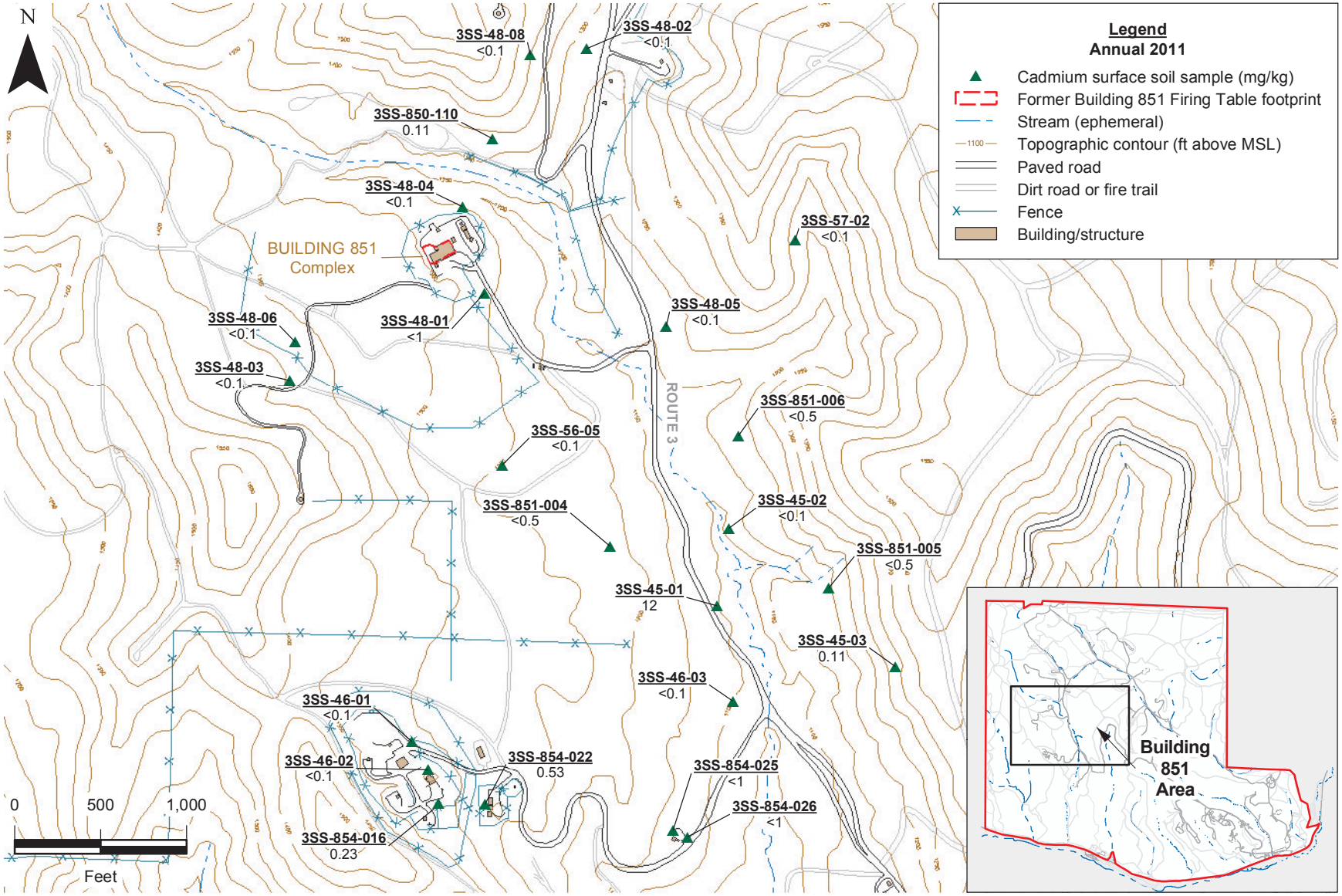


Figure 40. Surface soil cadmium concentrations in milligrams per kilogram (mg/kg) in the vicinity of Building 851 Firing Table used to calculate a 95% upper confidence limit of the mean to evaluate potential ecological hazard.

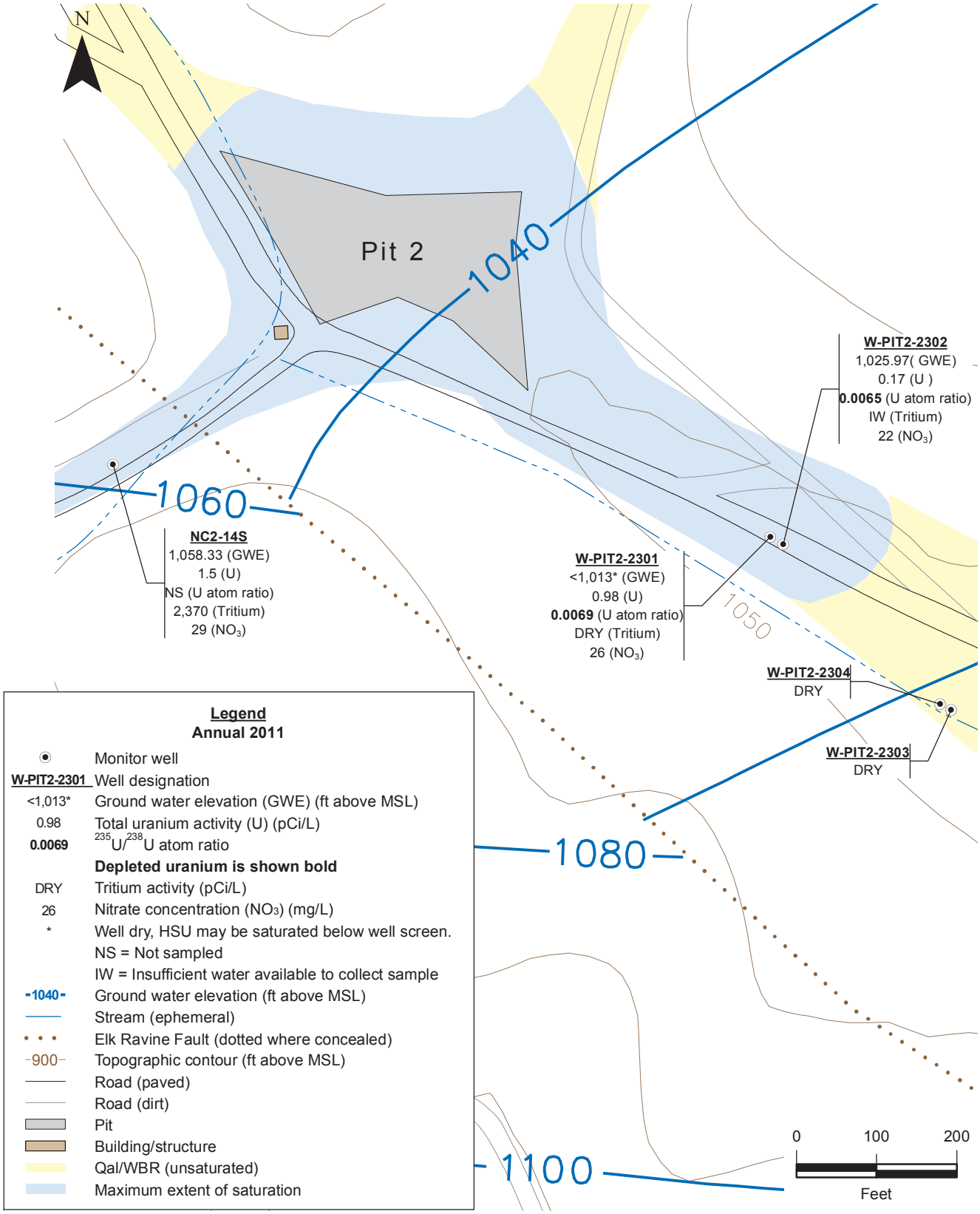


Figure 41. Pit 2 Landfill area site map showing monitor well locations, ground water potentiometric surface contours, and nitrate concentrations, uranium activities, $^{235}U/^{238}U$ atom ratios, and tritium activities in the Qal/WBR hydrostratigraphic unit.

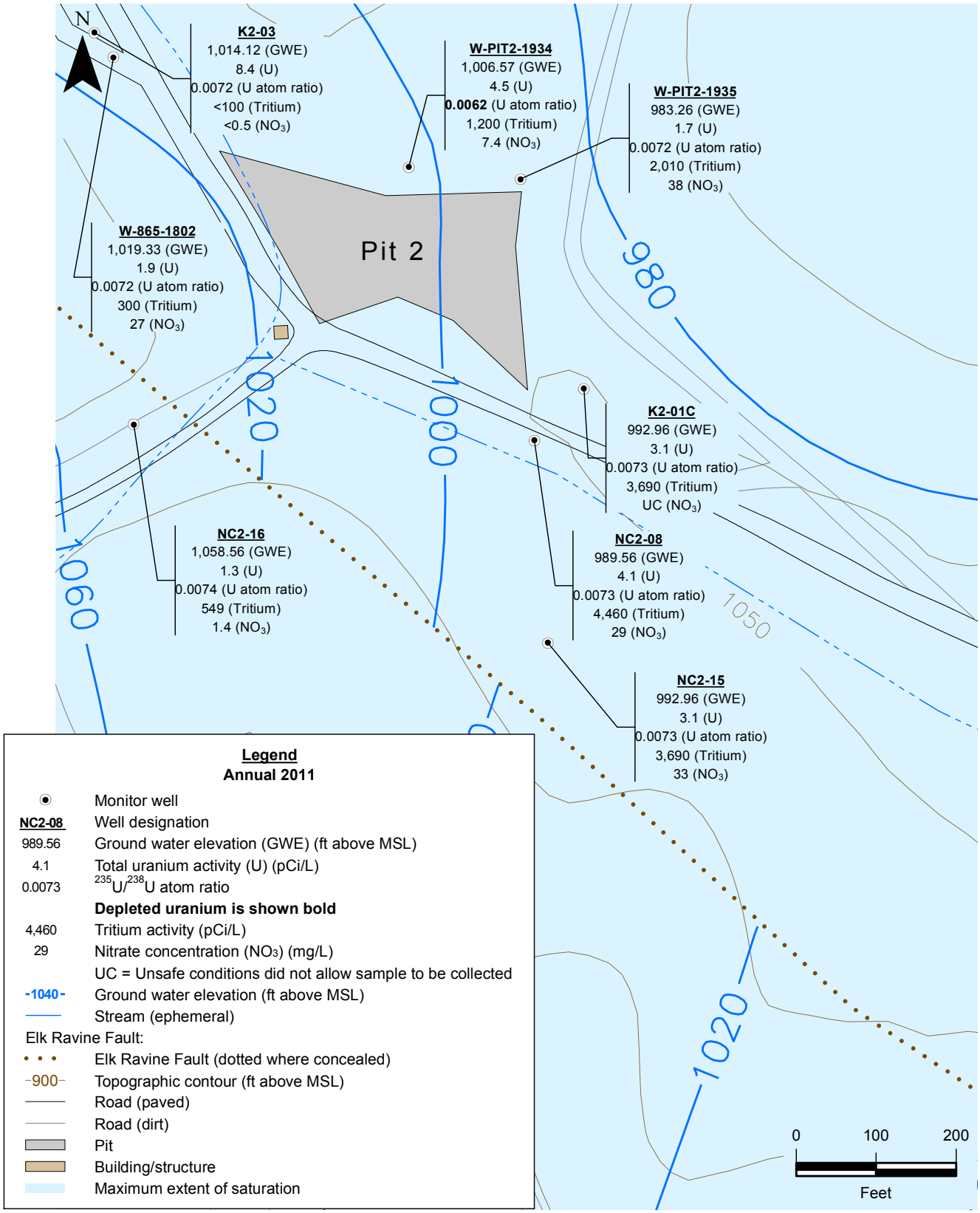


Figure 42. Pit 2 Landfill site map showing monitor well locations, ground water potentiometric surface contours, and nitrate concentrations, uranium activities, $^{235}U/^{238}U$ atom ratios, and tritium activities in the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

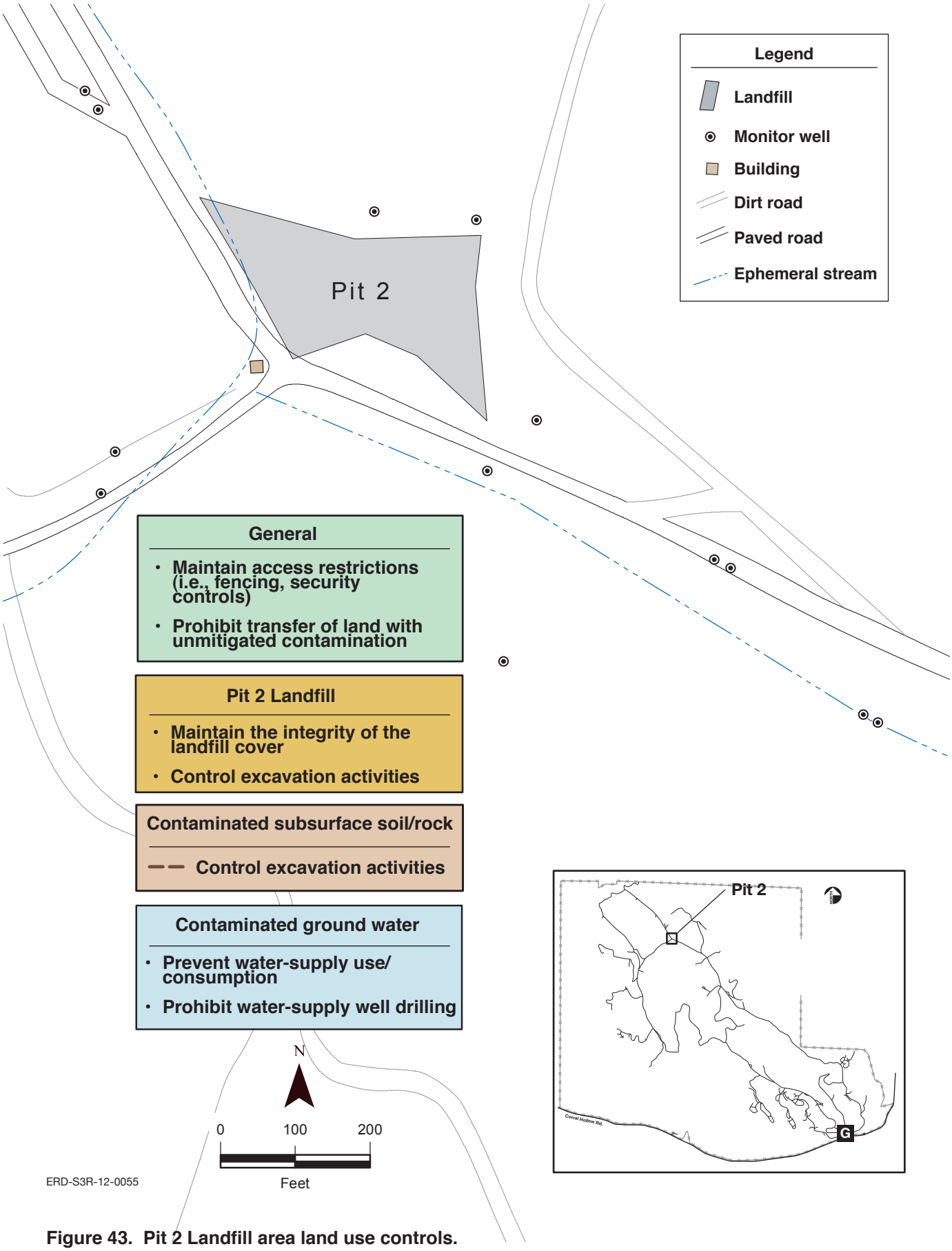
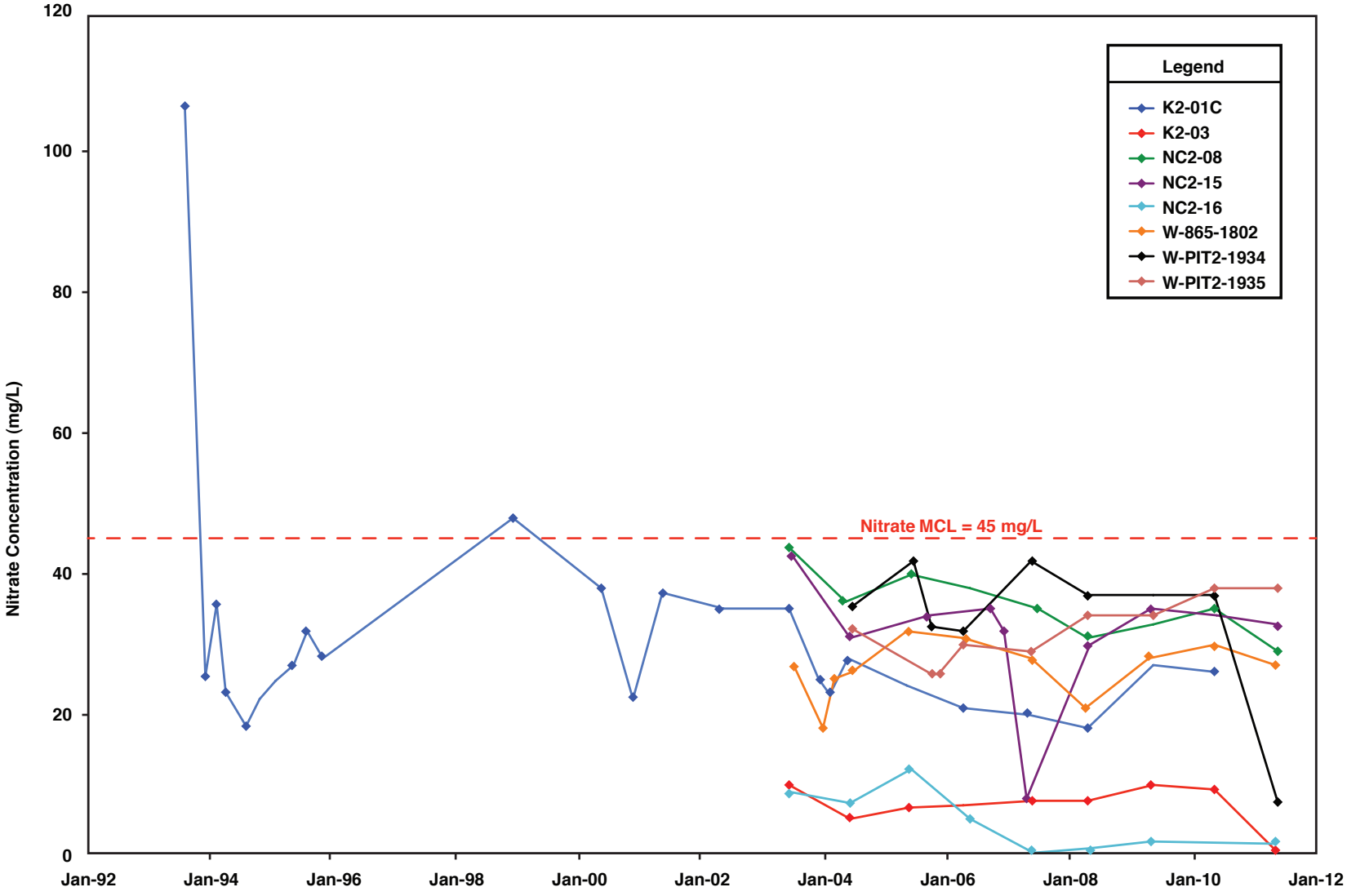


Figure 43. Pit 2 Landfill area land use controls.



ERD-S3R-12-0064

Figure 44. Time-series plots of nitrate in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Pit 2 Landfill area.

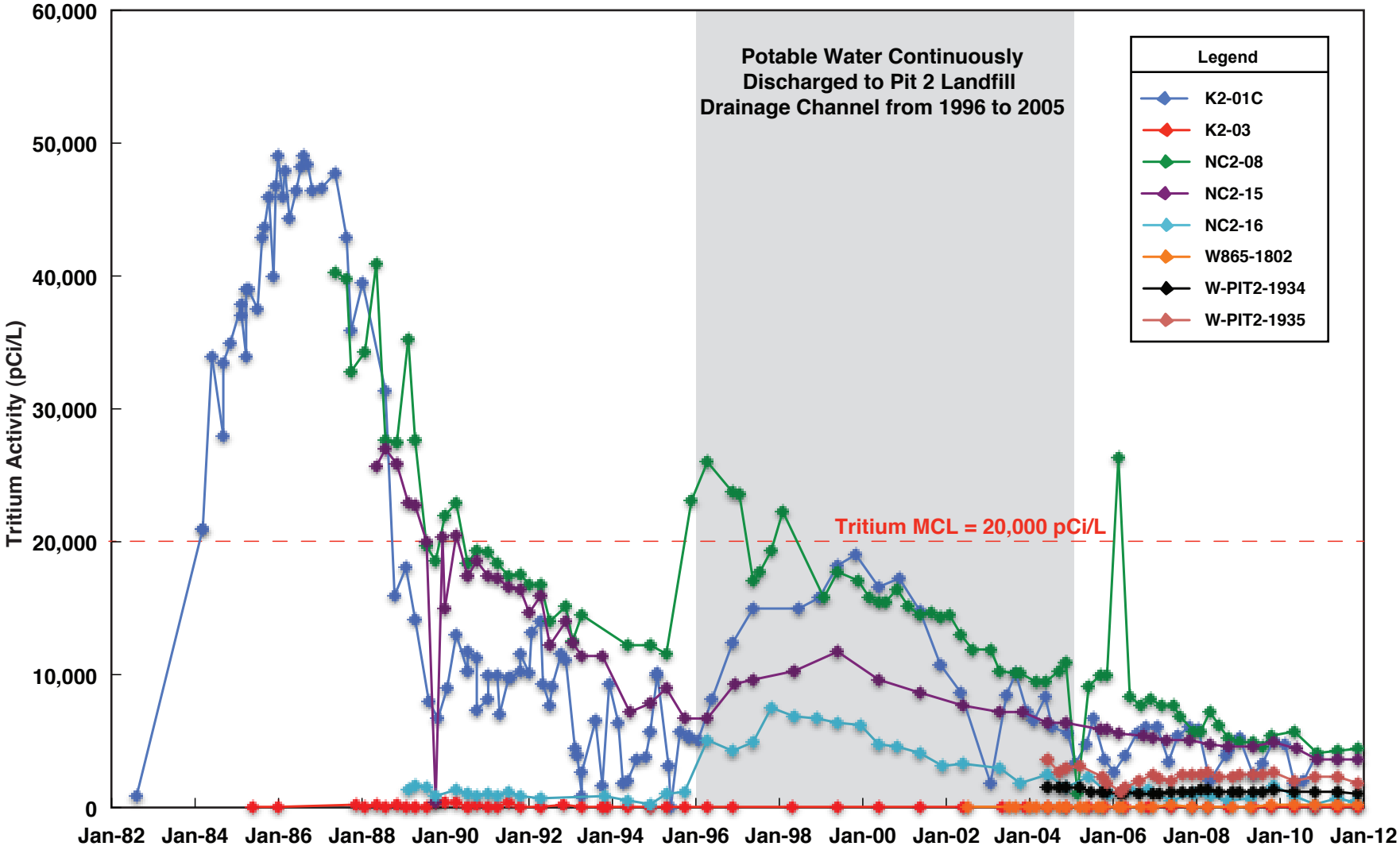


Figure 45. Time-series plots of tritium activities in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Pit 2 Landfill area.

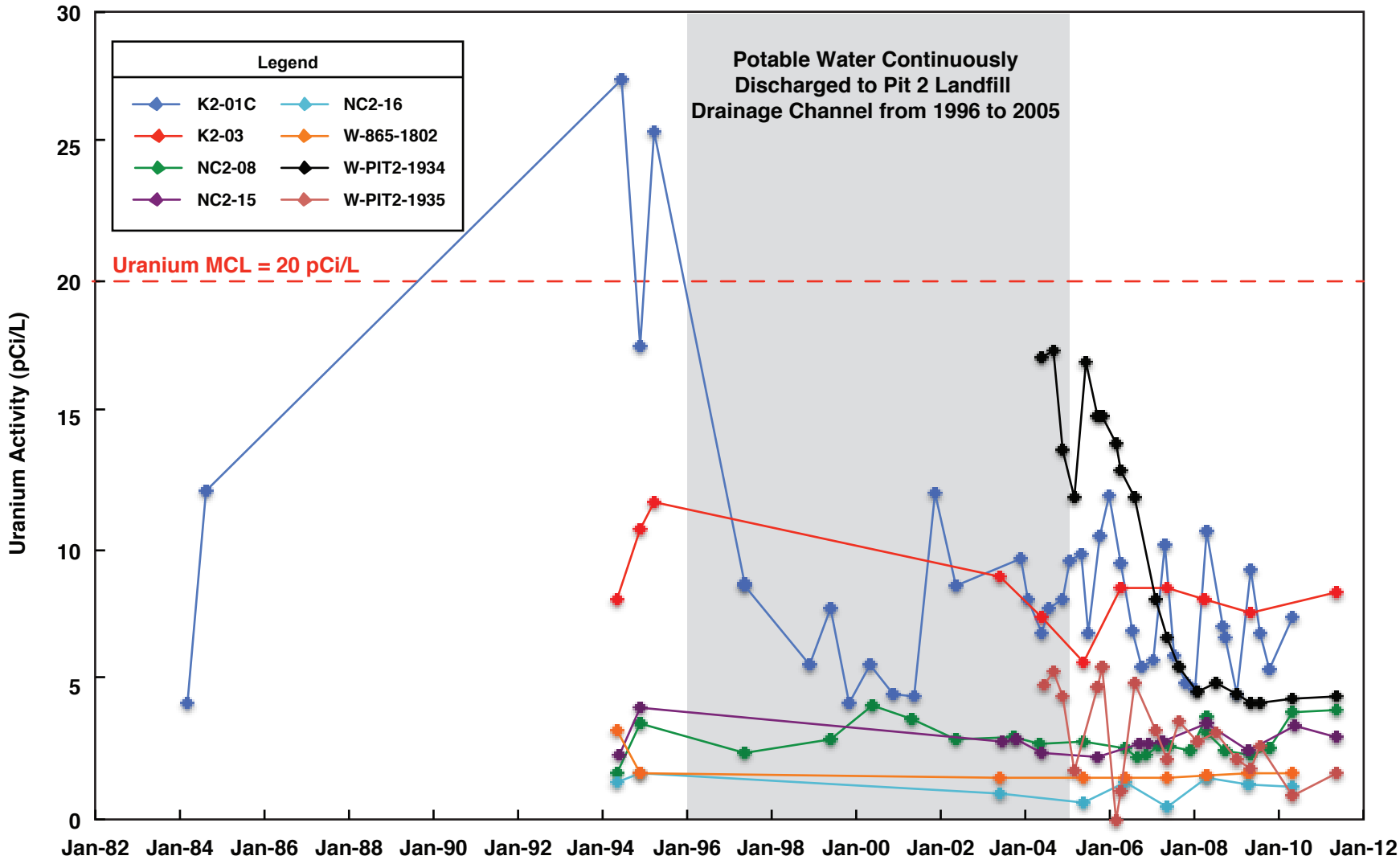
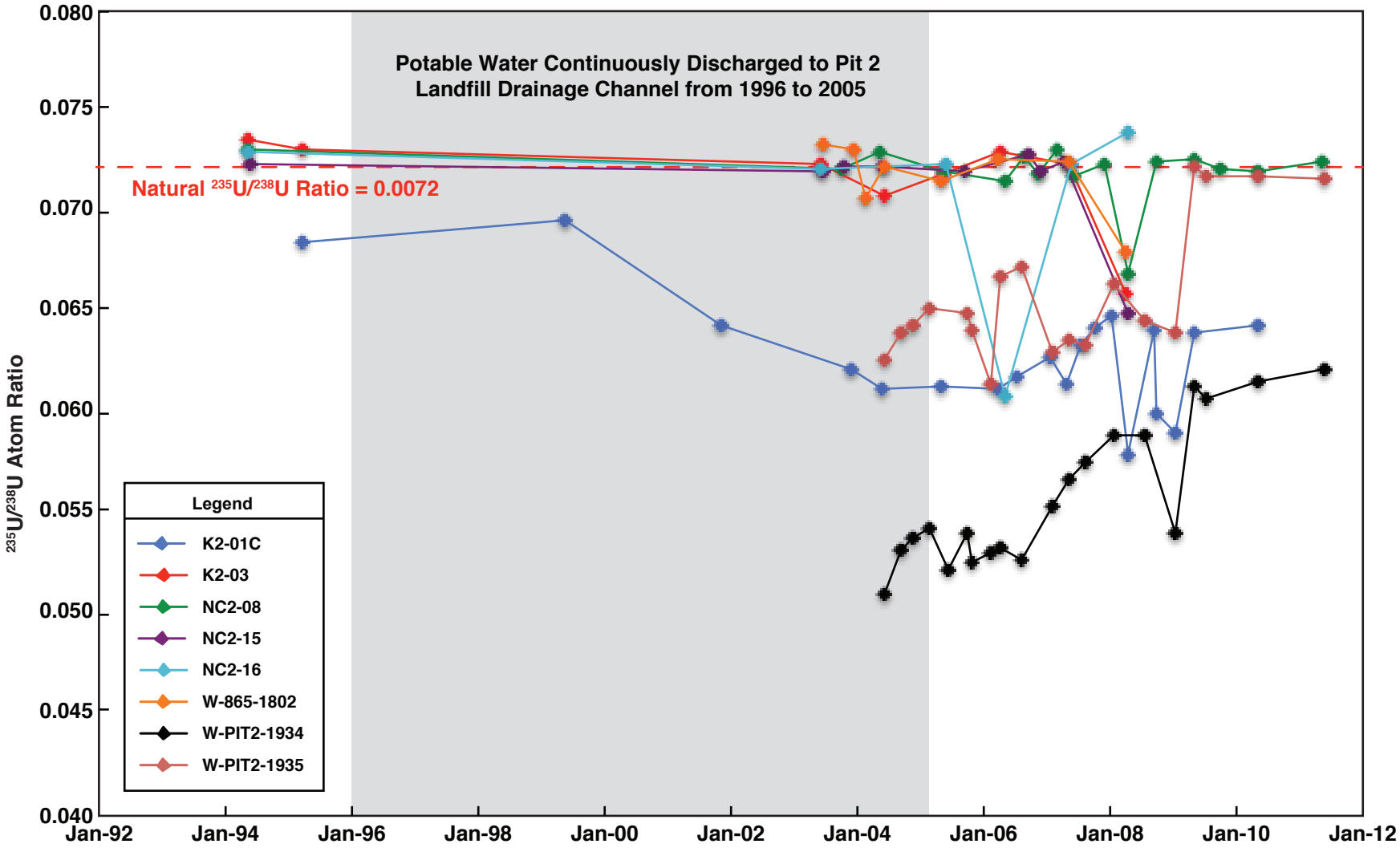


Figure 46. Time-series plots of uranium activities in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Pit 2 Landfill area.



ERD-S3R-12-0061

Figure 47. Time-series plots of $^{235}U/^{238}U$ atom ratios in $Tnbs_1/Tnbs_0$ hydrostratigraphic unit ground water in the Pit 2 Landfill area.

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Table 1. Actual annual costs for the Pit 6 Landfill Operable Unit and Operable Unit 8 for fiscal years 2007 through 2011.

Fiscal Year	Annual Budget	Actual Annual Cost	Cost Variance[a]
2007	$825,984.64	$839,655.08	-$13,670.44
2008	$905,026.58	$803,016.10	$102,010.48
2009	$460,037.44	$612,009.99	-$151,972.55
2010	$527,613.88	$617,291.15	-$89,677.27
2011	$616,931.38	$737,487.65	-$120,556.27

Notes:

[a] Cost variances were caused by increases in sample analysis costs, discretionary sampling, data management and performance evaluation effort.

Costs for the Pit 6 Landfill and Operable Unit 8 and captured in the same cost account therefore cannot be presented separately.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit.

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.	VOCs, and nitrate concentrations in ground water exceeding drinking water standards.	There are no existing or planned water-supply wells in the Pit 6 Landfill Operable Unit. Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. Prohibitions on drilling water-supply wells in areas of ground water contamination will be incorporated into an appropriate LLNL institutional planning document. Contamination is limited to onsite ground water. TCE is present in only one well at a concentration slightly exceeding the drinking water standard; all other VOCs in ground water are below drinking water standards. Nitrate is detected at a concentration exceeding the drinking water standard in only one well. The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.
Maintain the integrity of landfill cap as long as the pit waste remains in place.	Potential exposure to contaminants in pit waste[a].	DOE will inspect and maintain the landfill cap, and ground water monitoring system. Landfill cap maintenance and inspection requirements are specified in post-closure plan for the Pit 6 Landfill.
Control construction and other ground-breaking activities on the Pit 6 Landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.	Potential exposure to contaminants in pit waste[a].	All proposed ground-breaking construction activities must be cleared through LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, the LLNL Hazards Control ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination. Controls for construction and other ground-breaking activities will be incorporated into an appropriate LLNL institutional planning document.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain access restrictions to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste in the Pit 6 Complex Landfill remains in place.	Potential exposure to contaminants in pit waste[a].	Signage is in place and will be maintained at the Pit 6 Landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area (see administrative controls for ground-breaking construction activities above). These access restrictions will be incorporated into an appropriate LLNL institutional planning document.
Maintain access restrictions to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste in the Pit 6 Complex Landfill remains in place.	Potential exposure to contaminants in pit waste[a].	Site access by unauthorized trespassers is prevented by fences and warning signs at the site boundary and control entry systems at Site 300. These measures are maintained by the LLNL Security Department. There is no offsite contamination associated with the Pit 6 Landfill to which the public could be exposed. These access restrictions will be incorporated into an appropriate LLNL institutional planning document.
Maintain land use restriction in the vicinity of Spring 7 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	A 4 x 10^{-5} risk was identified for onsite workers continuously inhaling VOC vapors volatilizing from Spring 7 into outdoor air.	Spring 7 has been dry since 2003. Current activities in the vicinity of the Well 8 Spring are restricted to semi-annual spring sampling. The time spent sampling is well below the exposure scenario for which the unacceptable exposure risk was calculated, which assumed a worker would spend 8 hours a day, five days a week for 25 years working at Spring 7. DOE will conduct annual risk re-evaluations when water is present in Spring 7 to determine when the inhalation risk has been mitigated. The risk re-evaluation results will be reported in the Annual Site-Wide Compliance Monitoring Reports. Any significant changes in activities conducted in the Spring 7 area must be cleared through the LLNL Work Induction Board. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants as a result of the proposed area usage. If a potential for contaminant exposure is identified as a result of these changes in activities or area use, LLNL Hazards Control is notified and determines any necessary personal protective equipment to prevent exposure.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated waste and/or environmental media.	The Site 300 Federal Facility Agreement contains provisions that assure that DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1. Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and is agreed by the DOE, U.S. EPA, DTSC, and the RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into an appropriate LLNL institutional planning document.

Notes:

DOE = U.S. Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

LLNL = Lawrence Livermore National Laboratory.

RWQCB = California Regional Water Quality Control Board.

TCE = Trichloroethylene.

VOCs = Volatile organic compounds.

[a] **A risk for exposure to contaminants in the pit waste could not be calculated due to safety restrictions on penetrating landfill waste. Land use controls based on the potential exposure to contaminants in pit waste conservatively assume that the waste contaminants may pose a risk to human health.**

Table 3. Historical and current maximum concentrations of trichloroethene, chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, tetrachloroethene, 1,1,1-TCA, tritium, perchlorate, and nitrate in the Pit 6 Operable Unit compared to ground water cleanup standards.

Constituent	Historical Maximum			2011 Maximum			Cleanup Standard
	Concentration/Activity	Well	Sample Date	Concentration/Activity	Well	Sample Date	
Trichloroethene	250 µg/L	K6-19	Nov-88	9.3 µg/L	EP6-09	Apr-11	5 µg/L
Chloroform	14 µg/L	K6-19	May-94	<0.5 µg/L	All wells	N/A	80 µg/L[a]
1,2-DCA	3.5 µg/L	BC6-13	Nov-87	<0.5 µg/L	All wells	N/A	0.5 µg/L
Cis-1,2-DCE	12 µg/L	BC6-13	Jan-90	3 µg/L	K6-01S	Oct-11	6 µg/L
Trans-1,2-DCE	33 µg/L	BC6-13	Jul-91	<0.5 µg/L	All wells	N/A	10 µg/L
Tetrachloroethene	3.2 µg/L	K6-19	Nov-88	<0.5 µg/L	All wells	N/A	5 µg/L
1,1,1-TCA	13	K6-18	May-90	<0.5 µg/L	All wells	N/A	200 µg/L
Tritium	3,420 pCi/L	BC6-13	May-00	403 pCi/L	K6-18	Jan-11	20,000 pCi/L
Perchlorate	65.2 µg/L	K6-19	Nov-98	<4 µg/L	All wells	N/A	6 µg/L
Nitrate	240 mg/L	K6-23	May-00	150 mg/L	K6-23	Jul-11	45 mg/L

Notes:

Apr = April.
Jan = January.
Jul = July.
Oct = October.
mg/L = Milligrams per liter.
Nov = November.
pCi/L = PicoCuries per liter.
µg/L = Micrograms per liter.
DCA = Dichloroethane.
DCE = Dichloroethene.
TCA = Trichloroethane.

[a] State and Federal Maximum Contaminant Level (MCL) for total trihalomethanes.

Table 4. Cadmium concentrations in the vicinity of Building 801 used to calculate the 95% Upper Confidence Limit of the mean.

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-06-03	<0.1	8/31/94	Collected as part of Site Wide Remedial Investigation and Site Wide Feasibility Study background determination.
3SS-07-01	0.2	9/20/91	
3SS-08-01	<0.1	9/20/91	
3SS-11-01	0.2	9/20/91	
3SS-11-02	0.3	9/20/91	
3SS-12-01	<0.1	9/18/91	
3SS-12-02	<0.1	9/18/91	
3SS-12-03	<0.1	8/30/94	
3SS-13-01	0.1	9/18/91	
3SS-13-02	<0.1	8/31/94	
3SS-43-01	0.1	9/18/91	
3SS-57-01	0.1	8/31/94	
3SS-58-01	<0.1	8/30/94	
3SS-58-02	0.1	8/30/94	
3SS-58-03	<0.1	8/31/94	
3SS-801-001	<0.5	11/1/11	Collected as part of the current evaluation of cadmium impacts on ecological receptors.
3SS-801-002	<0.5	11/1/11	
3SS-801-003	<0.5	11/1/11	
3SS-801-004	<0.5	11/1/11	
3SS-801-005	<0.5	11/1/11	
3SS-801-006	<0.5	11/1/11	
MS-B801-001	<1	10/4/94	Collected as part of an investigation into the environmental impact of Building 801 cooling tower discharge. Estimated coordinates are available. Cooling tower discharge subsequently re-routed.
MS-B801-002	3.1	10/4/94	
MS-B801-003	14	10/4/94	
MS-B801-004	1.1	10/4/94	
MS-B801-011	<1	2/3/95	Collected as part of an investigation into the environmental impact of Building 801 cooling tower discharge. Estimated coordinates are not available but available documentation indicates the locations to be a bit further downgradient from above locations.
MS-B801-012	<1	2/3/95	
MS-B801-013	<1	2/3/95	
PC-B801-031	<1	6/27/97	Pre-construction soil sampling location for the construction of the Contained Firing Facility. The only preconstruction soil sample that was not subsequently paved over. Estimated coordinates available.

Table 4. Cadmium concentrations in the vicinity of Building 801 used to calculate the 95% Upper Confidence Limit of the mean. (Continued)

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-PIT1-100	<2	6/29/06	One of four samples collected as part of the Pit 1 investigation. Represents the approximate median of the samples.
3-DTPDDW01-03-SO	1.2	5/19/09	Collected adjacent to the Explosive Waste Treatment Detonation Pad near Building 845 as part of an ongoing permit application. Each data point represents the approximate median of four samples collected from each location. Locations are approximate.
3-DTPDDW02-01-SO	1.1	5/20/09	
3-EWTFDW01-02-SO	0.97	5/18/09	Collected downwind of the Explosive Waste Treatment Facility at Building 845 as part of an ongoing permit application. Each data point represents the approximate median of four samples collected from each location. Locations are approximate.
3-EWTFDW02-04-SO	0.91	5/18/09	
3-EWTFDW03-02-SO	1.3	5/19/09	
3-EWTFDW04-02-SO	1.2	5/19/09	
3-EWTFUW01-01-SO	1.3	5/21/09	Collected upwind of the Explosive Waste Treatment Facility at Building 845 as part of an ongoing permit application. The data point represents the approximate median of four samples collected from the location. Location is approximate.
N	37		
Average[a]	-0.8323		
Std[b]	1.2524		
H statistic[c]	2.6930		
95% UCL[d]	1.67 mg/kg		

Notes:

N = Number of soil samples used in calculation.

mg/kg = Milligrams per kilogram.

Std = Standard Deviation.

95% UCL = 95 Percent Upper Confidence Limit of the Mean.

ID = Identification.

[a] Average of the lognormally-transposed data.

[b] Standard Deviation of the lognormally-transposed data.

[c] H statistic interpolated from Table A12 (pg. 265) in Gilbert, 1987.

[d] 95% Upper Confidence Limit of the mean in standard un-transposed units.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8.

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.	*Buildings 801 and 833* VOC concentrations in ground water exceeding drinking water standards.	There are no existing or planned water-supply wells in the vicinity of Buildings 801 or 833. Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. Prohibitions on drilling water-supply wells in areas of ground water contamination will be incorporated into an appropriate LLNL institutional planning document. 1.2-DCA in Building 801 ground water is limited to only 2 wells at concentrations only slightly exceeding the state drinking water standard and are decreasing. All other VOCs in Building 801 ground water are below drinking water standards. VOCs in Building 833 ground water are limited to a shallow, perched, ephemerally saturated aquifer. There is no pathway for the VOC in ground water to migrate offsite. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.
Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.	*Building 801 Dry Well* Potential exposure to VOCs at depth in subsurface soil[a]. *Building 845 Firing Table* Potential exposure to depleted uranium and HMX at depth in subsurface soil[a]. *Building 851 Firing Table* Potential exposure to depleted uranium and VOCs at depth in subsurface soil[a]. *Building 833* Potential exposure to VOCs at depth in subsurface soil[a].	All proposed excavation activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, LLNL Hazards Control ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain engineering controls to prevent onsite site worker inhalation exposure to VOCs inside Building 833 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	A risk of 1 x 10^{-6} was identified for onsite workers from potential inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833.	Engineering controls (heating, ventilating, and air-conditioning system for Building 833) were implemented to prevent onsite worker exposure to VOCs that could migrate from the subsurface into the building until the inhalation risk was mitigated through remediation.
Maintain the integrity of landfill covers as long as the pit waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	DOE will inspect and maintain the landfill covers and ground water monitoring systems. Landfill cap maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan.
Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	All proposed ground-breaking construction activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, LLNL Hazards Control ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination. Controls for construction and other ground-breaking activities will be an appropriate LLNL institutional planning document.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain access restrictions to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	Signage will be maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area (see administrative controls for ground-breaking construction activities above). These access restrictions will be incorporated into an appropriate LLNL institutional planning document.
Maintain access restrictions to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	Site access by unauthorized trespassers is prevented by fences and warning signs at the site boundary and control entry systems at Site 300. These measures are maintained by the LLNL Security Department. There is no offsite contamination associated with the Pit 2, 8, or 9 landfills to which the public could be exposed. These access restrictions will be incorporated into an appropriate LLNL institutional planning document.
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated waste and/or environmental media.	The Site 300 Federal Facility Agreement contains provisions that assure that DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1. Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and is agreed by the DOE, U.S. EPA, DTSC, and the RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into an appropriate institutional LLNL planning document.

Notes appear on the following page.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Notes:

DCA = Dichloroethane.

DOE = United States Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

HMX = High melting explosive.

LLNL = Lawrence Livermore National Laboratory.

RWQCB = California Regional Water Quality Control Board.

VOCs = Volatile organic compounds.

[a] Risk for onsite worker exposure to contaminants at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction activities conservatively assume that these subsurface soil contaminants may pose a risk to human health.

[b] A risk for exposure to contaminants in the pit waste could not be calculated due to safety restrictions on penetrating landfill waste. Land use controls based on the potential exposure to contaminants in pit waste conservatively assume that the waste contaminants may pose a risk to human health.

Table 6. Historical and current maximum concentrations of ground water contaminants of concern in the Operable Unit 8 compared to ground water cleanup standards.

Constituent	Hydrostratigraphic Unit Impacted	Historical Maximum			2011 Maximum			Cleanup Standard
		Concentration/ Activity	Well	Sample Date	Concentration/ Activity	Well	Sample Date	
Building 801 and Pit 8 Landfill area								
1,2-DCA	$Tnbs_1/Tnbs_0$	5 µg/L	K8-01	Jan-90	1.8 µg/L	K8-01	May-11	0.5 µg/L
TCE	$Tnbs_1/Tnbs_0$	6 µg/L	K8-01	Apr-92	3.8 µg/L	K8-01	May-11	5 µg/L
Chloroform	$Tnbs_1/Tnbs_0$	2.4 µg/L	K8-02B	Apr-92	<0.5 µg/L	All wells	NA	80 µg/L
Perchlorate	$Tnbs_1/Tnbs_0$	5 µg/L	K8-04	May-03	<4 µg/L	All wells	NA	6 µg/L
Nitrate	$Tnbs_1/Tnbs_0$	64 mg/L	K8-01	Jun-02	57 mg/L	K8-04	May-11	45 mg/L
Building 833 area								
TCE	Tpsg	2,100 µg/L	W-833-03	Aug-92	150 µg/L	W-833-33	Feb-11	5 µg/L
cis-1,2-DCE	Tpsg	58 µg/L	W-833-12	Feb-93	<0.5 µg/L	All wells	NA	6 µg/L
Building 851 Firing Table area								
Uranium	Tmss	3.2 pCi/L	W-851-07	Oct-91	0.962 pCi/L	W-851-08	Nov-11	20 pCi/L
Pit 2 Landfill area								
Nitrate	Qal/WBR	42 mg/L	NC2-14S	Jun-03	29 mg/L	NC2-14S	May-11	45 mg/L
Nitrate	$Tnbs_1/Tnbs_0$	106 mg/L	K2-01C	Aug-93	38 mg/L	W-PIT2-1935	May-11	45 mg/L

Notes:

1,2-DCA = 1,2-Dichloroethane.
cis-1,2-DCE = cis-1,2-Dichloroethene.
Apr = April.
Aug = August.
Feb = February.
Jan = January.
Jul = July.
Jun = June.
mg/L = Milligrams per liter.
NA = Not applicable.
Nov = November.
Oct = October.
pCi/L = PicoCuries per liter.
TCE = Trichloroethene.
Tmss = Miocene Cierbo Formation—lower siltstone/claystone member.
$Tnbs_0$ = Neroly silty Sandstone.
$Tnbs_1$ = Tertiary Neroly Lower Blue Sandstone.
Tpsg = Tertiary Pliocene sand and gravel.
Qal/WBR = Quaternary alluvium/Weathered bedrock.
µg/L = Micrograms per liter.

Building 845 and Pit 9 Landfill have no identified COCs in ground water.

Table 7. Historical maximum concentrations/activities of surface soil and vadose zone contaminants of concern in the Building 845 and Building 851 Firing Tables compared to regulatory screening criteria.

Constituent	Area	Concentration/ Activity	Sample Date	Industrial PRG[a]	Industrial RSL[b]
Historic Maximum of Vadose Zone COCs					
HMX	Building 845 Firing Table	0.54 mg/kg	1988	NA	49,000 mg/kg
Uranium-238	Building 845 Firing Table	1.2 pCi/g	1988	1.8 pCi/g	NA
TCE	Building 851 Firing Table	0.0003 mg/kg	1990	NA	6.4 mg/kg
cis-1,2-DCE	Building 851 Firing Table	0.012 mg/kg	1988	NA	2,000 mg/kg
Uranium-238	Building 851 Firing Table	11 pCi/g	1990	1.8 pCi/g	NA
Historic Maximum of Surface Soil COCs					
RDX	Building 851 Firing Table	0.031 mg/kg	1990	NA	24 mg/kg
Cadmium	Building 851 Firing Table	9 mg/kg	1990	NA	800 mg/kg
Copper	Building 851 Firing Table	79 mg/kg	1990	NA	41,000 mg/kg
Zinc	Building 851 Firing Table	360 mg/kg	1990	NA	310,000 mg/kg
Uranium-238	Building 851 Firing Table	14.1 pCi/g	1990	1.8 pCi/g	NA

Notes:

cis-1,2-DCE = cis-1,2-Dichloroethene.
COCs = Contaminants of concern.
HMX = High Melting Explosive.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
pCi/g = PicoCuries per gram.
PRG = Preliminary Remediation Goals.
RDX = Research Department explosive.
RSL = Regional Screening Levels.
TCE = Trichloroethene.
µg/L = Micrograms per liter.

[a] Preliminary Remediation Goals promulgated by the EPA Pacific Southwest, Region 9, October 2004 (http://www.epa.gov/region9/superfund/prg/).

[b] Regional Screening Levels (formerly PRGs) promulgated by the EPA Pacific Southwest, Region 9, April 2012 (http://www.epa.gov/region9/superfund/prg/).

Table 8. Cadmium concentrations in the vicinity of Building 851 used to calculate the 95% Upper Confidence Limit of the mean.

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-45-01 D[a]	0.1	9/24/91	Collected as part of Site Wide Remedial Investigation and Site Wide Feasibility Study background determination.
3SS-45-01	12	9/24/91	
3SS-45-02	<0.1	9/2/94	
3SS-45-03	0.11	9/13/94	
3SS-46-01	<0.1	9/17/91	
3SS-46-01	<0.1	9/17/91	
3SS-46-02	<0.1	9/17/91	
3SS-46-03	<0.1	9/2/94	
3SS-48-01	<1	9/24/91	
3SS-48-02	<0.1	9/23/91	
3SS-48-03	<0.1	9/24/91	
3SS-48-04	<0.1	9/24/91	
3SS-48-05	<0.1	8/31/94	
3SS-48-06	<0.1	8/31/94	
3SS-48-08	<0.1	8/31/94	
3SS-56-05	<0.1	9/2/94	
3SS-57-02	<0.1	9/14/94	
3SS-850-110	0.11	7/26/94	Collected as part of the Building 850 investigation.
3SS-851-004	<0.5	11/1/11	Collected as part of the current evaluation of cadmium impacts on ecological receptors.
3SS-851-005	<0.5	11/1/11	
3SS-851-006	<0.5	11/1/11	
3SS-854-016	0.23	11/22/95	Representative locations from the Building 854 investigation. All locations are on native soil and have available coordinates.
3SS-854-022	0.53	11/22/95	
3SS-854-025	<1	11/22/95	
3SS-854-026	<1	11/22/95	
N	24		
Average[b]	-1.5019		
Std[c]	1.2283		
H statistic[d]	2.826		
95% UCL[e]	0.98 mg/kg		

Notes appear on the following page.

Table 8. Cadmium concentrations in the vicinity of Building 851 used to calculate the 95% Upper Confidence Limit of the mean. (Continued)

Notes:

N = Number of soil samples used in calculation.

mg/kg = Milligrams per kilogram.

Std = Standard Deviation.

95% UCL = 95 Percent Upper Confidence Limit of the Mean.

ID = Identification.

[a] Not used in the calculation of the 95% UCL.

[b] Average of the lognormally-transposed data.

[c] Standard Deviation of the lognormally-transposed data.

[d] H statistic interpolated from Table A12 (pg. 265) in Gilbert, 1987.

[e] 95% Upper Confidence Limit of the mean in standard un-transposed units.

Attachment A

Attachment A

Attachment A1. Pit 6 Landfill Operable Unit (OU) 3 Five-Year Review Site Inspection Checklist

Attachment A2. Building 801 and Pit 8 Landfill Area Operable Unit (OU) 8 Five-Year Review Site Inspection Checklist

Attachment A3. Building 845 and Pit 9 Landfill Area Operable Unit (OU) 8 Five-Year Review Site Inspection Checklist

Attachment A4. Building 851 Operable Unit (OU) 8 Five-Year Review Site Inspection Checklist

Attachment A5. Building 833 Operable Unit (OU) 8 Five-Year Review Site Inspection Checklist

Attachment A6. Pit 2 Landfill Area Operable Unit (OU) 8 Five-Year Review Site Inspection Checklist

Attachment A1
Pit 6 Landfill Operable Unit (OU) 3
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Pit 6 Landfill Operable Unit (OU 3), LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Installation of a landfill cover to prevent infiltrating rainwater from further leaching contaminants from the buried waste and to mitigate potential inhalation risks.
- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Pit 6 Landfill Operable Unit.
  - Inspect the Pit 6 Landfill cover periodically for damage that could compromise the integrity and repair any damage found.
  - Prevent onsite workers exposure to volatile organic compounds (VOCs) volatilizing from surface water (Spring 7).
  - Sample outdoor ambient air annually for VOCs near Spring 7 when surface water is present and reevaluate risk until risk $<10^{-6}$ for 2 consecutive years.
- Monitoring Natural Attenuation (MNA) of VOCs and tritium in ground water.

Site Map: See Pit 6 Landfill OU Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Pit 6 Landfill OU remedy are ongoing. Remedy performance, landfill inspections and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection checksheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Pit 6 Landfill OU remedy. In addition, DOE/LLNS presents and discusses any landfill inspection and maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Pit 6 Landfill OU remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in collaboration with full-time

staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Pit 6 Landfill OU remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

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1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Readily available and up-to-date
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Pit 6 Landfill are maintained in the LLNL Environmental Restoration Department files and the Construction Quality Assurance for Pit 6 Landfill Closure (GCS, 1997). The Pit 6 Landfill is maintained as described in the Post-Closure Plan for the Pit 6 Landfill Operable Unit (Ferry, et al., 1998). Site 300 Management coordinates the Pit 6 Landfill inspections and maintenance. A registered civil engineer or certified engineering geologist performs the inspections and maintenance is performed by the LLNS Maintenance Department as necessary. Inspections of the cap and drainage channels are performed annual and after each major storm. Inspections and maintenance activities are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports. Operation and maintenance activities associated with the Pit 6 Landfill OU ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

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2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Pit 6 Landfill OU remedial action is included in the "Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

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3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Pit 6 Landfill OU.

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5. Gas Generation Records

Gas Generation Records:	Not applicable

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6. Settlement Monument Records

Settlement Monument Records:	Readily available

Remarks: Benchmarks placed at Site 300 are surveyed using Mt. Diablo, a U.S. Geological Survey marker located near the West Observation Post (the Elk Monument), and a third benchmark located approximately 5 miles southwest of the Elk Monument. Benchmarks at the site are primarily 3-in.- diameter stainless steel discs set in concrete, although there are a few brass discs set in concrete and others consisting of railroad spikes driven into Corral Hollow Road. All of the Site 300 benchmarks were resurveyed in 1984 to within 0.01 ft. Following completion of the Pit 6 Landfill cap and construction of the rifle range, survey points were installed at the four corners of the landfill cap using locally established benchmarks. Benchmarks are inspected primarily during use; if the survey crew finds a benchmark shifted out of position during the course of any job, they will resurvey its position and reestablish the benchmark. Benchmarks around the Pit 6 Landfill will be inspected at least annually.

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7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Pit 6 Landfill OU are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

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8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

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9. Discharge Compliance Records

Air: Not applicable
Water: Not applicable

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10. Daily Access/Security Logs

Daily Access/Security Logs: Readily available and up-to-date

Remarks: The entire perimeter of Site 300, including the vicinity of the Pit 6 Landfill, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is

U.S. government property, an explosives test facility, and that trespassing is forbidden by law. The outdoor firing range, located on the Pit 6 Landfill cap, is used by the LLNL Security Forces for small firearms training. A gate located off Corral Hollow Road at the entrance to firing range is used to control access to the firing range. The gate remains open during firing range operating hours and is locked at all other times. An electric eye posted at the gate triggers a bell in Building 899B when a vehicle or person passes through the gate. A member of the small firearms training staff and/or Building Coordinator is stationed at Building 899B, when the gate is open. All LLNL personnel and visitors to the firing range are required to check in and out with the training staff or Building Coordinator at Building 899B and provide information regarding the purpose of their visit. As a precautionary measure, a red warning flag is flown, which is visible from the gate during times when firearms practice is actively occurring at the firing range. The entrance gate is locked at all times during hours when the firing range is closed.

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Pit 6 Landfill OU during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Pit 6 Landfill OU restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

2. Signs and Other Security Measures

Signs and Other Security Measures In place: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented: No
Site conditions imply ICs not being fully enforced: No

Type of monitoring (e.g., self-reporting, drive by): Physical inspection
Frequency:
Physical ICs are inspected annually
ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency: U.S DOE
Contact Name: Claire Holtzapple
Title: DOE-LFO Site 300 Environmental Restoration RPM
Phone No.: 925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to the Institutional Controls section of the Pit 6 Landfill OU Five-Year Review for further details on institutional controls.

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2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Pit 6 Landfill OU Five-Year Review for further details on institutional controls.

D. General

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1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

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2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Pit 6 Landfill OU since the Site-Wide Record of Decision and none are anticipated. Most of the land in the Pit 6 Landfill OU is undeveloped and is not used for LLNL programmatic activities. The only LLNL buildings located within the OU boundary are used to support firearms training operations by the LLNL Protective Forces Department. Pistol and rifle ranges are operated in the OU. The rifle range was built on top of the Pit 6 Landfill cap. See the Land and Resource Use section of the Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Pit 6 Landfill OU sits at the southeastern boundary of Site 300. The Carnegie SVRA, located across Corral Hollow Road from Pit 6 Landfill OU is an outdoor recreational facility operated by the California Department of Parks and Recreation for riding and racing private and commercial off-road motorcycles and four-wheel drive vehicles. The Carnegie SVRA continues to expand on the property to the south of the OU. In addition, the Carnegie SVRA owns a pie shaped piece of land north of Corral Hollow Road at the eastern boundary of the OU. See the Land and Resource Use section of the Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

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1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Pit 6 Landfill OU is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Pit 6 Landfill cap, drainage ways, and wells are in good condition.

VII. LANDFILL COVERS Applicable

A. Landfill Surface

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1. Settlement (Low spots) Settlement not evident

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2. Cracks Cracking not evident

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3. Erosion	Erosion not evident
4. Holes	Holes not evident
5. Vegetative Cover	No signs of stress
Remarks: A rifle range sits Pit 6 Landfill cap.	
6. Alternative Cover	Not applicable
7. Bulges	Bulges not evident
8. Wet Areas/Water Damage	Wet Areas/Water Damage not evident
9. Slope Instability	No evidence of slope instability
B. Benches	Not applicable
C. Letdown Channels	Not applicable
D. Cover Penetrations	Not applicable
E. Gas Collection and Treatment	Not applicable
F. Cover Drainage Layer	Not applicable
G. Detention/Sedimentation Ponds	Not applicable
H. Retaining Walls	Not applicable

I. Perimeter Ditches/Off-Site Discharge	Applicable
1. Siltation	Siltation not evident
2. Vegetative Growth	No vegetation impeding flow
3. Erosion	Erosion not evident
4. Discharge Structure	Functioning
VIII. VERTICAL BARRIER WALLS	Not applicable
IX. GROUND WATER/SURFACE WATER REMEDIES	Applicable
A. Groundwater Extraction Wells, Pumps, and Pipelines	Not applicable
B. Surface Water Collection Structures, Pumps, and Pipelines	Not applicable
C. Treatment System	Not applicable
D. Monitoring Data	

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation Applicable

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1. Monitoring Wells (natural attenuation remedy)

Properly secured/locked:	Yes
Functioning:	Yes
Routinely sampled:	Yes
Good condition:	Yes
All required wells located:	Yes
Needs maintenance:	None

Remarks: MNA is the remedy for VOCs and tritium. Samples are collected annually and reported in the Compliance Monitoring Reports.

X. OTHER REMEDIES Not Applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Pit 6 Landfill OU is intended to contain contaminant sources, prevent further plume migration, reduce contaminant concentrations in ground water to cleanup standards, and mitigate VOC inhalation risk to onsite workers. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Pit 6 Landfill OU is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Pit 6 Landfill OU Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Pit 6 Landfill OU were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions

sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Pit 6 Landfill OU.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Pit 6 Landfill OU may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy optimization:

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1. Monitor trichloroethene (TCE) concentrations in ground water at well EP6-09 at the Pit 6 Landfill (OU 3). If concentrations increase or remain above 5 micrograms per liter (µg/L), remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.

Attachment A1

Pit 6 Landfill Operable Unit (OU3)
Five-Year Review Inspection Checklist Photographs*

*** There are no remediation systems associated with Operable Unit 8.**

A 2.5-acre engineered cap was constructed over the Pit 6 Landfill as a CERCLA removal action in 1997.

The multi-layered cap is designed to: (1) prevent rain and surface water infiltration, (2) divert surface water, (3) eliminate safety hazards associated with subsidence into voids in the buried waste, (4) prevent volatilization of vapors from buried waste, (5) reduce ground water recharge near the contaminant plumes, and (6) prevent burrowing animals and vegetation from causing water infiltration pathways.

The cap contains a geocomposite drainage layer/biotic barrier, a low permeability high density polyethylene geosynthetic clay liner, and a geonet drainage layer to redirect infiltrating water and deter animals from burrowing beneath the Pit 6 Landfill cover.

Pit 6 Landfill design included surface drainage channels to divert water away from the landfill.

A Rifle Range was constructed on top of the Pit 6 Landfill cover.

Attachment A2
Building 801 and Pit 8 Landfill Area
Operable Unit (OU) 8
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Building 801 and Pit 8 Landfill area located in Operable Unit (OU) 8, LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Building 801 and Pit 8 Landfill area Operable Unit.
  - Inspect the Pit 8 Landfill cover periodically for damage that could compromise the integrity and repair any damage found.

Site Map: See Building 801 and Pit 8 Landfill area OU Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Building 801 and Pit 8 Landfill area remedy are ongoing. Remedy performance, landfill inspections and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Building 801 and Pit 8 Landfill area remedy. In addition, DOE/LLNS presents and discusses any landfill inspection and maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Building 801 and Pit 8 Landfill area remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in

collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Building 801 and Pit 8 Landfill area remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

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1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Not applicable
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Pit 8 Landfill are not available. The unlined landfill was constructed in 1958 in a narrow ravine about 500 feet northeast of the Building 801 Complex. The Pit 8 Landfill is maintained as described in the Compliance Monitoring Plan (Dibley, et al., 2009b). Site 300 Management coordinates the Pit 8 Landfill area inspections and maintenance. A registered civil engineer or certified engineering geologist performs the inspections and maintenance is performed by the LLNS Maintenance Department as necessary. Inspections of the cap and drainage channels are performed annually. Inspections and maintenance activities are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports. Operation and maintenance activities associated with the Building 801 and Pit 8 Landfill area ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

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2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Building 801 and Pit 8 Landfill area remedial action is included in the "Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

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3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Building 801 and Pit 8 Landfill area OU.

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5. Gas Generation Records

Gas Generation Records:	Not applicable

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6. Settlement Monument Records

Settlement Monument Records:	Not applicable

7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Building 801 and Pit 8 Landfill area are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

9. Discharge Compliance Records

Air: Not applicable
Water: Not applicable

10. Daily Access/Security Logs

Daily Access/Security Logs: Not applicable

Remarks: The entire perimeter of Site 300, including the vicinity of the Building 801 and Pit 8 Landfill area, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Access to the site is obtained through a guarded gate for only those individuals that possess the appropriate identification (i.e., badge).

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Building 801 and Pit 8 Landfill area during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Building 801 and Pit 8 Landfill area restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

1. Signs and Other Security Measures

Signs and Other Security Measures In place Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented:	No
Site conditions imply ICs not being fully enforced:	No

Type of monitoring (e.g., self-reporting, drive by):	Physical inspection
Frequency:	Physical ICs are inspected annually ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency:	U.S DOE
Contact Name:	Claire Holtzapple
Title:	DOE-LFO Site 300 Environmental Restoration RPM
Phone No.:	925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to the Institutional Controls section of the Building 801 and Pit 8 Landfill area Five-Year Review for further details on institutional controls.

2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Building 801 and Pit 8 Landfill area Five-Year Review for further details on institutional controls.

D. General

1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

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2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Building 801 and Pit 8 Landfill area since the Site-Wide Record of Decision and none are anticipated. Building 801 continues to be used for indoor explosive testing. See the Land and Resource Use section of the Building 801 and Pit 8 Landfill area Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Building 801 and Pit 8 Landfill area is approximately 5,000 feet from the Site 300 northeastern boundary. The surrounding land is used for cattle grazing, a fireworks storage facility, and an ecological reserve. A developer purchased land for a housing development to the north and east of Site 300. However, a Final Environmental Impact Report for this development that was prepared for the City of Tracy proposes to designate land along the northeast border of the Site 300 as open space. The open space would create a buffer of approximately one to one and a half miles between Site 300 and residential elements of the development. The buffer zone would be used for cattle or sheep grazing, and would have limited access points at existing trails for hikers, mountain bikers and equestrians. In the past, development in the immediate vicinity of Site 300 has been hindered by the limited availability of potable water, opposition by local residents and landowners, and the presence of endangered species habitat. If these issues are resolved in the future, it is possible that residential development of the land in the vicinity of Site 300 could occur. See the Land and Resource Use section of the Building 801 and Pit 8 Landfill area Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 801 and Pit 8 Landfill area is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Pit 8 Landfill cover and monitor wells are in good condition.

VII. LANDFILL COVERS Applicable

A. Landfill Surface

1. Settlement (Low spots) Settlement not evident

2. Cracks Cracking not evident

3. Erosion Erosion not evident

4. Holes Holes not evident

5. Vegetative Cover No signs of stress

6. Alternative Cover Not applicable

7. Bulges	Bulges not evident
8. Wet Areas/Water Damage	Wet Areas/Water Damage not evident
9. Slope Instability	No evidence of slope instability
B. Benches	Not applicable
C. Letdown Channels	Not applicable
D. Cover Penetrations	Not applicable
E. Gas Collection and Treatment	Not applicable
F. Cover Drainage Layer	Not applicable
G. Detention/Sedimentation Ponds	Not applicable
H. Retaining Walls	Not applicable
I. Perimeter Ditches/Off-Site Discharge	Applicable
1. Siltation	Siltation not evident
2. Vegetative Growth	No vegetation impeding flow
3. Erosion	Erosion not evident

4. Discharge Structure	Functioning
VIII. VERTICAL BARRIER WALLS	Not applicable
IX. GROUND WATER/SURFACE WATER REMEDIES	Applicable
A. Groundwater Extraction Wells, Pumps, and Pipelines	Not applicable
B. Surface Water Collection Structures, Pumps, and Pipelines	Not applicable
C. Treatment System	Not applicable
D. Monitoring Data	

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation	Not applicable
X. OTHER REMEDIES	Not Applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Building 801 and Pit 8 Landfill area is intended to contain contaminant sources, prevent further plume migration, and reduce contaminant concentrations in ground water to cleanup standards. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Building 801 and Pit 8 Landfill area is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Building 801 and Pit 8 Landfill area Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Building 801 and Pit 8 Landfill area were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Building 801 and Pit 8 Landfill area.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Building 801 and Pit 8 Landfill area may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy optimization:

1. Install additional monitor wells in the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit (HSU) in the vicinity of the Pit 8 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells located north of the landfill and potentially one monitor well located south of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

Attachment A3
Building 845 and Pit 9 Landfill Area
Operable Unit (OU) 8
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Building 845 and Pit 9 Landfill area located in Operable Unit (OU) 8, LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Building 845 and Pit 9 Landfill area Operable Unit.
  - Inspect the Pit 9 Landfill cover periodically for damage that could compromise the integrity and repair any damage found.

Site Map: See Building 845 and Pit 9 Landfill area OU Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Building 845 and Pit 9 Landfill area remedy are ongoing. Remedy performance, landfill inspections and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Building 845 and Pit 9 Landfill area remedy. In addition, DOE/LLNS presents and discusses any landfill inspection and maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Building 845 and Pit 9 Landfill area remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in

collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Building 845 and Pit 9 Landfill area remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

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1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Not applicable
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Pit 9 Landfill are not available. The unlined landfill was constructed in 1958 in a narrow ravine about 500 feet northeast of the Building 801 Complex. The Pit 9 Landfill is maintained as described in the Compliance Monitoring Plan (Dibley, et al., 2009b). Site 300 Management coordinates the Pit 9 Landfill area inspections and maintenance. A registered civil engineer or certified engineering geologist performs the inspections and maintenance is performed by the LLNS Maintenance Department as necessary. Inspections of the cap and drainage channels are performed annually. Inspections and maintenance activities are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports. Operation and maintenance activities associated with the Building 845 and Pit 9 Landfill area ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

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2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Building 845 and Pit 9 Landfill area remedial action is included in the "Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

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3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Building 845 and Pit 9 Landfill area OU.

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5. Gas Generation Records

Gas Generation Records:	Not applicable

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6. Settlement Monument Records

Settlement Monument Records:	Not applicable

7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Building 845 and Pit 9 Landfill area are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

9. Discharge Compliance Records

Air: Not applicable
Water: Not applicable

10. Daily Access/Security Logs

Daily Access/Security Logs: Not applicable

Remarks: The entire perimeter of Site 300, including the vicinity of the Building 845 and Pit 9 Landfill area, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Access to the site is obtained through a guarded gate for only those individuals that possess the appropriate identification (i.e., badge).

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Building 845 and Pit 9 Landfill area during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Building 845 and Pit 9 Landfill area restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

1. Signs and Other Security Measures

Signs and Other Security Measures In place Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented:	No
Site conditions imply ICs not being fully enforced:	No

Type of monitoring (e.g., self-reporting, drive by):	Physical inspection
Frequency:	Physical ICs are inspected annually ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency:	U.S DOE
Contact Name:	Claire Holtzapple
Title:	DOE-LFO Site 300 Environmental Restoration RPM
Phone No.:	925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to the Institutional Controls section of the Building 845 and Pit 9 Landfill area Five-Year Review for further details on institutional controls.

2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Building 845 and Pit 9 Landfill area Five-Year Review for further details on institutional controls.

D. General

1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

---

2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Building 845 and Pit 9 Landfill area since the Site-Wide Record of Decision and none are anticipated. Building 801 continues to be used for indoor explosive testing. See the Land and Resource Use section of the Building 845 and Pit 9 Landfill area Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Building 845 and Pit 9 Landfill area is approximately 4,500 feet west of the Site 300 northeastern (closest) boundary. The surrounding land is used for cattle grazing, a fireworks storage facility, and an ecological reserve. A developer purchased land for a housing development to the north and east of Site 300. However, a Final Environmental Impact Report for this development that was prepared for the City of Tracy proposes to designate land along the northeast border of the Site 300 as open space. The open space would create a buffer of approximately one to one and a half miles between Site 300 and residential elements of the development. The buffer zone would be used for cattle or sheep grazing, and would have limited access points at existing trails for hikers, mountain bikers and equestrians. In the past, development in the immediate vicinity of Site 300 has been hindered by the limited availability of potable water, opposition by local residents and landowners, and the presence of endangered species habitat. If these issues are resolved in the future, it is possible that residential development of the land in the vicinity of Site 300 could occur. See the Land and Resource Use section of the Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 845 and Pit 9 Landfill area is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Pit 8 Landfill cover and monitor wells are in good condition.

VII. LANDFILL COVERS Applicable

A. Landfill Surface

1. Settlement (Low spots) Settlement not evident

2. Cracks Cracking not evident

3. Erosion Erosion not evident

4. Holes Holes not evident

5. Vegetative Cover No signs of stress

6. Alternative Cover Not applicable

7. Bulges	Bulges not evident
8. Wet Areas/Water Damage	Wet Areas/Water Damage not evident
9. Slope Instability	No evidence of slope instability
B. Benches	Not applicable
C. Letdown Channels	Not applicable
D. Cover Penetrations	Not applicable
E. Gas Collection and Treatment	Not applicable
F. Cover Drainage Layer	Not applicable
G. Detention/Sedimentation Ponds	Not applicable
H. Retaining Walls	Not applicable
I. Perimeter Ditches/Off-Site Discharge	Applicable
1. Siltation	Siltation not evident
2. Vegetative Growth	No vegetation impeding flow
3. Erosion	Erosion not evident

4. Discharge Structure	Functioning
VIII. VERTICAL BARRIER WALLS	Not applicable
IX. GROUND WATER/SURFACE WATER REMEDIES	Applicable
A. Groundwater Extraction Wells, Pumps, and Pipelines	Not applicable
B. Surface Water Collection Structures, Pumps, and Pipelines	Not applicable
C. Treatment System	Not applicable

D. Monitoring Data

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation	Not applicable
X. OTHER REMEDIES	Not Applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Building 845 and Pit 9 Landfill area is intended to contain contaminant sources and reduce contaminant concentrations in ground water to cleanup standards. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Building 845 and Pit 9 Landfill area is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Building 845 and Pit 9 Landfill area Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Building 845 and Pit 9 Landfill area were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Building 845 and Pit 9 Landfill area.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Building 845 and Pit 9 Landfill area may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy optimization:

1. Install additional monitor wells in the $Tnsc_0$ HSU in the vicinity of the Pit 9 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells east of the landfill and potentially one monitor well west of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

Attachment A4
Building 851
Operable Unit (OU) 8
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Building 851 area located in Operable Unit (OU) 8, LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Building 851 area.

Site Map: See Building 851 area Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Building 851 area remedy are ongoing. Remedy performance and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Building 851 area remedy. In addition, DOE/LLNS presents and discusses any maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

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2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Building 851 area remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Building 851 area remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental

health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Not applicable
Maintenance logs:	Not applicable

Remarks: As-built drawings for the Building 851 area are not available because no construction activities are associated with the remedy. Operation and maintenance activities associated with the Building 851 area ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Building 851 area remedial action is included in the "Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Building 851 area.

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5. Gas Generation Records

Gas Generation Records: Not applicable

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6. Settlement Monument Records

Settlement Monument Records: Not applicable

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7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Building 851 area are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

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8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

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9. Discharge Compliance Records

Air:	Not applicable
Water:	Not applicable

10. Daily Access/Security Logs

Daily Access/Security Logs: Readily available and up-to-date

Remarks: The entire perimeter of Site 300, including the vicinity of the Building 851 area, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Access to the site is obtained through a guarded gate for only those individuals that possess the appropriate identification (i.e., badge).

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Building 851 area during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Building 851 area restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location:	Fencing in good condition
Gate secured:	Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

2. Signs and Other Security Measures

Signs and Other Security Measures In place	Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented:	No
Site conditions imply ICs not being fully enforced:	No

Type of monitoring (e.g., self-reporting, drive by):	Physical inspection
Frequency:	Physical ICs are inspected annually ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency:	U.S DOE
Contact Name:	Claire Holtzapple
Title:	DOE-LFO Site 300 Environmental Restoration RPM
Phone No.:	925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to the Institutional Controls section of the Building 851 area Five-Year Review for further details on institutional controls.

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2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Building 851 area Five-Year Review for further details on institutional controls.

D. General

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1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

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2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Building 851 area since the Site-Wide Record of Decision and none are anticipated. The Building 851 Firing Table continues to be used for explosives testing. See the Land and Resource Use section of the Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: Building 851 is located in the northwestern part of Site 300 and is approximately 3,300 feet east of the closest (western) site boundary. The surrounding land is used for cattle grazing, a fireworks storage facility, and an ecological reserve. A developer purchased land for a housing development to the north and east of Site 300. However, a Final Environmental Impact Report for this development that was prepared for the City of Tracy proposes to designate land along the northeast border of the Site 300 as open space. The open space would create a buffer of approximately one to one and a half miles between Site 300 and residential elements of the development. The buffer zone would be used for cattle or sheep grazing, and would have limited access points at existing trails for hikers, mountain bikers and equestrians. In the past, development in the immediate vicinity of Site 300 has been hindered by the limited availability of potable water, opposition by local residents and landowners, and the presence of endangered species habitat. If these issues are resolved in the future, it is possible that residential development of the land in the vicinity of Site 300 could occur. See the Land and Resource Use section of the Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 851 area is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Building 851 area wells are in good condition.

VII. LANDFILL COVERS Not applicable

VIII. VERTICAL BARRIER WALLS Not applicable

IX. GROUND WATER/SURFACE WATER REMEDIES Applicable

A. Groundwater Extraction Wells, Pumps, and Pipelines Not applicable

B. Surface Water Collection Structures, Pumps, and Pipelines Not applicable

C. Treatment System Not applicable

D. Monitoring Data

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation Not applicable

X. OTHER REMEDIES Not applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Building 851 area is intended to reduce contaminant concentrations in ground water to cleanup standards. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Building 851 area is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Building 851 area Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Building 851 area were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Building 851 area.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Building 851 area may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy optimization:

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1. Install additional monitor wells in the Tmss HSU in the vicinity of Building 851 to ensure full monitoring capability under the nearly flat ground water gradient. Up to two monitor wells located southwest and northwest of Building 851 are being considered to accomplish this objective. The proposed locations of the additional

monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

Attachment A5
Building 833
Operable Unit (OU) 8
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Building 833 area located in Operable Unit (OU) 8, LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Building 833 area.
  - Prevent onsite worker inhalation of volatile organic compounds (VOCs) volatilizing from the subsurface and migrating into Building 833 indoor air.
  - Re-evaluate risk for indoor ambient air annually for VOCs in Building 833, until risk is $<10^{-6}$ and HI <1 for at least two years.

Site Map: See Building 833 area Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Building 833 area remedy are ongoing. Remedy performance and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Building 833 area remedy. In addition, DOE/LLNS presents and discusses any maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Building 833 area remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water

Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Building 833 area remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

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1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Not applicable
Maintenance logs:	Not applicable

Remarks: As-built drawings for the Building 833 area are not available because no construction activities are associated with the remedy. Operation and maintenance activities associated with the Building 833 area ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

---

2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Building 833 area remedial action is included in the

"Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

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3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Building 833 area.

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5. Gas Generation Records

Gas Generation Records:	Not applicable

---

6. Settlement Monument Records

Settlement Monument Records:	Not applicable

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7. Ground water Monitoring Records

Ground water Monitoring Records:	Readily available and up-to-date

Remarks: Ground water monitoring records for the Building 833 area are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports

that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

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8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

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9. Discharge Compliance Records

Air: Not applicable
Water: Not applicable

---

10. Daily Access/Security Logs

Daily Access/Security Logs: Readily available and up-to-date

Remarks: The entire perimeter of Site 300, including the vicinity of the Building 833 area, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Access to the site is obtained through a guarded gate for only those individuals that possess the appropriate identification (i.e., badge).

IV. O&M COSTS

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1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

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2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Building 833 area during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental

Restoration Department provides monthly reports to the DOE-LFO RPM on Building 833 area restoration planned and actual costs with explanations/justifications of any cost variances.

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3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

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1. Fencing Damaged

Fencing damaged location:	Fencing in good condition
Gate secured:	Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

---

2. Signs and Other Security Measures

Signs and Other Security Measures In place	Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

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1. Implementation and Enforcement

Site conditions imply ICs not properly implemented:	No
Site conditions imply ICs not being fully enforced:	No

Type of monitoring (e.g., self-reporting, drive by): Physical inspection
Frequency:
Physical ICs are inspected annually
ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency: U.S DOE
Contact Name: Claire Holtzapple
Title: DOE-LFO Site 300 Environmental Restoration RPM
Phone No.: 925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date: Yes
Reports are verified by the lead agency: Yes
Specific requirements in deed or decision document have been met: Yes
Violations have been reported: Not Applicable
Other problems or suggestions: None

Remarks: Refer to the Institutional Controls section of the Building 833 area Five-Year Review for further details on institutional controls.

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2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Building 833 area Five-Year Review for further details on institutional controls.

D. General

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1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

---

2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Building 833 area since the Site-Wide Record of Decision and none are anticipated. The Building 833 is currently used as storage and offices for the ERD sampling personnel. See the Land and Resource Use section of the Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Building 833 area is approximately 1,800 feet west of the closest (eastern) boundary of Site 300. Current offsite land use near the OU includes agriculture, private residences, and an ecological preserve. See the Land and Resource Use section of the Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

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1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 833 area is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Building 833 area wells are in good condition.

VII. LANDFILL COVERS Not applicable

VIII. VERTICAL BARRIER WALLS Not applicable

IX. GROUND WATER/SURFACE WATER REMEDIES Applicable

A. Groundwater Extraction Wells, Pumps, and Pipelines Not applicable

B. Surface Water Collection Structures, Pumps, and Pipelines Not applicable

C. Treatment System Not applicable

D. Monitoring Data

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation Not applicable

X. OTHER REMEDIES Not applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Building 833 area is intended to reduce contaminant concentrations in ground water to cleanup standards. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Building 833 area is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Building 833 area Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Building 833 area were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Building 833 area.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Building 833 area may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy optimization:

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1. DOE/NNSA recommends dropping cis-1,2-dichloroethene (DCE) as a ground water COC because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells including well W-833-30, screened in the deeper $Tnbs_1$ HSU. However, ground water samples from Building 833 monitor wells would still be analyzed for volatile organic compounds (VOCs) by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports.

Attachment A6
Pit 2 Landfill Area
Operable Unit (OU) 8
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Pit 2 Landfill area located in Operable Unit (OU) 8, LLNL Site 300

Date of inspection: August 16, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) – Livermore Field Office (LFO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls specified in the Record of Decision (ROD) for the Pit 2 Landfill area Operable Unit.
  - Inspect the Pit 2 Landfill cover periodically for damage that could compromise the integrity and repair any damage found.

Site Map: See Pit 2 Landfill area OU Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Pit 2 Landfill area remedy are ongoing. Remedy performance, landfill inspections and maintenance, and any related issues are managed in real-time in collaboration with the Field Operations Manager and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Pit 2 Landfill area remedy. In addition, DOE/LLNS presents and discusses any landfill inspection and maintenance or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager (LLNS).
- Michael Taffet, Site 300 ER Hydrogeologist (LLNS).
- John Valett, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Eric Walter, Site 300 ER Sampling Coordinator (LLNS).
- Jon Ulrech, Site 300 ER Sampling Technician (LLNS).
- Mario Silva, Site 300 ER Sampling Technician (Weiss Associates – LLNS Subcontractor).

Remarks: As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and Site 300 ER Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Pit 2 Landfill area remedy are ongoing. Any remedy, landfill or monitor well issues are managed in real-time by the entities listed above in collaboration with full-time

staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single "interview" of O&M staff or interview results that can be referenced. The information contained within this inspection check sheet is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the Pit 2 Landfill area remedy.

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3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

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1. O&M Documents

O&M manual:	Not applicable
As-built drawings:	Not applicable
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Pit 2 Landfill are not available. The unlined landfill was constructed in 1956 and is located in the northeastern part of Site 300 south of Building 865. The Pit 2 Landfill is maintained as described in the Compliance Monitoring Plan (Dibley, et al., 2009b). Site 300 Management coordinates the Pit 2 Landfill area inspections and maintenance. A registered civil engineer or certified engineering geologist performs the inspections and maintenance is performed by the LLNS Maintenance Department as necessary. Inspections of the cap and drainage channels are performed annually. Inspections and maintenance activities are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports. Operation and maintenance activities associated with the Pit 2 Landfill area ground water monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

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2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the "Site Safety Plan for LLNL CERCLA Investigations at Site 300." Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the Pit 2 Landfill area remedial action is included in the "Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300."

Emergency responses are also contained in Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan and the Self-Help Plans.

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3. O&M and OSHA Training Records

O&M and OSHA Training Records	Readily available and up-to-date

Remarks: O&M and OSHA training records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System. OSHA HAZWOPER training for LLNS ER Department staff is up-to-date.

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4. Permits and Service Agreements

Air discharge permit:	Not applicable
Effluent discharge permit:	Not applicable
Waste Disposal:	Not applicable
Other permits:	Not applicable

Remarks: There are no permits associated with the Pit 2 Landfill area OU.

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5. Gas Generation Records

Gas Generation Records:	Not applicable

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6. Settlement Monument Records

Settlement Monument Records:	Not applicable

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7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Pit 2 Landfill area are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

9. Discharge Compliance Records

Air: Not applicable
Water: Not applicable

10. Daily Access/Security Logs

Daily Access/Security Logs: Not applicable

Remarks: The entire perimeter of Site 300, including the vicinity of the Pit 2 Landfill area, is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Access to the site is obtained through a guarded gate for only those individuals that possess the appropriate identification (i.e., badge).

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the Pit 2 Landfill area during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Pit 2 Landfill area restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period.

V. ACCESS AND INSTITUTIONAL CONTROLS — Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

2. Signs and Other Security Measures

Signs and Other Security Measures In place Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented:	No
Site conditions imply ICs not being fully enforced:	No

Type of monitoring (e.g., self-reporting, drive by):	Physical inspection
Frequency:	Physical ICs are inspected annually ICs are reviewed annually for adequacy and protectiveness

Responsible party/agency:	U.S DOE
Contact Name:	Claire Holtzapple
Title:	DOE-LFO Site 300 Environmental Restoration RPM
Phone No.:	925/422-0670

IC Inspection Date: November 11, 2011

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to the Institutional Controls section of the Pit 2 Landfill area Five-Year Review for further details on institutional controls.

2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Institutional Controls section of the Pit 2 Landfill area Five-Year Review for further details on institutional controls.

D. General

1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

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2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the Pit 2 Landfill area since the Site-Wide Record of Decision and none are anticipated. See the Land and Resource Use section of the Pit 2 Landfill area Five-Year Review.

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3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Pit 2 Landfill area is approximately 6,300 feet south of the Site 300 (northern) boundary. The surrounding land is used for cattle grazing, a fireworks storage facility, and an ecological reserve. A developer purchased land for a housing development to the north and east of Site 300. However, a Final Environmental Impact Report for this development that was prepared for the City of Tracy proposes to designate land along the northeast border of the Site 300 as open space. The open space would create a buffer of approximately one to one and a half miles between Site 300 and residential elements of the development. The buffer zone would be used for cattle or sheep grazing, and would have limited access points at existing trails for hikers, mountain bikers and equestrians. In the past, development in the immediate vicinity of Site 300 has been hindered by the limited availability of potable water, opposition by local residents and landowners, and the presence of endangered species habitat. If these issues are resolved in the future, it is possible that residential development of the land in the vicinity of Site 300 could occur. See the Land and Resource Use section of the Pit 2 Landfill area Five-Year Review.

VI. GENERAL SITE CONDITIONS

A. Roads

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1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Pit 2 Landfill area is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Pit 2 Landfill cover and monitor wells are in good condition.

VII. LANDFILL COVERS	Applicable
A. Landfill Surface	
1. Settlement (Low spots)	Settlement not evident
2. Cracks	Cracking not evident
3. Erosion	Erosion not evident
4. Holes	Holes not evident
5. Vegetative Cover	No signs of stress
6. Alternative Cover	Not applicable
7. Bulges	Bulges not evident
8. Wet Areas/Water Damage	Wet Areas/Water Damage not evident
9. Slope Instability	No evidence of slope instability
B. Benches	Not applicable

C. Letdown Channels	Not applicable
D. Cover Penetrations	Not applicable
E. Gas Collection and Treatment	Not applicable
F. Cover Drainage Layer	Not applicable
G. Detention/Sedimentation Ponds	Not applicable
H. Retaining Walls	Not applicable
I. Perimeter Ditches/Off-Site Discharge	Applicable
1. Siltation	Siltation not evident
2. Vegetative Growth	No vegetation impeding flow
3. Erosion	Erosion not evident
4. Discharge Structure	Functioning
VIII. VERTICAL BARRIER WALLS	Not applicable
IX. GROUND WATER/SURFACE WATER REMEDIES	Applicable
A. Groundwater Extraction Wells, Pumps, and Pipelines	Not applicable

B. Surface Water Collection Structures, Pumps, and Pipelines Not applicable

C. Treatment System Not applicable

D. Monitoring Data

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to the Ground Water Remediation Progress Section of the Five-Year Review for further details on the progress of the remedial action.

E. Monitored Natural Attenuation Not applicable

X. OTHER REMEDIES Not Applicable

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the Pit 2 Landfill area is intended to contain contaminant sources and reduce contaminant concentrations in ground water to cleanup standards. Refer to the Remedy Selection section of the Five-Year Review for further details on the remedial action objectives.

The remedy at the Pit 2 Landfill area is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to the Technical Assessment and Protectiveness Statement sections of the Pit 2 Landfill area Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Pit 2 Landfill area were identified during this evaluation. Refer to the Deficiencies and Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the Pit 2 Landfill area.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the Pit 2 Landfill area may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

There were no DOE recommendations for remedy optimization for the Pit 2 Landfill.

Attachment B

Responses to Regulatory Comments

Attachment B

Attachment B1. Responses to Regulatory Comments on the Draft Five Year Review.

Attachment B2. Responses to Regulatory Comments on the Draft Final Five Year Review.

Attachment B1

Comment Responses for the Draft Five-Year Review Report for Operable Units (OUs) 3 and 8 at Lawrence Livermore National Laboratory (LLNL) Site 300

U.S. Environmental Protection Agency (EPA) Comments

GENERAL COMMENTS

1. EPA recommends revising the Report to consolidate the discussion of ICs (institutional controls) to the extent that common text appears in multiple sections. Consolidation would both shorten the document and make it more readable by eliminating repetitive text. The text in each ICs discussion beginning with the first paragraph -- "Land use controls are restrictions or controls . . ." -- through most of paragraph 6, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist." - could be consolidated into a single section that is referenced by the site specific discussion. In addition, text describing the LLNL dig permit and work induction board processes could be consolidated into a single general section with each site specific section simply referencing that discussion.

Response: **DOE/LLNL had considered trying to consolidate some sections of the OUs 3 and 8 Five-Year Review during preparation of the draft document to eliminate repetitive text. However, we decided against this as it would make it much more difficult to track the evaluation of each OU and release sites in OU 8 if the various text sections were segmented throughout the document. As presented, the Five-Year Review assessment and information presented is "stand-alone" for each OU and release site in OU 8. In addition, there are differences in the Institutional/Land Use Control section for the different OUs and release sites. Therefore, it would be difficult to consolidate it into one section that covered both OUs and all release sites. As a result, we felt that the benefits of consolidating and reducing text would be outweighed by the added difficulties in tracking the applicable information for each OU and release site.**

2. Many of the site-specific IC discussions reference the ROD (Record of Decision) as an IC; however, it is a decision document, not an enforcement tool, and references to it as such therefore should be deleted.

Response: **The text in Sections 2.3.4.2, 3.1.3.4.2, 3.2.3.4.2, 3.3.3.4.2, 3.4.3.4.2, and 3.5.3.4.2, the "Prohibit Transfer of Lands…" subsections have been modified to state: "Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD."**

Other modifications made to these sections include:

- **The title of these sections has been modified to: "Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls"**
- **The title of the subsections has been changed to "Proprietary Controls Implementation Status." This subsection has been modified to read:**

"To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 Federal Facility Agreement (FFA) and Site 300 ROD contain provisions that prevent DOE from transferring lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR, Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Record of Decision (ROD), and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h)."

3. DOE recommends removing certain analytes as contaminants of concern (COCs) for groundwater, but this raises additional issues. It is not clear that the Report is the appropriate document to propose these changes, as this would normally be done as part of an update to a Groundwater Long-Term Monitoring Plan. In addition, since COCs are specified by the remedy selection in the Site-Wide Record of Decision (ROD) (U.S. DOE, 2008), it is unclear if this change in COCs should be documented in a memorandum to the site file or an Explanation of Significant Difference to the ROD. Notwithstanding specific comments below requesting a delay in the removal of the COCs, revise the Five-Year Review to explain why this is the most appropriate document to recommend changes in COCs and to propose any documentation that might be required for a change to the remedy selected in the ROD.

Response: **The ROD specifies that the CERCLA remediation of the ground water COCs will be considered complete when the concentrations of contaminants of concern are reduced to and remain below the cleanup standard for two years.**

Cis-1,2-dichloroethene (DCE) has not been detected at concentrations above its 6 µg/L Maximum Contaminant Level (MCL) ground water cleanup standard in Pit 6 wells for over 19 years. Perchlorate concentrations have decreased to and remained below the 6 µg/L MCL cleanup standard and the 4 µg/L reporting limit in all Pit 6 wells for over three years (as of the Five-Year Review data cutoff date; now almost four years). Cis-1,2-DCE has not been detected at concentrations above its 6 µg/L MCL ground water cleanup standard in Building 833 (OU 8) wells for over 19 years.

The intent of the Pit 6 Landfill OU 3 Recommendations #3 and #7 and the Site-Wide OU Recommendation #1 was to demonstrate progress towards achieving CERCLA cleanup, by removing CERCLA COCs for which the cleanup standards and criteria has been met (cis-12-DCE and perchlorate at the Pit 6 Landfill and cis-1,2-DCE at Building 833). Because part of the objective of Five-Year Reviews is to evaluate remediation progress, DOE/LLNL believe that this is the most appropriate report to document that remediation of these COCs is complete. Because this does not change the remedy, but rather documents that remediation of these COCs is complete, a memorandum to site file or Explanation of Significant Difference (ESD) would not be necessary.

Any changes to monitoring for these COCs will be documented in the Site 300 Compliance Monitoring Reports.

4. The subsection entitled, "Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives" for each site indicate that inhalation risks associated with vapor intrusion from the subsurface into indoor and outdoor air for trichloroethene (TCE) for onsite workers were evaluated using the new TCE toxicity values and that no risk was identified for the vapor inhalation pathway, but these items are not included. Revise these subsections to provide the updated toxicity criteria and specify the TCE-specific risk and hazard.

Response: **As requested, the updated toxicity criteria, and the TCE-specific risk and hazard were added to the "Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives" and the "Risk Mitigation Remediation Progress" sections for each site (Pit 6 Landfill, and Building 801/Pit 8 Landfill) where the risk was re-evaluated as part of this report. At Building 833, the risk and hazard were assessed using the new TCE toxicity criteria as part of the 2011 Annual Compliance Monitoring Report (Dibley, et al., 2012). At all other OU 8 release sites (the Building 845 Firing Table and Pit 9 Landfill, the Building 851 Firing Table and the Pit 2 Landfill), the vapor inhalation risk was not assessed using the new TCE toxicity criteria**

because TCE was not detected above the reporting limit in ground water at these sites during the past two years (or longer). At sites where the TCE vapor inhalation risk were recently assessed (Pit 6, Building 833, and Building 801 and the Pit 8 Landfill), the cancer inhalation unit risk and the non-cancer reference concentration for TCE were updated to 4.0 x 10^{-6} (µg/m^3)$^{-1}$ and 2.0 x 10^3 mg /m^3, respectively.

5. The review of current toxicity criteria for chemicals of potential concern (COPC) should be revisited. While tetrachloroethene (PCE) is a chemical of potential concern (COPC) at various sites, the Five-Year Review does not indicate that toxicity criteria for PCE were updated in February 2012. Please revise the Report to clarify that toxicity criteria for PCE were updated, present the impacts to cumulative risk and hazard for each site as a result of the updated toxicity criteria, specify if the selected remedy is still protective, provide the updated toxicity criteria, and specify the PCE-specific risk and hazard. Also, revisit the toxicity criteria for all other site COPCs and ensure that all toxicity updates and associated impacts are addressed in the Five Year Review.

Response: **The vapor inhalation risk and hazard were assessed at all sites within OUs 3 and 8 where: (1) a VOC was present in ground water above the reporting limit within the past two years that could potentially migrate from the subsurface to outdoor or indoor air and pose an inhalation risk to onsite workers, and (2) the toxicity criteria changed in the last five years. As discussed in the response to EPA's General Comment #4 above, risk and hazard were calculated using the current TCE toxicity criteria for OU 3 (Pit 6 Landfill) and the OU 8 release sites where TCE is present in ground water (Building 833 and Building 801/Pit 8).**

PCE has not been detected above the reporting limit in ground water in any OU 3 or OU 8 well during the past five years. Therefore, although the toxicity criteria for PCE were updated in February 2012, the re-evaluation of risk and hazard for PCE was not warranted. (Although the February 2012 update to the PCE toxicity criteria occurred outside this review period [January 1, 2007 to January 1, 2012], DOE has included references to this change in the document.)

At the Pit 6 Landfill OU (3), the only other VOC besides TCE that is currently detected above the reporting limit is cis-1,2-DCE; which is detected in only one monitor well (K6-01S). However, there have been no changes to the toxicity criteria for cis-1,2-DCE in the past five years. Therefore, the inhalation risk and hazard were not re-evaluated.

While 1,2-DCA is currently detected in Building 801/Pit 8 Landfill (OU 8) area, there were no changes to the toxicity criteria for 1,2-DCA during the five-year review period. Therefore, the inhalation risk and hazard for 1,2-DCA were not

re-evaluated. No other VOCs besides TCE and 1,2-DCA are detected in ground water in this area.

TCE is the only VOC currently detected in the Building 833 (OU 8) area. Therefore, no additional inhalation risk and hazard re-evaluations were necessary besides that conducted for TCE.

There are no VOCs currently detected in ground water at the Building 845/Pit 9, Building 851, or Pit 2 Landfill OU 8 release sites. Therefore, the inhalation risk and hazard were not re-evaluated.

The "Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives" and the "Risk Mitigation Remediation Progress" sections for OU 3 and the OU 8 release sites were updated to include this information.

6. See "Specific Comments" item numbers 11-16 which refer to the discussion of Pit 6, but are also applicable to the discussion of the OU-8 sites. Apply them as appropriate to revise the OU-8 text too.

Response: **DOE/LLNL checked "Specific Comments" item numbers 11-16 which refer to the discussion of Pit 6, and applied them as appropriate to revise the text for the OU 8 release sites.**

7. The phrase "risk and hazard management" is used throughout the text without noting that this phrase refers to, or at least includes, LUCs (see e.g., page 3, paragraphs 2 and 7). The references should be revised to clarify what is meant by "risk and hazard management" and that the phrase does encompass LUCs.

Response: **Risk and Hazard Management is defined in Section 2.9.1.2 of the Site 300 Record of Decision. Risk and Hazard Management was selected as an element of each OU/release site's cleanup alternative. The following activities are included in risk and hazard management actions, as appropriate to a release site or OU:**

- **Implement land use controls to manage risks:**
  - **Establish building occupancy and/or land use restrictions to ensure that the risks and hazards estimated in the baseline risk assessment are not exceeded due to changing conditions at the site, and that the remedy remains protective of human health and the environment.**
  - **Erect warning signs to ensure compliance with area access restrictions and site-specific building occupancy and land use restrictions.**

- **Continue to implement a risk and hazard monitoring and assessment program:**
  - **Collect and analyze air, water, or soil samples to determine current exposure concentrations of COCs.**
  - **Where applicable, conduct wildlife surveys by biologists to evaluate the presence of the San Joaquin kit fox or other fossorial vertebrate species of special concern and if found, consult with the appropriate wildlife agencies to develop response actions such as monitoring or animal relocation, and evaluate the presence of new species of special concern.**
  - **Integrate these data into risk assessment calculations to determine any changes in risks and hazards until no risk is indicated for two successive years.**
  - **Review these data to evaluate compliance with Remedial Action Objectives (RAOs).**
  - **Report results to stakeholders.**

The Five-Year Review was revised to add "including land use controls" after risk and hazard management references in Sections 1.1 through 1.6.

EPA SPECIFIC COMMENTS

1. **Five-Year Review Summary Form, Page i**: The dates included in the Five-Year Review Summary Form (e.g., construction completion date, triggering date) do not identify the specific day for these dates as specified in the Comprehensive Five-Year Review Guidance (the Guidance); only the month and year were included. In addition, the August 16, 2011 Five-Year Review Inspection mentioned on page 82 is not included. Review the Guidance and revise the Five-Year Review Summary Form to include specific days in all dates, including the August 16, 2011 date for the Five-Year Review Inspection.

Response: **Five-Year Review Summary Form was revised to include a complete date (month, day, and year) for the construction completion, triggering, inspection dates, as requested. The inspection checklist was inadvertently left out of the draft report and was provided to the regulatory agencies at the December 11, 2012 Remedial Project Manager's (RPM) meeting. Attachment A has been included in the draft final version.**

2. **Five-Year Review Summary Form**, **Pages ii – xi, Summary Forms, designation of "Implementing Party:** The designation of the implementing party as a "Federal Facility" is too generic; revise to specify DOE and/or LLNL.

Response: **DOE and/or LLNL were not options provided on the drop down menu of the Summary Form provided by the EPA. However, the Summary Form was revised to replace Federal Facility with DOE.**

3. **Five-Year Review Summary Form**, **Page ii, Recommendation #1:** As no issues are identified in the remedy, it is unclear how the recommendation is a protectiveness issue. If it is not, then it should be removed; if it is, then the "Issue" entry should be revised to reflect the protectiveness issue being addressed by the recommendation.

Response: **EPA is correct that recommendations are not protectiveness issues. However, DOE is the lead agency for the LLNL Site 300 cleanup and therefore, the Five-Year Review is a DOE document. As such, the Five-Year Review Summary Form provides a useful tool to identify recommended additional scope of work to optimize cleanup in the OU for DOE management and to support funding requests. For this reason, the recommendations were not removed from the Summary Form. Text was added to Pit 6 Landfill Recommendation #1, Building 801/Pit 8 Landfill Recommendation #1, Building 845 Firing Table Recommendation #1, and Building 851 Firing Table Recommendation #1 indicating that while no deficiencies in the overall remedy were identified and the remedy is performing as intended, some follow-up actions are recommended to optimize remediation. This should provide EPA with the necessary justification not to include and track them in the EPA database.**

4. **Five-Year Review Summary Form, Page xii, Protectiveness Statement:** a) Should be revised to address both current and future protectiveness not, as now drafted, just current protectiveness; b) The last paragraph refers to a land use control that "prohibits the transfer of lands with unmitigated contamination" and states that this prohibition is "included in the Site-Wide Record of Decision." As noted in General Comment 2, above, the ROD is only a decision document - it selects and describes the selected remedy, but it does not implement the selected remedy. The reference to the "prohibition" being included in the ROD therefore should be changed to the extent that it suggests the ROD is an enforcement tool.

Response: **The 1st paragraph of the Summary Form Protectiveness Statement has been replaced with the following text: "The remedies at OU 3 (also called Pit 6 Landfill OU) and OU 8 currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media, and the remedy will reduce COC concentrations to meet cleanup standards."**

The 4th paragraph of the Protectiveness Statement has been modified to state: "Because some volatile organic compounds (VOCs) may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. The land use control

consists of implementing a land use covenant per Title 22 California Code of Regulations (CCR), Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h) in the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future. This land use control requirement is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substances Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present."

Each individual Protectiveness Statements in Sections 2.10 (Pit 6 Landfill), 3.1.1 (Building 801/Pit 8 Landfill), 3.2.10 (Building 845/Pit 9 Landfill), 3.3.10 (Building 833), 3.4.10 (Building 851 Firing Table), 3.5.10 (Pit 2 Landfill) was also revised as described above.

5. **Section 1, Introduction, Page 1:** The second paragraph states that the "purpose of a Five-Year Review is …to determine whether the remedy will continue to be protective of human health and the environment," but the Five-Year Review must also evaluate whether the remedy is currently protective of human health and the environment. Revise the purpose statement to state that the Five-Year Review must evaluate whether the remedy is currently protective of human health and the environment.

   The triggers for the start of the first five year review identified in Section 1, the Remedial Action Completion Report (Holtzapple, 2008) and the ROD do not include the month or day of these triggering dates. Revise Section 1 to identify the month, day, and year for all triggering actions.

Response: **The first sentence of the second paragraph of Section 1 was revised to state: "The purpose of a Five-Year Review is to evaluate the implementation and performance of a remedy to determine whether the remedy is currently and will continue to be protective of human health and the environment." In addition, the second sentence of the 5th paragraph of Section 1 was revised to include month and day of trigger dates for the Remedial Action Completion Report and ROD.**

6. **Section 1.1, Pages 3 & 4:** The respective discussions of the Central GSA and HEPA in the introduction section do not mention the off-site groundwater and ICs issues. The text should be revised to incorporate a reference to these issues.

Response: **Sections 1.1 and 1.3 were revised to reference that the Five-Year Reviews for the GSA and High Explosives Process Area determined that additional off-**

site land use controls are necessary for long-term protectiveness due to the presence of contamination in offsite ground water.

7. **Section 2.2.1.1, Page 10, second full paragraph:** Revise text to read "well CARNRW1 is used for dust and fire suppression, including to fill a residence pond" or, as appropriate, "well CARNRW1 is used for dust and fire suppression, to fill a residence pond".

Response: **The text in the third sentence of the third paragraph in Section 2.2.1.1 was revised to read, "Water pumped from well CARNRW1 is used to fill a residence pond and for dust and fire suppression.…"**

8. **Section 2.2.1.2, Page 12, second full paragraph:** The text notes that access to the well CARNRW2 is limited. The reasons for the limits, impacts (if any) on the remedy, and efforts to improve access, should be described.

Response: **The wellhead to water-supply well CARNRW2 is sealed and does not allow water level measurements to be taken. However, this well is routinely sampled by collecting water from a sample port at the wellhead. Section 2.2.1.2 (Subsection "Influence of CARNRW1 pumping") was revised to include this information.**

Note: Water-supply well CARNRW2 is owned, maintained, and operated by the California Department of Parks and Recreation (CDPR). In the past, LLNL had approached the California DPR about allowing LLNL to place a transducer in the well to measure water levels. However, the CDPR's legal department advised against allowing a non-CDPR entity to breach sanitary seal (to place equipment in the well) for liability reasons. Therefore, the CDPR denied the request.

9. **Section 2.3.1, Remedy Selection, Page 16, item # 2, second sentence:** This is the only text in the related bullet points that is written in the future tense, suggesting that LUCs have a different status than the other remedial measures. This issue could be resolved by revising the sentence to state: "Implementation of ICs/LUCs . . . ." Also, references to ICs/LUCs should be consistent throughout the document (e.g., cf, page 17 just before the heading for Section 2.3.3, the text only refers to LUCs and heading to Section 2.3.4, "Institutional and Land Use Controls."

Response: **Section 2.3.1, item #2 in the third paragraph was revised to read, "Risk and hazard management to prevent onsite worker exposure to VOCs volatilizing from Spring 7. Land use controls to prevent human exposure to contamination and to protect the integrity of the remedy." In addition, the entire document was reviewed for consistency as requested and the title of Section 2.3.4 was revised to "Land Use Controls."**

10. **Section 2.3.4, Pit 6, Page 18, Landfill:** It appears that there are no institutional controls to protect off-site groundwater users and that monitoring may not be sufficient. There are two off-site water supply wells (CARNRW1 and CARNRW2) that are downgradient of the Pit 6 groundwater plumes. Tritium has been detected at concentrations below the maximum contaminant level (MCL) in guard well W-PIT6-1819, based on recent quarterly groundwater reports, so the lack of institutional controls to protect off-site groundwater users should be discussed in this section. In addition, an additional guard well should be considered. Revise Section 2.3.4 to discuss the lack of institutional controls to protect off-site groundwater users and consider whether an additional guard well is needed.

Response: **The maximum historical tritium activity detected in guard well W-PIT6-1819 is 295 pCi/L (April 2007). The tritium activity in the most recent sample collected from this well in October 2012 was 125 pCi/L, slightly above the 100 pCi/L analytical reporting limit. All tritium activities in well W-PIT6-1819, including the historical maximum and most recent sample, are far below the 20,000 pCi/L MCL, as well as the 400 pCi/L California State Public Health Goal.**

Institutional controls are not needed to protect offsite ground water users in this area because:

- **Historical data indicates that tritium activities in all ground water samples from all Pit 6 wells, including guard well W-PIT6-1819, have always been far below the MCL cleanup standard.**
- **All tritium activities in well guard well W-PIT6-1819, including the historical maximum and most recent sample, are far below the 20,000 pCi/L MCL, as well as the 400 pCi/L California State Public Health Goal.**
- **Tritium activities in the samples collected from water-supply CARNRW1 and CARNRW2 since 1984 have all been near or below the 100 pCi/L analytical reporting limit.**

The installation of an additional guard well is not necessary because the maximum historical tritium activity in guard well W-PIT6-1819 (295 pCi/L) is orders of magnitude below the MCL, and is currently only slightly above the analytical reporting limit.

11. **Section 2.3.4.1, Page 19:** There is no LUC objective for protection from off-site contaminated groundwater, but there should be given the off-site contamination. Revise.

Response: **As indicated in the response to Comment # 10 above, there is no offsite contamination in this area. Therefore, a land use control (LUC) objective for the protection from offsite contaminated ground water is not needed for the Pit 6 Landfill OU. The release sites in OU 8 are all well within the interior of Site 300 and there is no contamination associated with these release site either offsite or**

anywhere near the site boundary. Therefore, a LUC objective for the protection from offsite contaminated ground water is not needed for the OU 8 release sites.

12. **Section 2.3.4.2, Page 21, second full paragraph:** The text refers to "LLNL process for review of proposed new work", but does not describe the "process" as, or otherwise link the "process", to LUCs. Revise.

Response: **The LLNL process for review of proposed new work is described in the "Work Induction Board" subsection of Section 2.3.4.2 (on page 20 of the draft). The process specifies that any proposed onsite well drilling activities are submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. This process is linked to the Governmental Institutional Controls, in this case, used to prevent on-site water-supply use/consumption of contaminated water. No revisions are necessary.**

13. **Section 2.3.4.2, Page 21, first bullet point, Integrity…:** An "Inspection and Maintenance Program" is not an IC or, more broadly, a LUC. Also, as inspection and maintenance is not a LUC, then it should be possible to eliminate the section under the bold-faced heading "Maintain the Integrity of the Landfill Cover . . ." as this issue is addressed (albeit under a slightly different heading title) further down the page. Revise.

Response: **The subsections titled "Maintain the Integrity of Landfill Cover" were deleted from the Landfill Pit 6 (Section 2.3.4.2), Pit 8 (Section 3.1.3.4.2), Pit 9 Section 3.2.3.4.1), and Pit 2 (Section 3.5.3.2) Five-Year Reviews.**

14. **Section 2.3.4.2, Pages 21 & 22, dig permit and work induction board:** The text at various points concludes that the dig permit and work induction board processes "are effective" on the basis that no "excavation or construction activities were proposed" during the five-year period under review. Contrary to the text's conclusion, the effectiveness of these processes has not been demonstrated because they have not been tested. At most, the text should say that no excavation or construction activities were proposed.

Response: **Text was added to the "*Dig Permit Process*" subsection of Section 2.3.4.2 (Pit 6 Landfill Land Use Controls) that states that: "During this five-year review period, there were no dig permit applications to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Pit 6 Landfill OU."**

Text was added to the "*Work Induction Board*" subsection of Section 2.3.4.3 (Pit 6 Landfill Land Use Controls) that states that: "During this five-year review period, there were no proposals brought to the Work Induction Board to

drill and install new onsite water-supply wells within areas of onsite ground water contamination in the Pit 6 Landfill OU."

As necessary, similar text was added to the Dig Permit and Work Induction Board subsections of the Land Use Control Sections for the OU 8 release sites (Section 3.1.3.4.2 [Building 801/Pit 8], Section 3.2.3.4.2 [Building 845/Pit 9], Section 3.3.3.4.2 [Building 833], Section 3.4.3.4.2 [Building 851 Firing Table], Section 3.5.3.4.2 [Pit 2 Landfill]).

15. **Section 2.3.4.2, Page 22, section titled "Physical Barrier Implementation Status:** a) The text does not refer to fencing around Site 300 or OU-6; b) The text concludes that the physical barriers are effective, but does not state or document that there were no incidents of the unauthorized access a fact that is the predicate to the stated conclusion. Revise.

Response: **Note that there are two sections titled "Physical Barrier Implementation Status" in Section 2.3.4.2. The second section discussed fencing. The text was revised to combine the sections to eliminate confusion. In addition, the text was revised to include that the physical barriers are routinely inspected, these inspections are documented in the Annual Compliance Monitoring Report land use control checklist, and there were no incidents of unauthorized access.**

Similar revisions were incorporated in the Landfill Pit 8, Pit 9, and Pit 2 Five-Year Reviews.

16. **Section 2.3.4.2, Page 23, section titled "Enforcement Tools Implementation Status:** a) The first sentence should be revised to state: "the Site 300 FFA contains provision to prevent DOE from transferring lands . . . ." b) Also the text discusses implementation of a land use control, but not deed restrictions which are statutorily required when contamination remains in place but, following the structure of the FYR, these should be set out in a separate section titled "Proprietary Controls." Instead, this section should describe the FFA provision/requirements. c) As with the conclusion in the dig permit/work induction section, the text draws an unsupported conclusion that the transfer prohibition in the FFA is effective even though no prohibited land transfers were even proposed during the FYR period.

Response: **The "*Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools*" Section was significantly revised. The text in Sections 2.3.4.2, 3.1.3.4.2, 3.2.3.4.2, 3.3.3.4.2, 3.4.3.4.2, and 3.5.3.4.2 (Prohibit Transfer) has been modified to state: "Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD."**

Other modifications made to these sections include:

- **The title of these sections has been modified to: "Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls"**
- **The title of the subsections has been changed to "Proprietary Controls Implementation Status." This subsection has been modified to read:**

"To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 Federal Facility Agreement (FFA) and Site 300 ROD contain provisions that prevent DOE from transferring lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR, Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Record of Decision (ROD), and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h)."

17. **Section 2.5.1.1.3, Springs, Pages 28 and 29:** The text states, "DOE continues to monitor well BC6-11, which is used to monitor Spring 7, for water" but this well is not included on Figures 4, 10, or 13. As a result, it is not possible to evaluate whether this well is appropriate to monitor this well for water. Include well BC6-11 on at least one of these figures and reference that figure in the quoted statement.

Response: **The text referenced in the comment above contained a typographic error. The well used to monitor Spring 7 is BC6-13, shown on Figures 4, 10, and 13. The text was changed from BC6-11 to BC6-13.**

18. **Section 2.7, Pit 6 Landfill OU Technical Assessment, Page 39; Section 3.1.7, Building 801 and Pit 8 Landfill Technical Assessment, Page 60; Section 3.2.7, Building 845 Firing Table and Pit 9 Landfill Technical Assessment, Page 76;**

Section 3.3.7, Building 833 Technical Assessment, Page 91; Section 3.4.7, Building 851 Firing Table Technical Assessment, Pages 106 and 107; and Section 3.5, Pit 2 Landfill Technical Assessment, Page 123: It appears that the Technical Assessments for each site do not follow the Guidance in clearly presenting Questions A, B, and C as detailed in Appendix E of the Guidance, Page E-27. Revise all technical assessments to clearly and specifically present and answer Questions A, B, and C.

Response: **The guidance lists Question A as follows: "Question A: Is the remedy functioning as intended by the decision documents?" The Technical Assessment sections of the Five-Year Reviews (Sections 2.7.1, 3.1.7.1, 3.2.7.1, 3.3.7.1, 3.4.7.1, and 3.5.7.1) states, "The remedy was determined to be functioning as intended at the time of the decision documents because:" then lists the reasons this was concluded in the bullets that followed.**

The guidance lists Question B as follows: "Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?" The Technical Assessment sections of the Five-Year Reviews (Sections 2.7.2, 3.1.7.2, 3.2.7.2, 3.3.7.2, 3.4.7.2, and 3.5.7.2) states: "The assumptions used in the decision-making process was determined to still be valid because:" then lists the reasons this was concluded in the bullets that followed.

The guidance lists Question C as follows: "Question C: Has any other information come to light that could call into question the protectiveness of the remedy?" The Technical Assessment sections of the Five-Year Reviews (Sections 2.7.3, 3.1.7.3, 3.2.7.3, 3.3.7.3, 3.4.7.3, and 3.5.7.3) states, "No additional information was identified that would call the protectiveness of the remedy into question:" then lists the reasons this was concluded in bullets.

All the information suggested in the Guidance is contained in the Five-Year Reviews except the use of the "Question A, B, or C" labeling.

19. **Section 2.9, Pit 6 Landfill OU Recommendations and Follow-up Actions, Page 40:** None of the recommendations discussed in Section 2.9 include any completion dates or milestone dates, as suggested in Table 8: Recommendations and Follow-up Actions on Page E-30 of Appendix E of the Guidance. Review the guidance and provide milestone dates for all recommendations and Follow-up actions.

Response: **The guidance was reviewed. DOE determined that a table of recommendations as suggested in the Guidance as Table 8 would be redundant with the Summary Form that tabulates all recommendations and includes milestones.**

20. **Section 2.9, Pit 6 Landfill OU Recommendations and Follow-up Actions, Page 40; Section 3.3.9, Building 833 Recommendations and Follow-Up Actions, Page 93:** A number of recommendation/follow-up action items discussed in Section 2.9 are to remove certain COCs which have been historically detected, but are not presently detected, such as cis-1,2-dichloroethene (cis-1,2-DCE) and perchlorate; however, since this is the First Five-Year review and there are new wells, it is premature to remove any historically detected COCs. For example, perchlorate (which has only been below the reporting limit for about three years) and cis-1,2-DCE, which could increase as TCE degrades, should be monitored until the next Five-Year Review in order to establish that the decreasing trends are consistent. Similarly, since TCE is still present in Building 833 groundwater, it is premature to remove cis-1,2-DCE as a COC. Revise the recommendations and follow-ups to delay removing historically detected COCs until the next Five-Year Review.

Response:

Pit 6 Landfill (OU 3) Recommendations

The Pit 6 Landfill Recommendation #3 in the Five-Year Review was to remove cis-1,2-DCE as a CERCLA ground water COC at the Pit 6 Landfill OU because it has not been detected at concentrations above its 6 µg/L MCL ground water cleanup standard since 1993 (over 19 years). As specified in the ROD, the CERCLA remediation of the ground water COC will be considered complete when the concentrations of COCs are reduced to and remain below the cleanup standard for two years. The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing the cis-1,2-DCE and other CERCLA VOC COCs for which the cleanup standards and criteria has been met.

Ground water samples are collected from the Pit 6 Landfill detection monitor wells and remedial action monitor wells and analyzed for halogenated VOCs by EPA Method 601 that includes cis-1,2-DCE. Therefore, cis-1,2-DCE would be detected and evaluated as part of the semi-annual compliance (detection and remedial action) monitoring and reporting. For example, cis-1,2-DCE that may be present as TCE breakdown product would be detected and evaluated to determine the effectiveness of the monitored natural attenuation (MNA) remedy for TCE at the Pit 6 Landfill. In the event that cis-1,2-DCE concentrations increase above its cleanup standard in the future, Five-Year Reviews and the LLNL Site 300 Contingency Plan includes processes for increases in contaminant concentrations that could impact human health or the environment.

The Pit 6 Landfill Recommendation #7 was to remove perchlorate as a CERCLA ground water COC because perchlorate concentrations in all Pit 6 wells have decreased to and remained below the 6 µg/L MCL cleanup standard and the 4 µg/L reporting limit for over three years (since the Five-Year Review data cutoff date; now almost four years). As discussed above, the CERCLA remediation of the ground water COCs will be considered complete when the

COC concentrations are reduced to and remain below the cleanup standard for two years. The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing perchlorate as a ground water contaminant of concern for because the cleanup standards and criteria have been met. However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill.

While EPA is correct that DOE installed two new monitor wells W-PIT6-2816 and -2817 in the Pit 6 Landfill area in 2012, cis-1,2-DCE and perchlorate have not been detected above their reporting limits in either well. Both wells will continue to be monitored for VOCs by EPA Method 601 that includes cis-1,2-DCE. Perchlorate has never been detected above the reporting limit in wells EP6-07 and -08 that are located less than 50 ft from new well W-PIT6-2816 since monitoring began in these wells in 1999 and 1998, respectively. Wells K6-24, K6-26, and K6-27 are located less than 50 ft from new well W-PIT6-2817. Perchlorate has never been detected above the reporting limit in wells K6-26, and K6-27 since monitoring in these wells began in 1998. Perchlorate was detected once in well K6-24 in 2000, but has not been detected above the reporting limit in this well prior to or after the 2000 detection.

Building 833 (OU 8) Recommendation:
As specified in the ROD, the CERCLA remediation of the ground water COCs will be considered complete when the COC concentrations are reduced to and remain below the cleanup standard for two years. The Building 833 Recommendation #1 to drop cis-1,2-DCE as a CERCLA COC was made because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993 (over 19 years), (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells. The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing the cis-1,2-DCE as a ground water COC because its cleanup standard and criteria have been met.

However, ground water samples from Building 833 monitor wells would still be analyzed for halogenated VOCs by EPA Method 601 to monitor for TCE. Therefore, cis-1,2-DCE that may be present as TCE breakdown product would be detected and evaluated as part of the semi-annual remedial action compliance monitoring and reporting. In the event that cis-1,2-DCE concentrations increase above its cleanup standard in the future, Five-Year Reviews and the LLNL Site 300 Contingency Plan includes processes for increases in contaminant concentrations that could impact human health or the environment.

While EPA is correct that this is the first Five-Year Review for OUs 3 and 8, the selected remedy for these OUs is MNA or monitoring-only, and monitoring has been ongoing in these OUs for over 20 years. Therefore, DOE/LLNL believes there is sufficient data from which to demonstrate that cleanup of specific COCs is complete.

21. **Section 2.9, Protectiveness Statement, Page 42:** a) The text should state that the remedy is protective because there is "no completed exposure pathway." b) Text in the 3rd paragraph states that a "land use control prohibits the transfer of lands with unmitigated contamination," but this is inaccurate. As noted elsewhere, the ROD selected a remedy that requires ICs, but it is not a LUC. The FFA requires that any property transfer comply with the requirements of 42 U.S.C. § 9620(h) and thus does qualify as an enforcement tool type of IC and LUC, but the provision does not prohibit transfers, it just requires that appropriate restrictions be in place to protect human health and environment. Revise.

Response: **The first paragraph of the Protectiveness Statements in the Summary Form and Five-Year Reviews were revised as follows: "…currently protects human health and the environment in the short-term because there is no current exposure to site contamination. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. The remedy is protective in the long-term because institutional controls have been implemented to prevent potential future exposure to contaminated media."**

In addition, the last paragraph was revised to address the transfer of land comments as follows: "The land use control consists of implementing a land use covenant per Title 22 California Code of Regulations (CCR), Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h) in the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future. This land use control requirement is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. Environmental Protection Agency (EPA) risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substances Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present."

22. **Section 3.1.10, Page 62, item (2):** It appears that the word "no" was inadvertently omitted at the beginning of the text following the item number; cf. page 59, Section 3.1.5.4.

Response: **Section 3.1.10 was revised to read, "(2) human health risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were not identified for the Building 801 Dry Well or Pit 8 Landfill,…"**

23. **Section 3.2.2.6, Page 66:** Confirm that the FS addresses RCRA landfill closure requirements as ARARs, and whether there is not a requirement for more than just monitoring at the Bldg 845 Firing Table and Pit 9 Landfill.

Response: **None of the OU3 and OU8 Landfills are RCRA landfills. Pit 6 Landfill was capped under CERCLA in accordance with RCRA requirements to prevent further releases. There has been no evidence of releases from Pits 8 and 9 in the 20 years of monitoring. There are no additional requirements.**

24. **Section 3.2.3.1, Page 66:** The discussion in this section seems contradictory. On the one hand the first sentence states that no RAOs are applicable because "there is no ground water contamination or human health or ecological risks or hazards identified." On the other hand, bullet point 3 states that the final remedy includes "Risk and hazard management to prevent human exposure to contamination . . . ." Consider revising for clarity.

Response: **As discussed in the response to EPA comment #7, Risk and Hazard Management is defined in Section 2.9.1.2 of the Site 300 Record of Decision and does not necessarily mean there is a human or ecological risk identified. Risk and Hazard Management was selected as an element of the cleanup alternative because it includes erecting warning signs (i.e., no excavating in the landfills), monitoring, and reporting the results to stakeholders.**

25. **Section 3.2.3.4, LUCs, Page 68, 3rd full paragraph, penultimate sentence:** LLNL seems to be relying on regulatory agency approval of the LUCs/ICs checklist as evidence of adequacy. Text should clearly state that DOE has the responsibility to determine adequacy.

Response: **The Five-Year Review states, "The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan." This sentence was included in the Five-Year Review to document that the regulators were provided the opportunity to review and approve the checklist that DOE uses to review the land use controls annually. No discussion of adequacy was implied.**

26. **Section 3.2.3.4.2, Physical Barrier Implementation Status, Page 72, 2nd paragraph:** This comment is covered by OU-3/Pit 6 comments, but just to be sure: The statement of effectiveness is not supported by any text/evidence to support the claim (e.g., no incidents of unauthorized access, digging, etc.). Revise.

Response: **Please see response to EPA comment #15.**

27. **Sections 3.3.3.1 and 3.3.3.2, Page 83:** a) Delete the term "the" in the 2 sentence paragraph before items 1 & 2 at the end of Section 3.3.3.1 (this same comment applies to other sections related to Building 833); b) Revise the parenthetical paragraph reference in the 1st paragraph of Section 3.3.3.2 to read "3.3.3.4".

Response: **The word "the" as in "the Building 833" was deleted as requested. The first paragraph of Section 3.3.3.2 was revised to read "3.3.3.4" as requested.**

28. **Section 3.4.2.3, Page 96, 1st sentence:** The word "have" should be changed to "has".

Response: **The text was revised as requested.**

29. **Section 3.4.2.5, Page 96, 2nd paragraph:** The first sentence refers to an agreement among regulatory agencies and LLNL; it should reference how the agreement was documented.

Response: **The Interim Record of Decision (DOE, 2001) documented the industrial land use agreement, however, the first sentence was deleted as it is not necessary to the discussion of Contaminants of Concern.**

30. **Section 3.5.2.1.1, Page 109, and Section 3.5.2.2, Page 110, 1st paragraph:** The description of Pit 2's location is inconsistent: Section 3.5.2.1.1 says "located in the northeastern part of Site 300" and Section 3.5.2.2 says "located in the central portion of Site 300." Revise the copy for clarity.

Response: **Pit 2 is located in the north-central portion of Site 300. The text was revised as appropriate.**

31. **Section 3.5.5.4, Page 122, 3rd paragraph and Section 3.5.10, Page 125, item 3:** The text appears inconsistent with regard to releases from the Pit 2 Landfill: Section 3.4.4.4 says "there is evidence of a possible new release of depleted uranium from the landfill" and Section 3.5.10 says "(3) no contaminant release have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005."

Response: **Section 3.5.5.4 was modified to state that: "Although there was evidence of a possible new release of depleted uranium from the landfill prior to 2005 when clean water was discharged in the surface water drainage adjacent to the Pit 2 Landfill, re-evaluation of risk does not appear to be warranted at this time because total uranium activities are below its cleanup standard, there is no threat of impacts to water-supply wells, and uranium activities decreased following discontinuation of the water discharge."**

Section 3.5.10 was revised to say, "(3) no new contaminant releases have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005."

32. Section 4, Page 125: Date of the next review presumably is in 2018, not 2017.

Response: **The date was changed to 2018.**

MINOR COMMENT

1. **Sections 2.1.5.4.1 through 2.1.5.4.4, Pages 34 and 35:** These sections appear to have been mis-numbered as they follow Section 2.5.1.4 (page 33). Correct the subsection numbering.

Response: **The numbering was corrected.**

Regional Water Quality Control Board (RWQCB)-Central Valley Region Comments

1. **Page 40, Section 2.9. Pit 6 Landfill OU Recommendations and Follow-Up Actions:** The Department of Energy (DOE)/National Nuclear Security Administration (NNSA) recommends delisting 1,2-dichloroethane (1,2-DCA), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE) tetrachloroethene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), and perchlorate from the groundwater contaminant of concern (COC) list at the Pit 6 Landfill because these constituents have either never been detected above reporting limits or have not been detected above their respective maximum contaminant levels (MCLs) for several years. These constituents will still be monitored and will be reported in the detection monitoring section of the Compliance Monitoring Reports, but will no longer be discussed in the contaminant concentration and distribution section of these reports, unless they are detected in the remedial action monitor wells. Regional Water Board staff concur with the recommendations to delist 1,2-DCA, trans-1,2-DCE, PCE, and 1,1,1-TCA from the groundwater COC list for the Pit 6 Landfill. However, Regional Water Board staff do not concur with the recommendation to delist cis-1,2-DCE and perchlorate from the groundwater COC as explained below:

    a. Cis-1,2-DCE is a breakdown product of TCE, and TCE is still being detected in the Pit 6 Landfill groundwater at concentrations above its MCL.
    b. Perchlorate has only been detected below the reporting limit of 4 µg/L since 2009. Prior to 2009, perchlorate was detected above or close to its MCL. Therefore, Regional Water Board staff find that it is premature to delist perchlorate from the groundwater COC list at this time.

Response to Comment 1a: **The Pit 6 Landfill Recommendation #3 in the Five-Year Review was to remove cis-1,2-DCE as CERCLA ground water COCs at the Pit 6 Landfill OU because it has not been detected at concentrations above its 6 µg/L MCL ground water cleanup standard since 1993. As specified in the ROD, the CERCLA remediation of the ground water COCs will be considered complete when their concentrations are reduced to and remain below the cleanup standard for two years. The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing the cis-1,2-DCE and other CERCLA VOC COCs for which the cleanup standards and criteria has been met.**

Ground water samples are collected from the Pit 6 Landfill detection monitor wells and remedial action monitor wells and analyzed for halogenated VOCs by EPA Method 601 that includes cis-1,2-DCE. Therefore, cis-1,2-DCE would be detected and evaluated as part of the semi-annual compliance (detection and remedial action) monitoring and reporting. For example, cis-1,2-DCE that may be present as TCE breakdown product would be detected and evaluated to determine the effectiveness of the MNA remedy for TCE at the Pit 6 Landfill. In

the event that cis-1,2-DCE concentrations increase above its cleanup standard in the future, Five-Year Reviews and the LLNL Site 300 Contingency Plan includes processes for increases in contaminant concentrations that could impact human health or the environment.

Response to Comment 1b: **As discussed in the response to Comment 1a above, the CERCLA remediation of the ground water COCs will be considered complete when their concentrations are reduced to and remain below the cleanup standard for two years. The Pit 6 Landfill Recommendation #7 was to remove perchlorate as a CERCLA ground water COC because perchlorate concentrations have decreased to and remained below the 6 µg/L MCL cleanup standard and the 4 µg/L reporting limit in all Pit 6 wells for over three years (as of the Five-Year Review data cutoff date; now almost four years). The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing perchlorate as a ground water COC for because the cleanup standards and criteria has been met. However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill.**

2. **Page 14, Section 2.2.4. Pit 6 Landfill OU Initial Response:** The diversion channel and the drainage channels discussed in the second paragraph need to be depicted on a site map (Figure 4), including flow directions.

Response: **The requested information was added to Figure 3.**

3. **Page 20, Section 2.3.4.2. Pit 6 Landfill Land Use Controls:**

   a. *Prevent Onsite Water-Supply Use/Consumption of Contaminated Ground Water: Government Institutional Controls:* The last paragraph on Page 20 states that "Nitrate is detected at a concentration exceeding the drinking water standard in only one well. The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated groundwater". DOE/NNSA needs to perform investigations or provide evidence to show that Pit 6 Landfill is not the source or a contributing source for the nitrate detected downgradient of the landfill. In the absence of evidence that shows that the Pit 6 Landfill is not contributing to the nitrate detected downgradient of the landfill, there needs to be land use controls for nitrate to prevent offsite water-supply use/consumption of contaminated groundwater.

   Response: **The statement referenced above that "The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill" is based on the following evidence:**

- **Nitrate (as NO_3) has consistently been detected above the 45 mg/L drinking water cleanup standard in well K6-23 at concentrations ranging between 130 and 240 mg/L since sampling of this well for nitrate analysis started in December of 1998.**

- **Well K6-23 is a shallow well with a sand pack from 15.5 to 25.7 feet (ft) below ground surface (bgs), a screened interval from 19.3 to 24.3 ft bgs), and is located within approximately 50 ft from the Rifle Range septic tank which is approximately 4.5 ft bgs. The depth to ground water in K6-23 ranges from 21 to 24 ft bgs.**

- **A sample was collected from well K6-23 to evaluate for septic effluent indicators using Pharmaceutical and Personal Care Products (PPCP) analysis. Of the 33 PPCP analytes, four were detected as follows: caffeine at 120 nanograms per liter (ng/L); DEET (mosquito repellant) at 18 ng/L; primidone (seizure medication) at 1.4 ng/L; and TCEP (fire retardant) at 1.5 ng/L. Of these four, caffeine and primidone are strong evidence for septic discharge in the sampled ground water.**

- **Septic systems are a known source of nitrate to ground water. When conventional septic systems operate properly, they convert organic nitrogen first to ammonium nitrogen, then to the nitrate form of nitrogen which is water-soluble and can migrate to ground water (NJ Department of Environmental Quality-Water Quality Division).**

- **The potentiometric surface in the vicinity of well K6-23 and the septic system is relatively "flat".**

- **With the exception of one detection of nitrate at 39 mg/L in well K6-21 in 1999, historical maximum nitrate concentrations in the Pit 6 detection monitor wells (and other wells located immediately downgradient of the pit) range from less than 0.5 to 18.1 mg/L. The current maximum concentrations in these monitor wells range from less than 0.5 to less than 1 mg/L. These concentrations are consistent with nitrate concentration in well upgradient from Pit 6 (up to 25.7 mg/L in K6-04).**

- **Waste in Pit 6 came from LLNL Livermore Site and Lawrence Berkeley National Laboratory, and high explosives (HE) compounds were not identified as being disposed of in Pit 6. Non-natural contributions of nitrate at Site 300 are typically attributed to the breakdown of HE compounds.**

- **Nitrate concentrations in wells further downgradient of the Pit 6 Landfill but upgradient of the septic system have been within the range of**

background concentrations (compared to concentrations in wells located upgradient of the pit) with two exceptions:

- **Nitrate was detected in well K6-24 at concentrations of 62 mg/L and 63 mg/L in January and April 2011, respectively. However, nitrate concentrations have ranged from less than 0.4 to 1.5 mg/L in all other samples from this well since 1998.**
- **Nitrate was detected at concentrations exceeding the 45 mg/L MCL in well K6-18 in December 1998 (78 mg/L) and in March and May of 2009 (52 and 54 mg/L). Nitrate concentrations in other samples from this well range from <0.5 (January 2012) to 38 mg/L (May 1999).**

Land use controls are not needed to prevent offsite water-supply use/consumption of nitrate because ground water with nitrate with concentrations above the 45 mg/L MCL cleanup standard is currently restricted to onsite ground water in one well (K6-23). Nitrate has never been detected above background levels in the offsite Carnegie water-supply wells CARNRW1 and CARNRW2. The maximum historical nitrate concentration detected in these wells are 1.1 mg/L in CARNRW1 and 2.9 mg/L in CARNRW2; which are well below the MCL cleanup/drinking water standard and within background levels for nitrate in ground water.

Well K6-23 is located cross-gradient from the offsite Carnegie water-supply wells CARNRW1 and CARNRW2. The maximum historical nitrate concentration detected in the closest upgradient well (W-PIT-1819) to these water-supply wells is 8.1 mg/L, which is also well below the MCL cleanup/drinking water standard and within background levels for nitrate in ground water.

b. *Control Construction and Other Ground-breaking Activities on the Landfill*: Governmental Institutional Controls: The second last paragraph makes reference to the Building 851 Firing Table. This sentence is misplaced and has no relevance to the Pit 6 Landfill. Please correct this discrepancy.

Response: **The section has been revised to change the reference to Building 851 Firing Table to the Pit 6 Landfill.**

4. **Page 26, Section 2.5.1.1.1. VOC Concentrations and Distribution by HSU, Qt-Tnbs$_1$ South HSU:** The fifth paragraph states that, "Data from 1988 was used to represent the pre-remediation time period because this was the year of maximum VOC concentrations, as previously depicted on Figure 14(a)." The referenced figure is missing from the 5-YR Review Report. Please include the referenced figure.

Response: **The referenced figure in this sentence should have been Figure 15(a), which does already exist. The text was modified to reference the correct figure.**

5. **Page 28, Section 2.5.1.1.3. Springs:** The first paragraph states that TCE has been historically detected in shallow well BC6-13, which monitors Spring 7. However, the last sentence of this paragraph states that"….DOE continues to monitor well BC6-11, which is used to monitor Spring 7, for water from which to collect a sample." The well identification discrepancy should be corrected. In addition, the last sentence of the first paragraph is also grammatically incorrect and needs to be revised.

Response: **The paragraph was revised as follows:**
TCE has historically been detected in shallow well BC6-13, which monitors Spring 7, at concentrations of up to 110 µg/L. This well (and spring) has been dry since 2000. TCE was detected in the last sample collected before the well and spring went dry at a concentration of 4 µg/L. DOE continues to monitor for the presence of water in well BC6-13, and if detected, will collect a sample.

6. **Page 30, Section 2.5.1.2.1. Tritium Activities and Distribution by HSU:** The 5-YR Review report states that monitoring well BC6-13, which yielded the historic maximum tritium activity at the Pit 6 Landfill is not shown on Figure 19 because it has been dry since 2000. Please include the activity trend for tritium in groundwater prior to 2000 for BC6-13 on Figure 19, to show how historical activities of tritium varied with time in this well during the times when it was not dry.

Response: **Historically, only three tritium samples have been collected from well BC6-13. The tritium activities for these samples are as follows:**

- **<200 pCi/L in November 1991 sample.**
- **1,210 pCi/L in January 2000 sample.**
- **3,420 pCi/L in May 2000 sample.**

These data were not added to Figure 9 as they are 13 to 23 years old and the data shown on Figure 9 represent the most recent data from these wells and the current tritium plume configuration (as of the data cutoff date for this Five-Year Review). The well was also dry from 1992 to 1997, therefore no samples were collected during this time period. In 1998 and 1999, while water was present in well BC6-13, this well was being sampled in accordance with the Pit 6 Post-Closure Plan that only required that samples from this well be analyzed for VOCs. Therefore, there are no tritium data available for this well in those two years.

7. **Page 32, Section 2.5.1.2.4. Tritium Remediation Progress Summary:** The third paragraph of the 5-YR Review Report states that tritium activities in ground water continue to decrease toward background levels. Please provide the value or range of values for background activities of tritium in the 5-YR Review Report.

Response: **The paragraph was revised to state: "Tritium activities in ground water continue to decrease toward background levels of 100 pCi/L and remain**

significantly below the 20,000 pCi/L cleanup standard, and the tritium plume extent is stable to decreasing."

8. Page 35, Section 2.1.5.4.4. Nitrate Remediation Progress Summary:

a. The first paragraph makes reference to Building 899 as the likely source of nitrate detected in well K6-23. Please indicate on the site map where Building 899 is located.

Response: Section 2.1.5.4.4 was renumbered to Section 2.5.1.4.4. Buildings 899A and 899B have been added to Figure 4. In addition, the fourth sentence of the first paragraph of Section 2.5.1.4.4 has been corrected to reference Building 899B.

b. The second paragraph states that nitrate is currently not detected in any of the Carnegies SVRA water supply wells or in the upgradient guard well W-PIT6-1819 above the reporting limit of 0.5 mg/L. However, the First Semester 2012 Compliance Monitoring Report (CMR) shows that nitrate was detected at 8.1 mg/L in W-PIT6-1819 and up to 2.9 mg/L in CARNRW2. Therefore, the statement is inaccurate and should be rephrased.

Response: **The data cutoff date for this Five-Year Review was the 4th quarter of 2011. Using this data cutoff date, the "current" nitrate concentrations in water-supply wells CARNRW1 and CARNRW2, and in W-PIT6-1819, as referenced in Section 2.5.1.4.4, were at or below the 0.5 mg/L reporting limit. However, the RWQCB is correct that nitrate concentrations in wells CARNRW2 and W-PIT6-1918 in the first semester of 2012 (after the five-year review data cutoff date) were above the reporting limit. Therefore, the first sentence of the second paragraph in Section 2.5.1.4.4 has been removed. The second sentence has been modified to state: "Nitrate concentrations in the Carnegie SVRA water-supply wells and the upgradient guard well W-PIT6-1819 have always been well below the 45 mg/L MCL cleanup standard and within the range of background levels."**

9. Page 56, Section 3.1.5.1. Building 801 and Pit 8 Landfill Contaminant Distribution, Concentrations, and Remediation Progress and Figure 27:

a. The first paragraph states that there are no COCs in groundwater at the Pit 8 Landfill. However, the subsequent paragraph states that VOCs are detected in groundwater beneath the landfill. The VOCs are attributed to releases from the former Building 801 dry well that have migrated beneath the landfill. The first paragraph should be revised for clarity.

Response: **The first paragraph of Section 3.1.5.1 has been modified to state: "There are no COCs in ground water, vadose zone, or surface soil attributable to releases from the Pit 8 Landfill. VOCs detected in samples from wells adjacent**

to Pit 8 originate from releases from the former Building 801D dry well that has migrated downgradient to the vicinity of the landfill."

b. DOE/NNSA's interpretation of groundwater flow, and the consequent source of the VOCs is based on groundwater elevations measured in the monitoring wells. The potentiometric surface at well K8-01 is about 1 foot higher than at well K8-04, which appears to be about 25 feet higher in elevation. Therefore, the potentiometric surface appears to dip away from the topographic surface shown on Figure 27. This is an unusual flow pattern, but is possible if the underlying stratigraphic structure dips to the east or northeast. DOE/NNSA needs to include a cross section through this site to show the stratigraphic structure, depth of well screens, and groundwater elevations to support the designation of the wells as upgradient or downgradient, and the consequent interpretation of the source of the VOCs.

Response: **In ground water systems, it is not necessary that the aquifer potentiometric surface and topographic surface have a similar slope and azimuth direction or that the direction not vary temporally. Since wells were installed at the Pit 8 landfill in 1989, ground water flow direction has ranged from northeast to southeast. This range of direction is actually towards higher ground. Ground water flows from regions of higher pressure/elevation head to regions of lower pressure/elevation head (recharge area to discharge area), irrespective of the topographic surface and stratigraphic dip. At Site 300, recharge areas are often located in valley bottoms. Because of the abundant hills and valleys, flow often is counter to topography. Cross-sections are not included in the report because all that is necessary to determine potentiometric surface, flow direction, and gradient are water elevation measurements from three or more wells completed in the same hydrostratigraphic unit (HSU) as was done on Figure 27. (LLNL staff met with the RWQCB RPM on January 31, 2013 and provided an overview of the topography, subsurface geology, HSUs screened by monitor wells, and ground water elevation data for the various OU 8 release sites discussed in the Five Year Review document.)**

c. It does not appear that the VOC plume (particularly 1,2-DCA which is detected above its MCL) has been fully delineated in the vicinity of Building 801 and the Pit 8 Landfill. DOE/NNSA needs to install additional monitoring wells to fully delineate the extent of the 1,2-DCA plume in this area.

Response: **As discussed in the Recommendation Section 3.1.9, three new wells are proposed for the Building 801/Pit 8 Landfill. These wells will be located one north, one east, and one south of Pit 8. DOE/LLNL will provide a map of the specific locations of these monitoring wells to the regulatory agencies prior to installation.**

10. **Page 58, Section 3.1.5.2. Pit 8 Landfill Detection Monitoring and Results:** The fourth paragraph states that "While TCE and 1,2-DCA are detected in wells downgradient of the landfill, concentrations of these COCs are also detected in wells upgradient of the landfill at higher concentrations. This data indicate that these constituents have migrated downgradient from the Building 801D former dry well area, and do not represent a release of VOCs from the Pit 8 Landfill." It is unclear to Regional Water Board staff how the monitoring wells in the vicinity of the Pit 8 Landfill and Building 801 have been designated as upgradient or downgradient wells. See Comment No. 9b.

Response: **The wells have been designated upgradient and downgradient based on the historic direction range of ground water flow in the area (ranging from northeast to southeast), as determined by the potentiometric surface. Based on the range of ground water flow direction since 1989, wells K8-02B, K8-04 and K8-05 have been generally downgradient of Pit 8 and wells K8-01 and K8-03B have been generally upgradient of Pit 8. All five of these wells have been generally downgradient of the Building 801D former dry well.**

11. **Page 62, Section 3.1.9. Building 801 and Pit 8 Landfill Recommendations and Follow-up Actions:** Regional Water Board staff concur with the recommendation to install additional monitoring wells in the vicinity of Pit 8 Landfill to increase detection monitoring coverage for the varied groundwater flow directions observed in this area. DOE/NNSA should provide the rationale for the number and location of the proposed monitoring wells.

Response: **Three new wells are proposed for the Building 801/Pit 8 Landfill. These wells will be located north, east, and south of Pit 8. These locations have been selected to provide a well downgradient of Pit 8, based on the range of flow direction (from north-north-east to southeast) observed in the area since 1989. The number and general locations of the proposed monitor wells are specified in Section 3.1.8 (Building 801 and Pit 8 Landfill Recommendations and Follow-up Actions) and in the Five-Year Review Summary Form (Building 801 and Pit 8 Landfill Recommendation #1). The exact well locations are dependent on a number of factors such as accessibility for the drill rig and post-installation monitoring, locations of utility lines or other infrastructure, and safety considerations that have not yet been evaluated. DOE/LLNL will provide a map of the specific locations of these monitoring wells to the regulatory agencies prior to installation.**

12. **Page 64, Section 3.2.2.2. Building 845 Firing Table and Pit 9 Landfill and Resources Use:** The second paragraph states that explosive wastes are treated in an open burn pan and/or cage, and ash waste is collected in drums for up to nine months near the open burn units. Please specify how DEO/NNSA disposes of these drums.

Response: **The drums of ash are shipped offsite as hazardous waste through the LLNL Radioactive and Hazardous Waste Management organization to a permitted treatment, storage or disposal facility. The California Department of Toxic Substances Control regulates the disposal and performs annual inspections of the facility and LLNL waste management practices.**

13. **Page 78, Section 3.2.9. Building 845 and Pit 9 Landfill Recommendations and Follow-Up Actions:** Regional Water Board staff concur with the recommendation to install additional monitoring wells in the vicinity of the Pit 9 Landfill to increase detection monitoring coverage for the varied groundwater flow directions observed in the area. DOE/NNSA should provide the rationale for the number and location of the proposed monitoring wells.

Response: **Three new wells are proposed for the Building 845/Pit 9 Landfill. These wells will be located northwest, northeast, and east of Pit 9. These locations have been selected to place the new wells along an arc that defines the downgradient side of Pit 9, based on the range of flow direction (from northwest to nearly east) observed since 1988. The number and general locations of the proposed monitor wells are specified in Section 3.2.9 (Building 845 Firing Table and Pit 9 Landfill Recommendations and Follow-up Actions) and in the Five-Year Review Summary Form (Building 845 Firing Table and Pit 9 Landfill Recommendation #1). The exact well locations are dependent on a number of factors such as accessibility for the drill rig and post-installation monitoring, locations of utility lines or other infrastructure, and safety considerations that have not yet been evaluated. DOE/LLNL will provide a map of the specific locations of these monitoring wells to the regulatory agencies prior to installation.**

14. **Page 82, Section 3.3.2.5. Building 833 Contaminant of Concern:** The first paragraph states that exposure, use, or ingestion of contaminated groundwater is highly unlikely because the perched water-bearing zone is naturally unsuitable for drinking water due to high total dissolved solids (TDS) and low sustainable yields. The 5-YR Review Report should reference the source of this information and specify the TDS concentration of the groundwater.

Response: **The U.S. EPA MCL for TDS is 500 parts per million (ppm). Historically, DOE/NNSA has collected samples from three wells in the Building 833 area for TDS analysis (five times). TDS measurements have exceeded (three times) or nearly exceeded (two times) the EPA MCL for TDS. These results include:**

- **W-833-03 = 1220 mg/L (12/22/1998).**
- **W-833-12 = 900 mg/L (2/11/1993) and 740 mg/L (5/29/1998).**
- **W-833-30 = 460 mg/L (6/12/1991) and 460 mg/L (12/9/1991).**

15. **Page 93, Section 3.3.9. Building 833 Recommendations and Follow-up Action:** DOE/NNSA recommends delisting cis-1,2-DCE as a groundwater COC because it

has only been detected in one well at concentrations below the reporting limit of 0.5 µg/L. Regional Water board staff do not concur with this recommendation because 1,2-DCE is a breakdown product of TCE, and TCE is COC in the subsurface soil and is still being detected above its MCL in groundwater.

Response: **As specified in the ROD, the CERCLA remediation of the ground water COCs will be considered complete when their concentrations are reduced to and remain below the cleanup standard for two years. The recommendation to drop cis-1,2-DCE as a CERCLA COCs at Building 833 was made because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells. The intent of this recommendation was to demonstrate progress towards achieving CERCLA cleanup, by removing the cis-1,2-DCE as a ground water COC because its cleanup standard and criteria have been met.**

However, as indicated in Recommendation #1 for Building 833, ground water samples from Building 833 monitor wells would still be analyzed for halogenated VOCs by EPA Method 601 to monitor for TCE. Therefore, cis-1,2-DCE that may be present as TCE breakdown product would be detected and evaluated as part of the semi-annual remedial action compliance monitoring and reporting. In the event that cis-1,2-DCE concentrations increase above its cleanup standard in the future, Five-Year Reviews and the LLNL Site 300 Contingency Plan includes processes for increases in contaminant concentrations that could impact human health or the environment.

16. **Page 107, Section 3.4.9. Building 851 Firing Table Recommendations and Follow-up Action:** Regional Water Board staff concur with the recommendation to install additional monitoring wells in the vicinity of Building 851 where the groundwater gradient is nearly flat, to provide additional groundwater data in this area. DOE/NNSA should provide the rationale for the number and location of the proposed monitoring wells.

Response: **Two new wells are planned for the Building 851 Firing Table area. These wells will be located west and east-northeast of the Building 851 Firing Table. These new well locations will supplement the existing four wells in completely surrounding the Building 851 Firing Table with a monitoring network and provide adequate coverage in the area with a nearly flat historic ground water gradient since 1991. The number and general locations of the proposed monitor wells are specified in Section 3.4.9 (Building 851 Firing Table Recommendations and Follow-up Actions) and in the Five-Year Review Summary Form (Building 851 Firing Table Recommendation #1). The exact well locations are dependent on a number of factors such as accessibility for the drill rig and post-installation monitoring, locations of utility lines or other**

infrastructure, and safety considerations that have not yet been evaluated. DOE/LLNL will provide a map of the specific locations of these monitoring wells to the regulatory agencies prior to installation.

17. **Page 119, Section 3.5.5.1. Pit 2 Landfill Contaminant Distribution, Concentrations, and Remediation Progress:** The first sentence states that nitrate is the only COC identified in groundwater in the Pit 2 Landfill area. However, tritium, uranium, and perchlorate are COCs also detected in groundwater within the Pit 2 Landfill area as discussed in the subsequent Section 3.5.5.2. Please clarify the statement that nitrate is the only COC identified in groundwater in the Pit 2 Landfill area.

Response: **Section 3.5.5.1 discusses the distribution, concentrations and remediation progress for the CERCLA contaminants of concern (COCs) at the Pit 2 Landfill as determined by CERCLA remedial investigation of this area. CERCLA contaminants of concern are those constituents that have been released to the environment (i.e., ground water) that exceed regulatory standards (MCL cleanup standards), and for which CERCLA remediation is warranted. Nitrate was the only CERCLA COC identified in Pit 2 Landfill ground water identified in the CERCLA ROD. Therefore, only nitrate in Pit 2 ground water is discussed in Section 3.5.5.1.**

Section 3.5.5.2 discusses the detection monitoring conducted at the Pit 2 Landfill to identify new releases from the landfill. Tritium, uranium, and perchlorate are identified as constituents of concern for the purposes of detection monitoring of the landfill. Constituents of concern, as defined by Title 23 of the California Code of Regulations (Chapter 15) for the purposes of leak detection monitoring of landfills, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in a landfill. The constituents of concern for detection monitoring at the Pit 2 Landfill are listed in the Compliance Monitoring Plan/Contingency Plan for Site 300 and include tritium, uranium, and perchlorate. Therefore, tritium, uranium, and perchlorate in ground water are discussed in Section 3.5.5.2 (Pit 2 Landfill Detection Monitoring Results).

18. **Page 121, Uranium:** The first paragraph refers to the maximum activity of tritium rather than uranium. Please correct this discrepancy.

Response: **The second sentence of first paragraph of the uranium subsection in Section 3.5.5.2 was revised as follows: "The maximum uranium activity in the Qal/WBR HSU ground water during the five-year review period was detected at an activity of 4,620 pCi/L (June 2007) in well NC2-14S, located upgradient of the landfill."**

19. **Figure 2:** OU 9 (Building 812) is not shown on this site map figure. Please include the location of OU 9 on this figure.

Response: **Figure 2 has been modified to include the location of OU 9 (Building 812).**

20. **Table 2, Description of land use Controls for the Pit 6 Landfill:**

    a. It is stated in the table that the elevated nitrate detected in groundwater at the Pit 6 Landfill is likely due to septic system discharge rather than from the landfill, and land use controls are therefore not needed to prevent offsite water-supply use/consumption of contaminated ground water. Regional Water Board staff do not concur. See Comment No. 3a.

Response: **Please refer to the response to RWQCB Comment 3a**.

    b. Table 2 makes reference to the LLNL Site 300 Integrated Strategic Plan (Plan) where land use controls for the Pit 6 Landfill will be incorporated. This Plan is not discussed anywhere in the text of the 5-Year Review Report and it is not clear whether this is an existing Plan or whether it is a Plan that will be prepared in the future. DOE/NNSA needs to provide an explanation of the Plan and the schedule of when the land use control will be incorporated into the Plan.

Response: **The original intent was to incorporate the land use controls for the Site 300 OUs into the LLNL Site 300 Integrated Strategic Plan. However, with the development of institutional/land use controls for the LLNL Livermore Site OU, LLNL is evaluating alternate institution-wide documents to find the best mechanism to incorporate the land use controls and institutionalize any associated restricted usage and activities (i.e., ensure that site activities do no conflict with land and resource restrictions throughout the life-cycle of the institutional/land use controls) for both the Livermore Site and Site 300.**

21. **Table 5, Description of land use Controls for the Operable Unit 8:** Similar to Table 2 above, Table 5 makes reference to the Plan into which land use controls for OU 8 will be incorporated. DOE/NNSA needs to provide an explanation of the Plan and the schedule of when the land use control will be incorporated into the Plan.

Response: **Please refer to the response to RWQCB Comment #20b.**

California Department of Toxic Substances Control (DTSC) Comments

1. **Five-Year Review Summary Form, page ii – OU3** Recommendation #1 is not clear; the recommendation is to monitor trichloroethene (TCE) concentrations in ground water at well (EP6-09; if concentrations increase or remain above 5 micrograms per liter (µg/L), remedial measures such as pump-and-treat or enhanced in situ bioremediation will be considered for this well. However, per Table 3 of the Five-Year Review Report and per the First Semester 2012 Compliance Monitoring Report, TCE was detected at concentrations above 5 (µg/L) in April 2011 and January 2012, respectively; therefore, your recommendation should be revised to indicate that remedial measures will be considered to reduce TCE concentrations below the cleanup goal.

Response: **As stated in Section 2.9 (Pit 6 Landfill OU Recommendations and Follow-Up Actions), DOE/LLNL will monitor TCE concentrations in ground water at well EP6-09 <u>over the next five years</u>. If concentrations increase or remain above 5 µg/L, remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well. The text in Recommendation #1 in the Summary Form will be modified to be consistent with the statement in Section 2.9.**

2. **Five-Year Review Summary Form, OU3 Recommendations 2, 3, 4, 5, 6, and 7 and OU8/Building 833, Recommendation 1** – Please see GSU Memo attached**.**

Response: **Please see responses to GSU comments below.**

3. **Section 2.3.3, Pit Landfill OU Operation and Maintenance, Page 18** – This section states that DOE proposed and the regulatory agencies agreed to modify the detection monitoring and reporting program for the Pit 6 Landfill for consistency with the Detection Monitoring Program in the Compliance Monitoring Plan and that DOE will submit an Addendum to the Compliance Monitoring Plan to incorporate the Pit 6 Detection Monitoring and Reporting Program which will supersedes the 1998 Post-Closure Monitoring Plan. Please add a sentence or two stating when DOE will submit the Addendum to the Compliance Monitoring Plan to **incorporate the Pit 6 Detection Monitoring and Reporting Program to the regulatory agencies.**

Response: **DOE will submit the Draft Compliance Monitoring Plan/Contingency Plan Addendum to the regulatory agencies by May 2, 2013. This information was not added to Section 2.3.3 as the date will have passed by the time the Five-Year Review is finalized.**

4. **Section 2.4.3, Document Review –** It is unclear if all documents listed are uploaded in www-erd.llnl.gov/library/index.html#reports.s300. For example, I did see "Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994)" and "Construction Completion Report for the

Pit 6 Landfill Operable Unit at Lawrence Livermore National Laboratory Site 300 (Holtzapple, 2008)". Please verify and make sure that all documents listed are uploaded.

Response: **The LLNL Environmental Restoration Department electronic library was checked for the documents reviewed as part of the Five Year Review. All documents were available with the exception of the Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994) and Construction Completion Report for the Pit 6 Landfill Operable Unit at Lawrence Livermore National Laboratory Site 300 (Holtzapple, 2008). The Final Site-Wide Remedial Investigation was created prior to online electronic storage availability. The document consists of 15 large binders and is too large to scan and place online. All the regulatory agencies received a copy of this document. The Construction Completion Report for the Pit 6 Landfill Operable Unit was a letter from Claire Holtzapple to the regulatory agencies. Letters are not stored in the online library.**

5. **Section 2.9, Pit 6 Landfill OU Recommendations and Follow-up Actions, Items 1-7 –** See comment 1.

Response: **Please refer to the response to DTSC comment 1.**

6. **Section 3.1.4.3, Documents Review –** It is unclear if all the documents listed are uploaded in www-erd.llnl.gov/library/index.html#reports.s300. Please verify. Do the same for Sections 3.2.4.3, 3.3.4.3, 3.4.4.3, and following sections discussing documents review.

Response: **Please refer to the response to DTSC comment 4.**

7. **Section 3.1.5.2, Pit 8 Landfill Detection Monitoring and Results –** Please identify Title 26 metals. Since analytical results are compared to background concentrations, please identify background concentrations for the constituents to concern.

Response: **The Compliance Monitoring Plan defines the LLNL Title 26 metals suite as antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.**

Background for metals in Site 300 ground water were presented in the Site Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999) as shown below:

Metal	Maximum Background Concentration in Site 300 Ground Water (mg/L)
Antimony	**0.007**
Arsenic	**0.22**
Barium	**0.29**
Beryllium	**0.004**
Cadmium	**0.0015**
Chromium	**0.026**
Cobalt	**0.001**
Copper	**0.05**
Lead	**0.02**
Mercury	**0.0018**
Molybdenum	**0.057**
Nickel	**0.021**
Selenium	**0.033**
Silver	**0.0004**
Thallium	**Not detected**
Vanadium	**0.17**
Zinc	**0.12**

8. **Section 3.1.6, Building 801 and Pit 8 Landfill Interviews and Site Inspection –** Please identify where Attachment A (Five-Year Review Inspection Checklist) can be found at. Make sure to add it to this report and list it on the table of content.

Response: **Attachment A was inadvertently left out of the report. Attachment A was provided to the regulatory agencies at the December 11, 2012 RPM meeting. Attachment A was added to the Draft Final Report.**

9. **Section 3.3.9, Building 833 Recommendations and Follow-up Actions –** Please see GSU Memo attached.

Response: **Please see responses to the GSU comments below.**

Geological Services Unit (GSU) comment 1: Proposal to remove chemicals of concern (COCs) from the monitoring program. The report defines a COC as "groundwater contaminant of concern" (Recommendation #2 page iii). However, in the Record of Decision (ROD), the regulatory framework for defining COCs was the California Code of Regulations (CCR) Title 23, Chapter 15 (e.g., see Section 2.5.2. Pit 6 Landfill Detection Monitoring and Results, page 35). Title 23 definitions are relevant to the proposal to remove certain COCs from the monitoring program of OU 3 (Recommendations 1-7) and OU 8 Building 833 (Recommendation 1). Title 23 framework for Post-Closure Monitoring includes the following conditions:

- Constituents are identified in disposal records or are potentially associated with the buried waste.
- Constituents are detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products can reasonably be expected to be associated with the type of waste disposed in the landfill.

The GSU is not recommending removal of the COCs due to the following:

- Because of the Title 23 definitions of COCs,
- Most of the COCs being proposed for elimination are trichloroethene (TCE) degradation products (e.g., 1,1-dichloroethene (DCE), trans-1,2-DCE, and cis-1,2-DCE), degrading TCE could easily result to any of these COCs. In fact, vinyl chloride (VC), another TCE degradation product should also be monitored. The GSA would like to request clarification why VC was not considered as a COC.
- Hazardous substances are left-in-place as part of the remedy, the ground water monitoring determines performance of the selected remedy.

Recommendations

GSU defers final review and approval to the Regional Water Quality Control Board who directly administer the post closure groundwater monitoring. However, GSU will be available to give comments and recommendations if requested.

Response: CERCLA Contaminants of Concern versus Title 23 CCR Chapter 15 Constituents of Concern:

The acronym COCs is used only for CERCLA contaminants of concern in LLNL Site 300 reports, including the Five-Year Review for OUs 3 and 8. Contaminants of concern are those chemicals, metals, radionuclides, or other contaminants that have been identified through the CERCLA process as having been released to and are present in environmental media (i.e., soil, ground water, surface water) at concentrations that pose: (1) an unacceptable risk or hazard to human or ecological receptors, or (2) a threat to ground water. Based on these criteria, the CERCLA ground water contaminants of concern identified for the Pit 6 Landfill were VOCs (chloroform, 1,2-dichloroethane [DCA], cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-trichloroethane [TCA], and TCE), tritium, perchlorate, and nitrate. The CERCLA ground water contaminants of concern identified for the Building 833 area were TCE and cis-1,2-DCE. Ground water cleanup standards were selected in the LLNL Site 300 ROD for these CERCLA ground water contaminants of concern to mitigate risk/hazard to human receptors (assuming that a water-supply well could potentially be drilled into the VOC plumes with concentrations exceeding drinking water Maximum Contaminant Levels [MCLs]) at the Pit 6 Landfill and Building 833. As specified in the ROD, the CERCLA remediation of the ground water contaminants of concern in these areas will be considered complete when the concentrations of these contaminants of concern are reduced to and remain below the cleanup standard for two years. The remedial action monitoring of CERCLA contaminants of concern is conducted to determine when these criteria are met and remediation under CERCLA is complete. Therefore, remedial action monitoring

for CERCLA contaminants of concern can be discontinued when their concentrations remain below ground water cleanup standards for two years.

Detection monitoring of ground water for constituents of concern is conducted at Pit 6 to identify any future releases from the landfill waste to ground water in accordance with the post-closure requirements of Title 23 CCR Chapter 15. Constituents of concern are different from the CERCLA contaminants of concern (COCs). As mentioned in the comment above and in Section 2.5.2 of the Five-Year Review, constituents of concern, as defined by Title 23 CCR Chapter 15 are:

- **Constituents identified in disposal records or that are potentially associated with the buried waste.**
- **Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.**
- **Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill.**

To avoid confusing CERCLA contaminants of concern (COCs) with constituents of concern under Title 23 CCR Chapter 15, only the CERCLA contaminants of concern are referred to by the acronym COCs in LLNL documents including this five-year review.

CERCLA contaminants of concern at the Pit 6 Landfill and Building 833, Title 23 CCR Chapter 15 constituents of concern at the Pit 6 Landfill, and monitoring thereof are discussed below.

Pit 6 Landfill Recommendations #2-7: **As discussed above, the CERCLA contaminants of concern at the Pit 6 Landfill include: chloroform, 1,2- DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1- TCA, and TCE, tritium, perchlorate, and nitrate. The Title 23 CCR Chapter 15 constituents of concern monitored in detection monitor wells at the Pit 6 Landfill include the CERCLA ground water contaminants of concern (constituents detected above background concentrations in ground water in the immediate vicinity of the landfill indicating a previous release), as well as other constituents identified in disposal records or that are potentially associated with the buried waste, and breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill (i.e., halogenated VOCs, beryllium, mercury, uranium, and other radiological constituents).**

The Pit 6 Landfill Recommendations #2-7 in the Five-Year Review were to remove cis-1,2-DCE, trans-1,2-DCE, 1,2-DCA, PCE, 1,1-TCA, and perchlorate in Pit 6 ground water as CERCLA ground water contaminants of concern because they have not been detected at concentrations above their ground water cleanup standards for two or more years. The intent of these recommendations were to demonstrate progress towards achieving CERCLA cleanup, by removing the CERCLA volatile organic compounds (VOC) contaminants of concern for which the cleanup standards and criteria has been met.

However, DOE is not proposing to remove these VOCs as constituents of concern under Title 23 CCR Chapter 15. DOE would continue to monitor these VOCs in the Pit 6 detection monitor wells to identify potential future releases from the landfill as long as long as the waste remains in place. For example, once CERCLA cleanup is complete in the Pit 6 Landfill OU, detection monitoring of the landfill would be transferred to a RWQCB Waste Discharge Requirement permit.

***Building 833 Recommendation #1*: The CERCLA contaminants of concern detected in ground water at Building 833 (TCE and cis-1,2-DCE) are the result of rinsewater or waste-water discharges to the ground surface and to a former rinse water lagoon adjacent to Building 833. When the concentrations of CERCLA contaminants of concern in Building 833 ground water are reduced to meet the MCL ground water cleanup standards and do not rebound for two years, remediation of the contaminant of concern is considered complete and remedial action monitoring can be discontinued. The recommendation to drop cis-1,2-DCE as a CERCLA contaminant of concern was made because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells. However, as indicated in Recommendation #1 for Building 833, ground water samples from Building 833 monitor wells would still be analyzed for halogenated VOCs by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports. Therefore, any cis-1,2-DCE that might be present in the future as a breakdown product of TCE would still be detected. As there are no landfills present at or in the vicinity of Building 833, and therefore no waste will be left in place, monitoring to detect future releases per Title 23 CCR Chapter 15 is not necessary.**

***Vinyl Chloride as a COC*:**
Vinyl chloride was not considered as a CERCLA contaminant of concern (COC) at the Pit 6 Landfill and Building 833 because it was either not detected in ground water or was not detected at concentrations that posed an unacceptable risk or hazard to human or ecological receptors. Vinyl chloride and other potential TCE breakdown products are analyzed for as part of the EPA Method 601 analysis of the samples collected from the Pit 6 Landfill detection monitor wells and for samples collected from the Pit 6 Landfill and Building 833 remedial action monitor wells. Therefore, vinyl chloride and other potential TCE breakdown products would be detected and evaluated as part of the semi-annual compliance (detection and remedial action) monitoring and reporting. Five-Year Reviews and the LLNL Site 300 Contingency Plan include processes for both the identification of new contaminants and increases in contaminant concentrations that could impact human health or the environment.

GSU comment 2: Use of USEPA Method 601 for TCE analyses: Please clarify why USEPA Method 601 is used for TCE analysis (instead of USEPA Method 8260).

Method 601 is generally used for municipal and industrial discharges.

Response: **The methods used for ground water analysis were specified in the regulatory-approved Compliance Monitoring Plan/Contingency Plan. The reporting limit of 0.5 micrograms per liter supplied by the analytical laboratories utilizing U.S. EPA Method 601 is sufficient for ground water monitoring.**

GSU comment 3: Recommendations for additional monitoring wells: The report recommends drilling of additional monitoring wells for OU-8 Building 801, 845, and 851. GSU supports the addition of monitoring wells.

Response: **Comment noted.**

Attachment B2

Comment Responses for the Draft Final Five-Year Review Report for Operable Units (OUs) 3 and 8 at Lawrence Livermore National Laboratory (LLNL) Site 300

U.S. Environmental Protection Agency (EPA) Comments

1. **General Comment #1:** Although EPA does not insist that LLNL reorganize the Five-Year Review (FYR) as suggested in its General Comment #1 on the Draft FYR, EPA continues to believe that the FYR would greatly benefit from such reorganization in terms of readability and comprehension.

Response: **Comment noted. As mentioned in the responses to General Comment #1 for the Draft FYR, it is DOE's continued position that the benefits of reorganizing the FYR to shorten the text as suggested in EPA's comment would be outweighed by the added difficulties in tracking the applicable information for each OU and release site. As stated previously, there are differences in the Institutional Controls/Land Use Controls (ICs/LUCs) sections for the different OUs and release sites. Therefore, to consolidate six sections into one section that covers both OUs and all release sites would likely lead to more rather than less confusion as the reader would be reviewing the ICs/LUCs prior to reading the information relevant to why the ICs/LUCs are needed for a particular OU/release site.**

2. **General Comment #2:** Please revise as follows the text in sections referenced in the RTC as revised in the Draft Final FYR:

   "The Site 300 ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health."

   "To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA has not been

modified during this five-year review period, and its provisions remain as originally stated."

Response: **The text in Sections 2.3.4.2, 3.1.3.4.2, 3.2.3.4.2, 3.3.3.4.2, 3.4.3.4.2, and 3.5.3.4.2, the "Prohibit Transfer of Lands…" subsections have been modified as requested.**

3. **General Comment #3:** The responses do not address the concerns underlying the original comments. Specifically, a number of monitoring wells at Pit 6 have gone dry, but contamination may be present in groundwater that is present below the screened intervals of those wells. Replacement wells should be installed so that it can be verified that contaminants that have been detected above cleanup standards, like cis-1,2-dichloroethene and perchlorate, are not present before these contaminants are removed from the list of contaminants of concern (COCs). This is not an issue for removal of COCs that have never been detected above cleanup levels like tetrachloroethene and 1,1,1-trichloroethane. It is also a concern if there are several years with higher than average rainfall (e.g. due to El Nino) that water levels could rise and contaminant levels could increase. Please retain COCs that have been detected above cleanup standards and ensure that monitoring conducted during and after years with higher than average rainfall includes all COCs that have been detected above cleanup standards.

Response: **At the May 2, 2013 Remedial Project Manager's (RPM) meeting, DOE/LLNL gave a presentation to address EPA's concerns expressed in this comment. The presentation is attached to these comment responses.**

At the conclusion of this RPM meeting presentation, EPA agreed that:

- **The data collected from the wells before they went dry, from nearby wells completed at greater depth than the wells that went dry, and from the two new replacement wells installed in 2012 were sufficient to verify that cis-1,2-dichloroethene (DCE), trans-1,2-DCE, 1,2-dichloroethane (DCA), and perchlorate were not present in the deeper zone beneath the screened interval of the dry wells.**
- **Well coverage, including the two new replacement wells installed in 2012, was sufficient and the installation of additional wells was not needed.**
- **Data trends for cis- and trans-1,2-DCE, and 1,2-DCA during the 1997-1998 El Niño event indicate that concentrations of these constituents will not increase above cleanup standards during years of higher than average rainfall.**
- **Monitoring data indicate that water level rises will not likely cause perchlorate concentrations to increase above the 6 µg/L cleanup standard during an El Niño-like event.**

- **There is sufficient data to demonstrate that the ROD requirements have been met (i.e., concentrations remain below cleanup standards for two years), and to justify deleting cis- and trans-1,2-DCE, 1,2-DCA, and perchlorate as COCs in ground water at the Pit 6 Landfill OU.**
- **Removal of these constituents as COCs demonstrates progress in the cleanup of Pit 6 Landfill ground water.**
- **Continued monitoring of cis- and trans-1,2-DCE, 1,2-DCA, and perchlorate will indicate if concentrations increase or any new release occur, and the Contingency Plan and 5-Year Review process provide the means to re-evaluate the status of these constituents (i.e., need to reinstate as a COC).**

Because trichloroethylene (TCE) is still present above its cleanup standard in Pit 6 ground water, DOE will continue to monitor for VOCs using EPA 601, which includes the analysis of 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, 1,1,1-trichloroethane (TCA), and perchloroethene (PCE) in all Pit 6 wells in accordance with the Compliance Monitoring Plan. Perchlorate will continue to be monitored in the Pit 6 detection monitor wells to determine if any new releases occur.

While monitoring data for 30 wells indicate that water level rises will not likely cause perchlorate concentrations to increase above the 6 µg/L cleanup standard during an El Niño-like event, EPA requested and DOE agreed to monitor Pit 6 wells during the next El Niño-like event. Ground water elevations in Pit 6 wells will continue to be monitored in accordance with the Compliance Monitoring Plan. Precipitation is also routinely monitored and compared to ground water elevations. (More than twice the amount of the annual average precipitation fell at Site 300 during the 1997-1998 El Niño event.) If an above-average precipitation year (i.e., an El Niño-like event) results in a significant increase in ground water elevations, DOE will collect samples from all Pit 6 wells for perchlorate analysis to determine if concentrations increase above the MCL cleanup standard. For example, ground water rises into the Pit 6 wells that have gone dry would be considered as a significant increase in ground water elevations.

In the event that any of the delisted compounds is detected above its cleanup standard, the DOE will take the steps outlined in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at the Lawrence Livermore National Laboratory Site 300.

4. **Specific Comment #4, 1st paragraph, 3rd line:** change the verb "protects" to "protect."

Response: **The text in the Five-Year Review Protectiveness Statement contained the correct verb "protect". The text in the comment response was modified from "protects" to "protect."**

5. **Specific Comment #4, 4th paragraph of the Protectiveness Statement and the individual protectiveness statements in the sections referenced:** Please revise as follows the text sections referenced in the Response to Comments as revised in the Draft Final FTR:

   "Because some volatile organic compounds (VOCs) may remain in subsurface soil following the achievement of these cleanup standards, the Site-Wide ROD requires implementation of land use controls to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination for purposes of residential or unrestricted land use. The Site 300 Federal Facility Agreement (FFA) prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substance s Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

Response: **The text was added to the 4th paragraph of the Protectiveness Statement and the Protectiveness Statements in Sections 2.10, 3.1.10, 3.2.10, 3.3.10, 3.4.10, and 3.5.10 as requested.**

6. **Specific Comment #16:** The RTC to EPA's General Comment #2 notes that the revised text included there is also incorporated into the sections referenced in the RTC to EPA's Specific Comment #16. Please ensure that the revised text set forth above in relation to EPA's General Comment 2 is in fact incorporated into the following Sections: 2.3.4.2, 3.1.3.4.2, 3.2.3.4.2, 3.3.3.4.2, 3.4.3.4.2, and 3.5.3.4.2.

Response: **The text above in General Comment #2 was added to the "Prohibit Transfer of Lands…"Sections 2.3.4.2, 3.1.3.4.2, 3.2.3.4.2, 3.3.3.4.2, 3.4.3.4.2, and 3.5.3.4.2, as requested.**

7. **Specific Comment #19:** The response does not fully address the concerns raised in the comment. While there might be some redundancy in the presentation of milestones and recommendations, the Comprehensive Five-Year Review Guidance

suggests including the requested table to detail recommendation, completion dates, and milestones. Also, the summary form does not consistently include milestone dates. Please revise the Five-Year Review Report to include a Recommendations and Follow-up Actions Table.

Response: **The Summary Form has been modified to include milestone dates for all recommendations.**

The milestone dates presented for the recommendations in the Summary form are considered to be completion dates. Footnotes have been added to each recommendation to identify the completion of the recommended action by the milestone date and any associated contingencies.

With the addition of the milestone dates for all recommendations, the information presented in the recommendations in the Summary form is identical to that which is suggested in Table 8, Appendix E (page E-30) of the EPA Five-Year Review Guidance including:

- **Issues.**
- **Recommendations.**
- **Responsible/Implementing Party.**
- **Oversight Agency.**
- **Milestone Date.**
- **Affect on Current and Future Protectiveness.**

Therefore, DOE considers that the information contained in the Summary Form Recommendations is consistent with that which is suggested in Table 8, Appendix E of the EPA guidance.

Regional Water Quality Control Board (RWQCB)-Central Valley Region Comments

1. Regional Water Board Staff concur with the Department of Energy's (DOE's) recommendations to delist groundwater contaminants of concern (1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, 1,1,1-TCA, PCE, and perchlorate at the Pit 6 Landfill, and cis-1,2-DCE at Building 833) for which cleanup standards have been met, as specified in the Final Record of Decision for the General Services Area Operable Unit, Lawrence Livermore National Laboratory, Site 300, with the understanding that these recommendations do not alter the Site 300 groundwater monitoring program, and that the delisted compounds will continue to be monitored and reported/discussed in the compliance monitoring reports. Additionally, in the event that any of the delisted compounds is detected above its cleanup standard, the DOE will take the steps outlined in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at the Lawrence Livermore National Laboratory Site 300.

Response: **As discussed in the response to EPA's General Comment #3 and at the May 2, 2013 RPM meeting, because TCE is still present above its cleanup standard in Pit 6 ground water, DOE will continue to monitor for VOCs using EPA 601, which includes the analysis of 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, 1,1,1-TCA, and PCE in all Pit 6 wells in accordance with the Compliance Monitoring Plan. Perchlorate will continue to be monitored in the Pit 6 detection monitor wells to determine if any new releases occur.**

While monitoring data for 30 wells indicate that water level rises will not likely cause perchlorate concentrations to increase above the 6 µg/L cleanup standard during an El Niño-like event, EPA requested and DOE agreed to monitor Pit 6 wells during the next El Niño-like event. (More than twice the amount of the annual average precipitation at Site 300 during the 1997-1998 El Niño event.) Ground water elevations in Pit 6 wells will continue to be monitored in accordance with the Compliance Monitoring Plan. Precipitation is also routinely monitored and compared to ground water elevations. If this comparison indicates that an above-average precipitation year (i.e., an El Niño-like event) results in a significant increase in ground water elevations, DOE will collect samples from all Pit 6 wells for perchlorate analysis to determine if concentrations increase above the MCL cleanup standard. For example, ground water rises into the Pit 6 wells that have gone dry would be considered as a significant increase in ground water elevations.

In the event that any of the delisted compounds is detected above its cleanup standard, the DOE will take the steps outlined in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at the Lawrence Livermore National Laboratory Site 300. (Please note that the ROD applicable to the Pit 6 Landfill and Building 833 is the Site-Wide ROD, not the Final ROD for the General Services Area Operable Unit as mentioned in the comment.)

2. Most of the 28 November 2012 Regional Water Board staff comments were incorporated into the 5-YR Review Report. However, other comments were only addressed in the Comment Responses and not incorporated into the 5-YR Review Report. To make the 5-YR Review Report complete, as a stand-alone document, the following comment responses need to be added to the 5-YR Review Report:

- The historical tritium activities for groundwater monitoring well BC6-13 provided in DOE's response to Specific Comment No. 6 needs to be incorporated into the 5-YR Review Report.
- DOE's response to Specific Comment No. 12, "The drums of ash are shipped offsite as hazardous waste through the LLNL Radioactive and Hazardous Waste Management organization to a permitted treatment, storage or disposal facility. The California Department of Toxic Substances Control regulates the disposal and performs annual inspection of the facility and LLNL waste management practices", needs to be included in Section 3.2.2.2 of the 5-YR Review Report.
- In addition, DOE's response to Specific Comment No. 14, which provides the total dissolved solids (TDS) concentrations of the groundwater at Building 833 and the TDS maximum contaminant level, needs to be incorporated into the 5-YR Review Report.

Response: **The comment has been addressed as follows:**

- **The historical tritium activities for groundwater monitoring well BC6-13 were added as the last sentence of the first paragraph in Section 2.5.1.2.1 as requested.**
- **The response to Specific Comment #12 on the Draft Final FYR was added as the sixth sentence of the second paragraph of Section 3.2.2.2 as requested.**
- **The TDS concentrations were added to Section 3.3.2.5 as requested.**

3. Regional Water Board staff concurs with DOE's explanation of the designation of upgradient and downgradient monitor wells based on groundwater elevation measurements, in response to Specific Comments No. 9b and 10. However, not only does groundwater flow from high head to low head, it also preferentially follows the path of least resistance. In a geologic setting such as at Site 300, there are varying thicknesses of unconsolidated alluvium deposited over bedrock that would have a permeability several degrees of magnitudes lower. Therefore, review of the document would be facilitated by providing a figure showing the hydrogeologic setting. In Figures 5 through 9, the 5-YR Review Report provides several cross-sections for the Pit 6 Landfill. Similar cross-sections need to be provided for all sites in Operable Unit (OU) 8.

Furthermore, on Figure 38, the groundwater gradient is noted as being nearly flat since 1991. However the groundwater elevation measurement in W-851-07 was 1,133.53 feet above mean seal level (MSL) and the groundwater elevation measurement in W-851-08 was 1,090.32 feet above MSL, a change of approximately 43 feet of head over a 25 feet distance. Therefore, Regional Water Board staff does

not concur that the groundwater gradient is nearly flat between these two wells. Please provide an explanation of why the groundwater gradient is considered to be nearly flat on Figure 38 and as requested above, please provide geologic cross-sections in the 5-YR Review Report to illustrate the subsurface geology, depth of well screens, and groundwater elevations for all sites in OU 8.

Response: **DOE has included cross sections for OU 8 areas in Attachment B2 as requested.**

The ground water elevations of wells W-851-07 and W-851-08 differ significantly because the wells are completed in different hydrostratigraphic units (HSUs) as shown on the cross section for Building 851 (Attachment B). The difference in ground water elevations (GWE) in wells W-851-05, -06, and -07, which are completed in the same HSU is less than one foot over a 170 to 500 ft distance (i.e., 0.81 ft GWE difference between W-851-05 and -06 over a 170 ft distance, 0.64 ft GWE difference between W-851-05 and -07 over a 500 ft distance, and 0.17 ft GWE difference between W-851-06 and -07 over a 445 ft distance). Therefore, DOE considers the ground water gradient to be nearly flat in this HSU.

California Department of Toxic Substances Control (DTSC) Comments

DTSC has reviewed comment responses for the Draft Five-Year Review Report for Operable Units 3 and 8 at Lawrence Livermore Nation Laboratory Site 300. DTSC finds these comment responses adequately and has no additional comments.

Building 801 and Pit 8 Landfill Area Cross-section A-A’

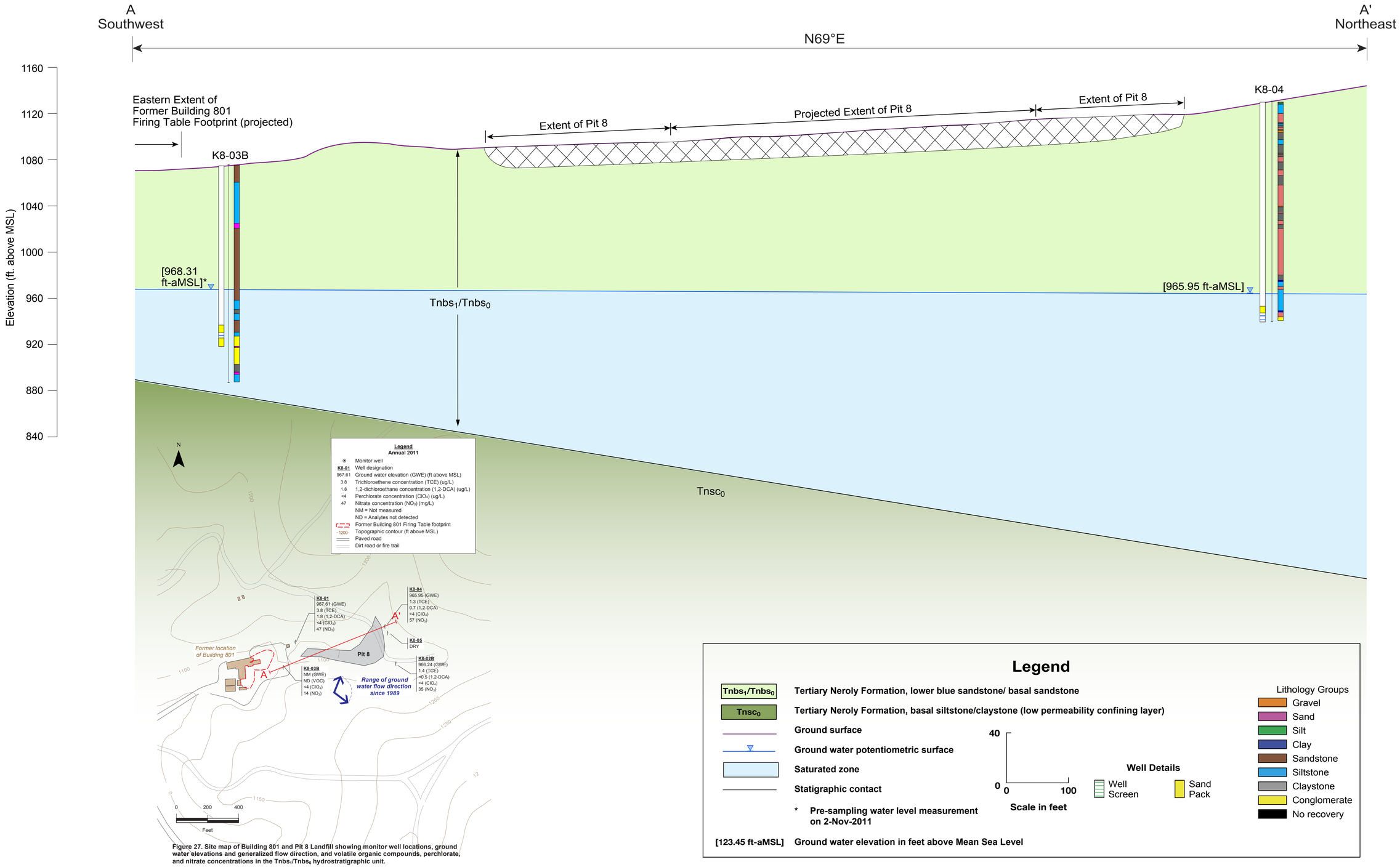
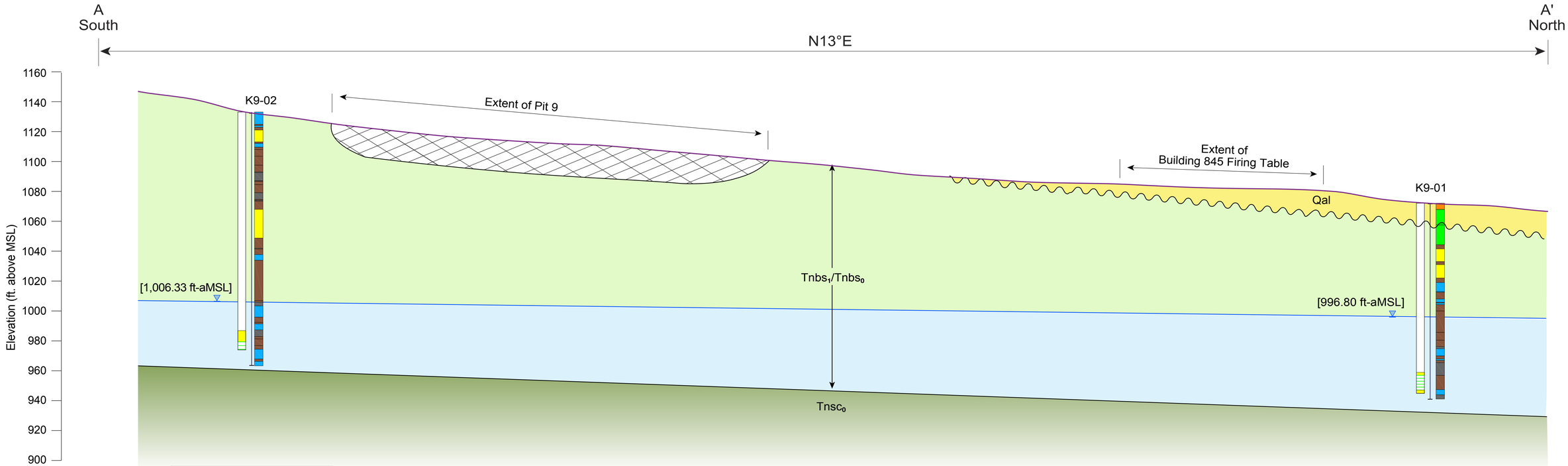


Figure 27. Site map of Building 801 and Pit 8 Landfill showing monitor well locations, ground water elevations and generalized flow direction, and volatile organic compounds, perchlorate, and nitrate concentrations in the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

Attachment B-1. Building 801 and Pit 8 Landfill Area hydrogeologic cross-section A-A’

Building 845 Firing Table and Pit 9 Landfill Area Cross-section A-A’



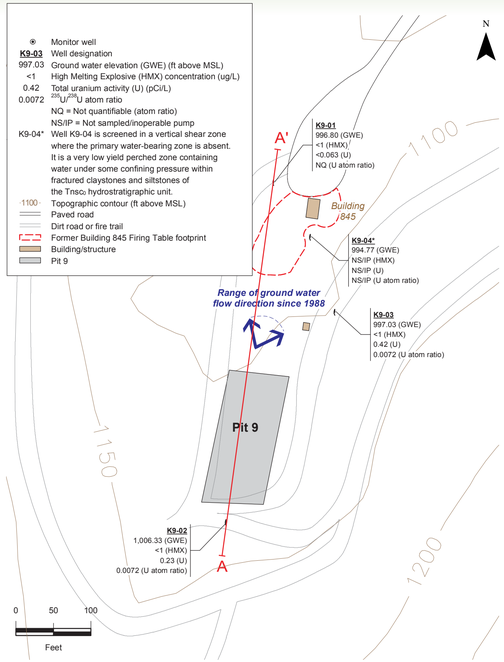


Figure 34. Site map of Building 845 Firing Table and Pit 9 Landfill area showing monitor well locations, ground water elevations and generalized flow direction, High Melting Explosive concentrations, uranium activities, and $^{235}U/^{238}U$ atom ratios in the $Tnsc_0$ hydrostratigraphic unit.

Legend

Qal	Quaternary alluvium/weathered bedrock
$Tnbs_1/Tnbs_0$	Tertiary Neroly Formation, lower blue sandstone/basal sandstone
$Tnsc_0$	Tertiary Neroly Formation, basal siltstone/claystone (low permeability confining layer)
	Ground surface
	Ground water potentiometric surface
	Saturated zone
	Unconformity
	Stratigraphic contact
[123.45 ft-aMSL]	Ground water elevation in feet above Mean Sea Level

40
0
0
100
Scale in feet

Well Details

Well Screen

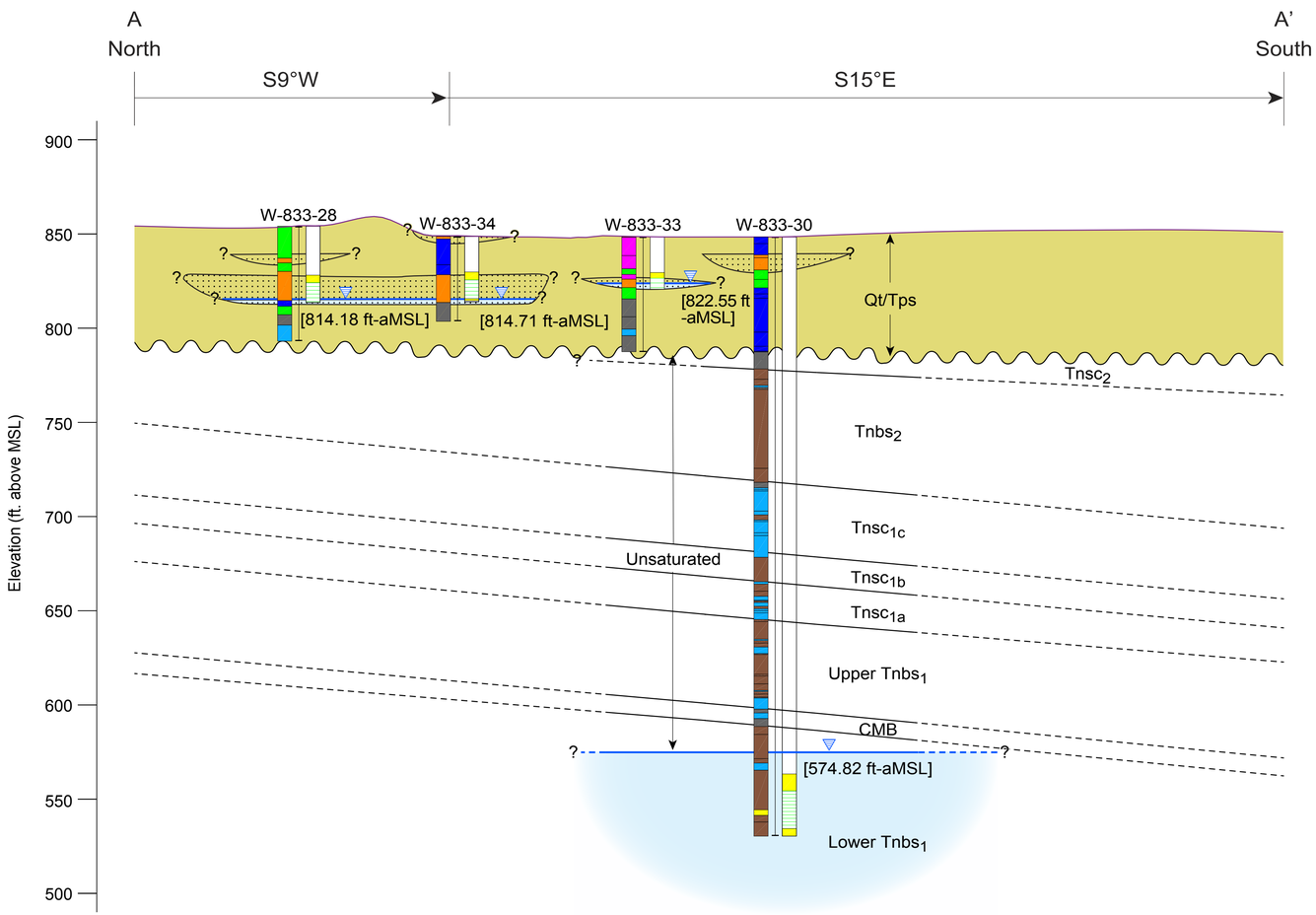
Sand Pack

Lithology Groups

- Gravel
- Sand
- Silt
- Clay
- Sandstone
- Siltstone
- Claystone
- Conglomerate

Attachment B-2. Building 845 Firing Table and Pit 9 Landfill Area hydrogeologic cross-section A-A’

Building 833 Area Cross-section A-A’



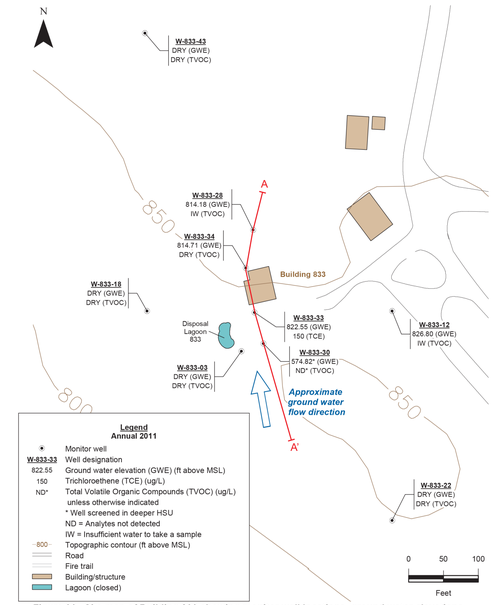


Figure 36. Site map of Building 833 showing monitor well locations, ground water elevations and generalized flow direction, and total volatile organic compound concentrations in the Tpsg hydrostratigraphic unit.

Legend

Qt/Tps	Quaternary terrace deposits/Pliocene nonmarine clay, silt, sand and channel deposits of sand, gravel, and conglomerate
$Tnsc_2$	Tertiary Neroly Formation, upper siltstone, claystone and rare conglomerate
$Tnbs_2$	Tertiary Neroly Formation, Sandstone and silty sandstone with some minor sandy siltstone
$Tnsc_1$	Tertiary Neroly Formation, siltstone and claystone [$Tnsc_{1c}$ (Upper), $Tnsc_{1b}$ (Middle), $Tnsc_{1a}$ (Lower)
$Tnbs_1$	Tertiary Neroly Formation, blue sandstone (upper and lower)
CMB	Tertiary Neroly Formation, claystone marker bed
	Ground surface
	Ground water potentiometric surface
	Saturated zone
	Unconformity
	Stratigraphic contact (dashed where inferred)
[123.45 ft-aMSL]	Ground water elevation in feet above Mean Sea Level

20
0
0 50
Scale in feet

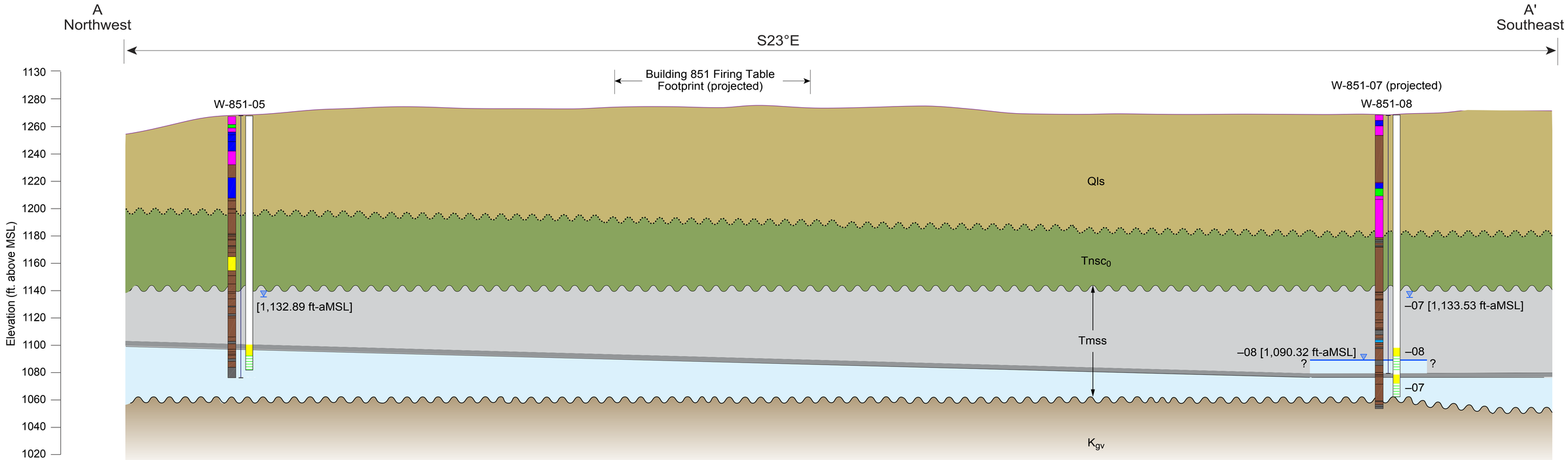
Lithology Groups
- Gravel
- Sand
- Silt
- Clay
- Sandstone
- Siltstone
- Claystone
- Conglomerate

Well Details
- Well Screen
- Sand Pack

Attachment B-3. Building 833 Area hydrogeologic cross-section A-A’

ERD-S3R-13-0069

Building 851 Firing Table Area Cross-section A-A’



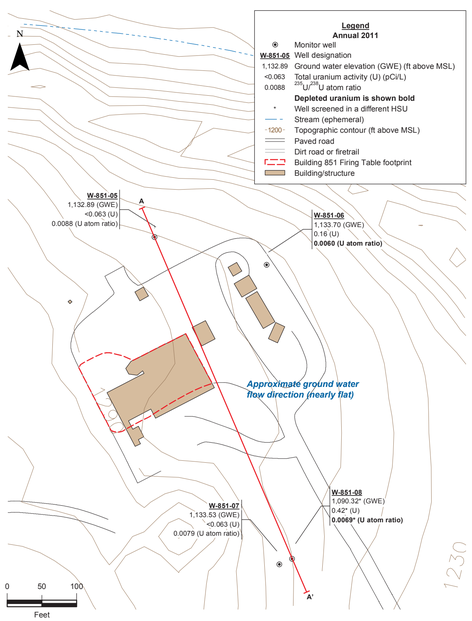
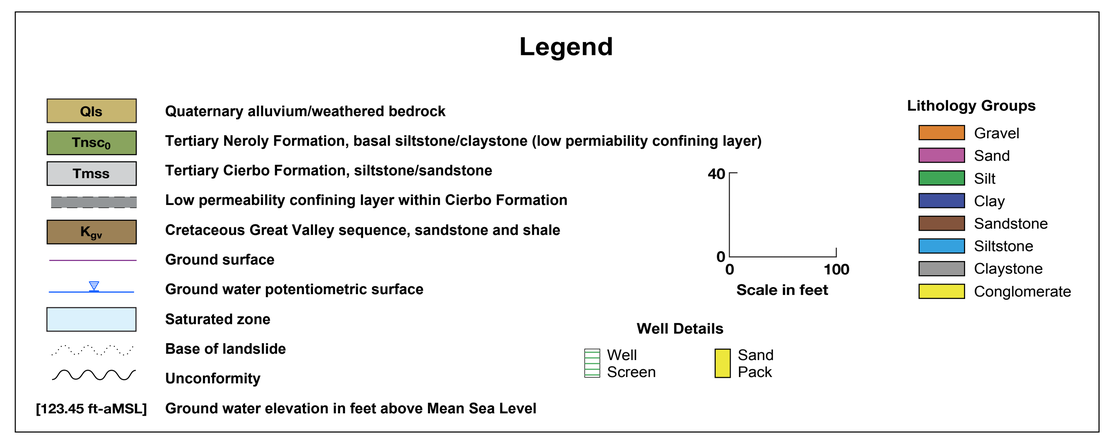
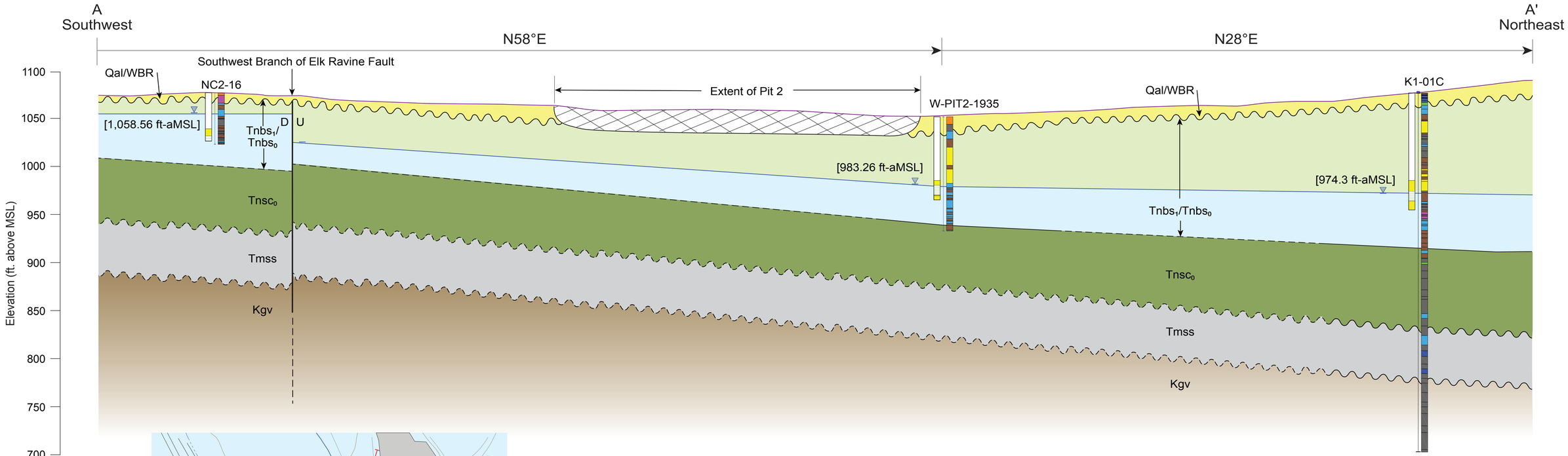


Figure 38. Site map of the Building 851 Firing Table area showing monitor well locations, ground water elevations and generalized flow direction, uranium activities, and $^{234}U/^{238}U$ atom ratios in the Tmss hydrostratigraphic unit.



Attachment B-4. Building 851 Firing Table Area hydrogeologic cross-section A-A’

Pit 2 Landfill Area Cross-section A-A’



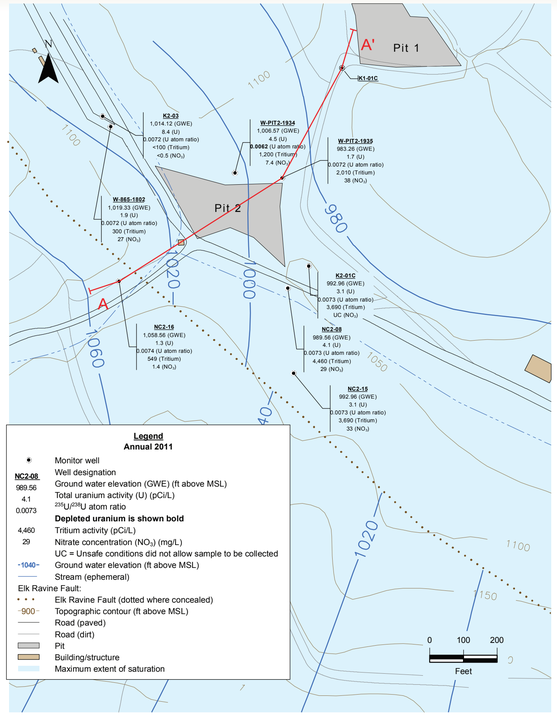


Figure 42. Pit 2 Landfill site map showing monitor well locations, ground water potentiometric surface contours, and nitrate concentrations, uranium activities, $^{235}U/^{238}U$ atom ratios, and tritium activities in the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

Legend

Qal/WBR	Quaternary alluvium/weathered bedrock
$Tnbs_1/Tnbs_0$	Tertiary Neroly Formation, lower blue sandstone/basal sandstone
$Tnsc_0$	Tertiary Neroly Formation, basal siltstone/claystone (low permeability confining layer)
Tmss	Tertiary Cierbo Formation, siltstone/sandstone
Kgv	Cretaceous Great Valley sequence sandstones and shale
	Ground surface
	Ground water potentiometric surface
	Saturated zone
	Unconformity (dashed where inferred)
	Stratigraphic contact (dashed where inferred)
[123.45 ft-aMSL]	Ground water elevation in feet above Mean Sea Level

Lithology Groups

- Gravel
- Sand
- Silt
- Clay
- Sandstone
- Siltstone
- Claystone
- Conglomerate

Well Details

Well Screen — Sand Pack

0 — 25 — 50
Scale in feet

Attachment B-5. Pit 2 Landfill Area hydrogeologic cross-section A-A’

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