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-670250

First Five-Year Review Report for the Building 850/Pit 7 Complex Operable Unit at Lawrence Livermore National Laboratory Site 300

Authors:

M. Taffet
L. Ferry
J. Radyk*
V. Madrid
T. Carlsen

Contributors:

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G. Lorega
Z. Demir
J. McKaskey*

April 2016

*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.

September 29, 2016

Michael J. Taffet　　　　Date
California Professional Geologist
No. 5616
License expires: May 30, 2017
California Certified Hydrogeologist
No. 129
License expires: May 30, 2017

Approval for the First Five-Year Review Report for the Building 850/Pit 7 Complex Operable Unit Lawrence Livermore National Laboratory Site 300

Prepared by:

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

Approved:

Claire S. Holtzapple Sept, 27, 2016
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 94105-3901

August 10, 2016

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 First Five-Year Review Report for OU5, Lawrence Livermore National Laboratory Site 300, April 2016

Dear Ms. Holtzapple:

The U.S. Environmental Protection Agency (EPA) has reviewed the First Five-Year Review ("FYR") Report for the Building 850/Pit 7 Complex Operable Unit ("Site") at Lawrence Livermore National Laboratory ("LLNL") Site 300 dated April 2016 ("Final Report").

EPA appreciates that, with the exception of the issue of consolidating LLNL Site 300 FYRs which EPA will address separately, DOE has addressed the majority of the Agency's concerns with the Draft and Draft Final Reports including inclusion of a Response to Comments ("RTC"). EPA concurs with the short-term protectiveness statements for all of the sub-sites addressed by the operable unit ("OU"). Based on its review of the Final Report and RTCs, as well as subsequent meetings and phone calls with LLNL to discuss the matter, however, EPA does not concur with the long-term protectiveness statement in the Final Report. For the reasons set forth below, EPA therefore has made the following protectiveness determination:

The remedy at LLNL Site 300, OU5, 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. After the completion of active remedial activities and amendment of the ROD, the remedy will protect human health and the environment in the long term because 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.

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 action is operating, the remedy is protective of human health because exposure pathways that could result in unacceptable risk to onsite 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. These ICs must remain in place and applicable in order to conclude that the remedy is protective in the short term. The remedy also currently is protective in the short term in relation to the on-site plume because there currently are no known completed exposure pathways for human or ecological receptors.

In order for the remedy to be protective in the long term, the FYR identifies three "actions" that need to be taken. Since the FYR also describes the role of the CAMU removal action in achieving and ensuring protectiveness in other portions of the document, EPA has determined that a fourth action must be completed to ensure long-term protectiveness: formalization in a decision document of the need for ICs in relation to the CAMU. It is EPA's understanding that LLNL will formally adopt ICs for the CAMU in conjunction with the process for amending the Site-Wide ROD to address perchlorate. The four actions necessary to address long-term protectiveness are:

1. Monitor HE compounds in Building 850 ground water to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases. [Milestone Date: 12/30/2020]
2. Collect subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water above cleanup standards. [Milestone Date: 12/30/2017]
3. Complete the characterization of perchlorate in subsurface soil at Building 850, present and evaluate remedial alternatives, and select and implement a remedy to address perchlorate in Building 850 ground water. [Milestone Date: 12/30/2020]
4. Formally adopt ICs for the CAMU in conjunction with the process for amending the Site-Wide ROD to address perchlorate. [Milestone Date: 12/30/2020]

The cleanup standards for groundwater are drinking water Maximum Contaminant Levels (MCLs). For contaminants in subsurface soil, the cleanup standards are based on reduction of concentrations to mitigate risk to onsite workers and prevent further impacts to groundwater to the extent technically and economically feasible. Because some contaminants may remain in subsurface soil following the achievement of these cleanup standards, the Record of Decision includes a land use control prohibiting the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition 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 showing no unacceptable risk for unrestricted use and unlimited exposure scenarios.

This FYR also identifies two additional issues and recommended responses 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. Since these issues and the responses do not directly impact remedy protectiveness at this time, we do not include them as FYR protectiveness issues.

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

Sincerely,

Angeles Herrera
Assistant Director, Superfund Division
Federal Facilities and Site Cleanup
Branch

Cc by Email:
Ariel Robertson, DOE
Leslie Ferry, LLNL
Jacinto Soto, DTSC
Aimee Phiri, CVRWQCB

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Lawrence Livermore National Laboratory Site 300, Building 850/Pit 7 Complex Operable Unit (OU) 5		
EPA ID: CA 2890090002		
Region: IX	State: California	City/County: San Joaquin/Alameda
SITE STATUS		
NPL status: Final		
Multiple OUs: No	Has the site achieved construction completion? Yes. May, 2010 (date of Remedial Action Completion Report)	
REVIEW STATUS		
Lead agency: United States (U.S.) Department of Energy (DOE)/National Nuclear Security Administration (NNSA)		
Author name: M. Taffet		
Author title: Senior Project Hydrogeologist	Author affiliation: Lawrence Livermore National Security, LLC - Livermore, California	
Review period: January 1, 2010 to December 31, 2014		
Date(s) of site inspection: March 24, 2015		
Type of review: Statutory		
Review number: 1		
Triggering action date: Remedial Action Completion Report for the Building 850/Pit 7 Complex OU: May 24, 2010		
Due date: May 24, 2015		

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS</th></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">OU(s) without Issues/Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td colspan="5">Not applicable.</td></tr>
<tr><td colspan="5">Issues/Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td rowspan="3">OU(s):
Building 850/Pit 7 Complex</td><td colspan="4">Issue Category: Changed site conditions</td></tr>
<tr><td colspan="4">Issue: Although high explosive (HE) compounds were not identified as contaminants of concern in the 2008 Site-Wide Record of Decision, Research Department Explosive (RDX) and High Melting Explosive (HMX) were detected in Building 850 ground water during the five-year review period. While data indicate that the extent of RDX and HMX in Building 850 ground water is currently limited, the concentrations and extent of these HE compounds are decreasing, and existing institutional/land use controls prevent exposure, the following recommendation was developed to determine if further actions need to be taken.</td></tr>
<tr><td colspan="4">Recommendation #1: Monitor HE compounds in Building 850 ground water semi-annually from monitor wells NC7-10, NC7-11, NC7-14, NC7-15, NC7-19, NC7-27, NC7-28, NC7-44, NC7-54, NC7-55, NC7-60, NC7-61, NC7-70, NC7-71, NC7-73, W-850-05, W-850-2313, W-850-2314, and W-850-2417 to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Potentially yes</td><td>DOE</td><td>EPA/State</td><td>December 30, 2020*</td></tr>
</table>

*** Monitoring will continue throughout the next five-year review period (January 1, 2015 through December 30, 2020). These data will be reported in the semi-annual and annual Compliance Monitoring Report. If any changes in HE compound concentrations or extent changes during this time indicate an immediate threat to human health or then environment, DOE will discuss possible actions with the regulatory agencies.**

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS Continued</th></tr>
<tr><td rowspan="3">OU(s):
Building 850/Pit 7 Complex</td><td colspan="4">Issue Category: Changed site conditions</td></tr>
<tr><td colspan="4">Issue: Although high explosive (HE) compounds were not identified as contaminants of concern in the 2008 Site-Wide Record of Decision, Research Department Explosive (RDX) and High Melting Explosive (HMX) were detected in Building 850 ground water during the five-year review period. While data indicate that the extent of RDX and HMX in Building 850 ground water is currently limited, the concentrations and extent of these HE compounds are decreasing, and existing institutional/land use controls prevent exposure, the following recommendation was developed to determine if further actions need to be taken.</td></tr>
<tr><td colspan="4">Recommendation #2: Collect subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water above cleanup standards.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Potentially yes</td><td>DOE</td><td>EPA/State</td><td>December 30, 2015 *</td></tr>
</table>

*** This drilling and HE compound soil sampling effort will be conducted as part of the drilling and perchlorate soil sampling effort that is currently being proposed in a Work Plan to be approved by the regulatory agencies. The drilling and sampling will commence after the work plan is approved by the regulatory agencies. If the regulators require additional sampling for HE compounds at Building 850, a new work plan and milestone date will need to be prepared/selected.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): Building 850/Pit 7 Complex	**Issue Category:** No Issue			
	Issue: Although no deficiencies or issues were identified with the Pit 7 Complex remedy, the following recommendation was developed to optimize the operation of the Pit 7-Source ground water extraction and treatment component of the Pit 7 Complex remedy.			
	Recommendation #3: Convert current extraction well NC7-25 to a monitor well and drill and install a larger diameter extraction well nearby to optimize ground water extraction of uranium in ground water at this location.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	September 30, 2018*

*** This milestone is contingent upon receiving adequate funding to drill a new extraction well to replace the current extraction well NC7-25 in 2018.**

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): Building 850/Pit 7 Complex	**Issue Category:** No Issue			
	Issue: Although no deficiencies or issues were identified with the Pit 7 Complex remedy, the following recommendation was developed to optimize the operation and/or maintenance of the drainage diversion system component of the Pit 7 Complex remedy.			
	Recommendation #4: Implement improvements to the surface and slope of the road and the roadside drainage way on the east side of the Pit 7 Complex landfills to minimize erosion and accumulation of sediment, reduce flooding during heavy rain events, and both improve operation and reduce maintenance requirements for the eastern drainage swale.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	DOE	EPA/State	December 30, 2019*

*** This milestone is contingent upon receiving adequate funding to complete upgrades in 2019.**

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT		
OU: The Building 850/Pit 7 Complex OU (5)	**Protectiveness Determination** Protective	**Addendum Due Date:** NA

Protectiveness Statement: The remedies at the Building 850/Pit 7 Complex Operable Unit (OU) (5) 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 remedies protect human health in the short-term because:

1. Tritium activities in Building 850 and Pit 7 Complex ground water have significantly decreased from their historical maximum, and natural attenuation will continue to reduce tritium activities in ground water and surface water (Well 8 Spring) to meet the cleanup standard in a reasonable timeframe. Modeling indicates that the tritium plume will not migrate offsite in the period of time it takes to natural attenuate to cleanup standards, and monitoring of the tritium plume is conducted to validate these modeling results (Taffet et al., 1996; Taffet et al., 2004; Taffet et al., 2005). In addition, institutional controls described in Sections 4.5.1.1, 4.5.2.1, and 4.5.1.5 of this Five-Year Review are in-place to prevent exposure to tritium in ground water and surface water at Well 8 Spring until cleanup standards are achieved.
2. The risk to onsite workers and ecological receptors associated with polychlorinated biphenyl- (PCB-), dioxin-, and furan-contaminated surface soil at the Building 850 Firing Table has been mitigated by the soil excavation and solidification removal action. Institutional/land use controls and inspection and maintenance procedures prevent further exposure by protecting the integrity of the Corrective Action Management Unit (CAMU).
3. Ground water monitoring of uranium and nitrate in Building 850 ground water will provide an early indication of changes in the concentrations/activities and/or extent of these constituents that could impact human health or the environment. As indicated in the Site-Wide Contingency Plan (Dibley et al., 2009), if ground water contaminant concentrations (i.e., uranium activities and/or nitrate concentrations in Building 850 ground water) increase in a consistent and significant manner for reasons not attributable to remediation efforts (e.g., cyclic pumping), or natural aquifer or laboratory variables, DOE will notify the regulatory agencies and modifications to the remedial action will be considered as necessary to protect human health.
4. The engineered drainage diversion system at the Pit 7 Complex will continue to control the contaminant source in the Pit 7 Complex landfills by preventing ground water level rises into the pit waste which would release contaminants from the waste to ground water.
5. Volatile organic compound (VOC) concentrations in Pit 7 Complex ground water have been reduced to below cleanup standards and are decreasing toward background levels, and ground water extraction and treatment continues to reduce uranium activities and perchlorate and nitrate concentrations in Pit 7 Complex ground water to cleanup standards.

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT Continued

Protectiveness Statement (continued):

6. The Pit 7 Complex landfill covers/caps. Couples with institutional/land use controls, prevents inadvertent exposure of onsite workers to contaminants in the pit waste.
7. Natural attenuation (radioactive decay) has mitigated the tritium inhalation risk to onsite workers at the Pit 3 Landfill, which is part of the Pit 7 Complex.
8. No new contaminant releases have been identified for the Pit 7 Complex landfill, and continued detection monitoring will provide an indication of any future releases.
9. Ground water monitoring will provide an early indication of migration of contaminants towards the site boundary.

Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of land use/institutional controls, the Health and Safety Plan, and the Contingency Plan. The cleanup standards for ground water at Site 300, including the Building 850/Pit 7 Complex OU, 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.

However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure long-term protectiveness:

1. Monitor high explosive (HE) compounds in Building 850 ground water to verify the continued decrease in Research Department Explosive (RDX) and High Melting Explosive (HMX) concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases.
2. Collect subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water above cleanup standards.
3. Complete characterization of perchlorate in subsurface soil at Building 850; present and evaluate remedial alternatives; and select and implement a remedy to address perchlorate in Building 850 ground water.

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 because:

- Some tritium and uranium may remain in subsurface soil following the achievement of ground water cleanup standards.
- Waste that may still contain contaminants will remain in place at the Pit 7 Complex landfills.

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT Continued
Protectiveness Statement (continued): • Solidified and consolidated soil contaminated with PCBs, dioxins, and furans will remain in place in the Building 850 CAMU. 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 the Comprehensive Environmental Response Compensation and Liability Act (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 California Code of Regulations (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. 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 is present for residential or unrestricted land use.

Table of Contents

List of Figures

List of Tables

Appendix A

Appendix B

Appendix C

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 Building 850/Pit 7 Complex Operable Unit (OU) 5 at Lawrence Livermore National Laboratory (LLNL) Site 300. (OU 5 is hereafter referred to as the Building 850/Pit 7 Complex OU.) 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 1, 2010 to December 31, 2014. 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 protective 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 (U.S. DOE, 2002) and the U.S. EPA (U.S. EPA, 2001).

DOE is preparing this Five-Year Review for the Building 850/Pit 7 Complex OU pursuant to Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendment Reauthorization Act (SARA), which requires that remedial actions resulting in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. The National Contingency Plan 40 Code of Federal Regulations Section 300.430(f)(4)(ii) 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 currently 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. 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, and 9 Landfills.
- Building 812 (OU 9).

Five-year reviews are currently conducted individually for each OU at Site 300, except for OUs 3 and 8. The Remedial Action Completion Report for the Building 850/Pit 7 Complex OU (Dibley et al., 2010) completed in May 2010 is the trigger for the start of the first five-year review period for the Building 850/Pit 7 Complex OU, in accordance with U.S. EPA guidance (U.S. EPA, 2002). At the other OUs where construction began prior to the Site-Wide Record of Decision (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 the Building 850/Pit 7 Complex OU. 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 1.1 through 1.9 include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300. Section 2 presents the chronology of significant environmental restoration events at the Building 850/Pit 7 Complex OU. Section 3 presents background and description for the Building 850/Pit 7 Complex OU. Section 4 discusses remedial actions selected and implemented in the Building 850/Pit 7 Complex OU, and progress towards meeting remedial action objectives and cleanup standards. Sections 5 and 6 provide a discussion of the five-year review process and the technical assessment of the remedy function and protectiveness, respectively. Sections 7 and 8 present issues identified during the review process and recommendations to address those issues. Section 9 summarizes the protectiveness of the remedy for the Building 850/Pit 7 Complex OU.

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 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 2014 maximum of 364 µg/L (April 2014) and has mitigated the risk to onsite workers from inhalation of VOCs inside Building 875.

1.1.2. Eastern GSA

The sources of contamination in the Eastern GSA are debris burial trenches that received craft shop debris that contained solvent residue. 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.

By 2005, VOC concentrations in both onsite and offsite ground water in the Eastern GSA area had been reduced to below the drinking water Maximum Contaminant Cleanup (MCL) cleanup standards. In February 2007, the ground water extraction and treatment system was shut down with regulatory concurrence. DOE/NNSA continued to monitor ground water for five years, during which time VOC concentrations remained below the cleanup standards, indicating that ground water cleanup had been successfully completed in the Eastern GSA. A Draft Close-out Report for the Eastern GSA was submitted to the regulatory agencies in December 2012 (Dibley and Ferry, 2012a). At the regulatory agencies request, additional characterization activities were conducted in 2014 to determine if polychlorinated biphenyls (PCBs,) semi-volatile organic compounds, and polycyclic aromatic hydrocarbons are present in subsurface soil in the Eastern GSA debris burial trench area. Per regulatory agreement, the results of these characterization activities will be presented in a Technical Memorandum.

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 results from septic system effluent but may also have natural sources. 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 Site-Wide ROD (U.S. DOE, 2001) and subsequent 2008 Site-Wide ROD (U.S. DOE, 2008). 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 2014 maximum of 180,000 µg/L (February 2014). TBOS/TKEBs in ground water have also been reduced from a historic maximum concentration of 7,300,000 µg/L in 1995 to a most recent maximum of 91 µg/L (August 2014). While nitrate concentrations have decreased from a historic maximum of 749 milligrams per liter (mg/L) in 2000 to a 2014 maximum of 300 mg/L (1st Semester 2014), the elevated nitrate concentrations continue to indicate an ongoing source of ground water nitrate. Sources of nitrate at Building 834 include the septic system leach field located in the vicinity of wells W-834-S1, and naturally occurring nitrate in soil. Nitrogenous compounds, like nitric acid or barium nitrate, might also have inadvertently been discharged into the septic system via a test cell floor drain. 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. Pit 6 Landfill (OU3)

From 1964 to 1973, approximately 1,900 cubic yards (yd^3) of waste from LLNL Livermore Site and Lawrence Berkeley Laboratory was buried in nine unlined trenches and animal pits at the Pit 6 Landfill. Infiltrating rainwater leached contaminants from pit waste resulting in tritium, VOC, and perchlorate contamination in ground water. Nitrate contamination in ground water results from septic system effluent. No COCs were identified in surface or subsurface soil.

In 1971, DOE excavated portions of the waste contaminated with depleted uranium. From 1973 to 1997, no waste was placed in the Pit 6 Landfill. In 1997, a landfill cap was installed as a CERCLA removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of decreasing VOC concentrations in ground water, the presence of TCE degradation products, and the short half-life of tritium (12.3 years), the selected remedy for VOCs and tritium at the Pit 6 Landfill is monitored natural attenuation (MNA). Because ground water monitoring data for perchlorate and nitrate were limited, DOE/NNSA continued to monitor ground water to determine if and when an active remedy for these contaminants might be necessary. The remedy also includes risk and hazard management. Construction completion was achieved in October 2002. No Remedial Design document was required for this area.

The extent of contamination at the Pit 6 Landfill is limited and continues to decrease with concentrations/activities near and below cleanup standards. Natural attenuation has reduced total

VOCs in ground water from a historic maximum of 250 µg/L in 1988 to a 2014 maximum of 5.2 µg/L (January 2014), consisting entirely of TCE. Tritium activities are well below the cleanup standard and continue to decrease towards background levels. Perchlorate has not been detected in any wells above the 4 µg/L reporting limit since 2011. The extent of nitrate at concentrations exceeding the cleanup standard continues to be limited to one well located near a septic system. Installation of the landfill cap mitigated the onsite worker inhalation risk. There is no evidence of new contaminant releases from the Pit 6 Landfill indicated by the ground water detection monitoring data.

DOE has performed one Five-Year Review for this OU (Buscheck et al., 2013.) The next Five-Year Review Report is scheduled for 2017.

1.4. High Explosives (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 selected in the Site-Wide ROD includes: (1) ground water extraction and treatment for VOCs, HE compounds, and perchlorate, and (2) 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. Five ground water extraction and treatment systems currently operate in the OU. In 2013, use of the 829-Source ground water treatment system was discontinued due to intermittent flow and very low production. Ground water extracted from the Building 829 source area is stored and transported to the 815-Source facility for treatment.

Ground water remediation efforts have reduced total VOC concentrations from a historic maximum of 1,013 µg/L in 1993 to a 2014 maximum of 40 µg/L (March 2014). Perchlorate concentrations have decreased from a historic maximum of 50 µg/L in 1998 to a 2014 maximum of 29 µg/L (July 2014). Research Department Explosive (RDX) in ground water has been reduced from a maximum historic concentration of 350 µg/L in 1988 to a 2014 maximum of 87 µg/L (March 2014). 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 next Five-Year Review Report is scheduled for 2017.

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 remedy selected for this OU in the Site-Wide ROD 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 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 2014 maximum of 92 µg/L (February 2014). Nitrate concentrations have decreased from a historic maximum of 260 mg/L in 2003 to a 2014 maximum of 130 mg/L (May 2014). Perchlorate concentrations in ground water have also decreased from 27 µg/L in 2003 to a 2014 maximum of 15 µg/L (1st Semester 2014). Risks to onsite workers from inhalation of VOC vapors and from exposure to PCBs, dioxins, and furans in surface soil have been mitigated.

DOE has performed two Five-Year Reviews for the Building 854 OU (Dibley et al., 2009a and Valett et al., 2014). The next Five-Year Review Report is scheduled for 2019.

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 selected in the Site-Wide ROD includes monitoring, risk and hazard management including land use controls, MNA for nitrate, and ground water and soil vapor extraction and treatment. The 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 2014 maximum of 2,100 µg/L (August 2014). Perchlorate concentrations have been reduced from a historic maximum of 51 µg/L in 1998 to a 2014 maximum of 9.7 µg/L (February 2014). 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 VOC inhalation risk to onsite workers in outdoor ambient air near Building 830, and in indoor ambient air in Building 832F.

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. Site-Wide (OU 8)

Operable Unit 8 includes the contaminant release sites that have a monitoring-only remedy: the Building 801 Dry Well and Pit 8 Landfill, Building 833, Building 845 and Pit 9 Landfill, the Building 851 Firing Table, and the Pit 2 Landfill. OU 8 release sites have a monitoring-only remedy because either: (1) contaminants in surface and subsurface soil/bedrock do not pose a risk to humans or plant and animal populations or a threat to ground water, (2) there is no ground water contamination, (3) contaminant concentrations in ground water do not exceed cleanup standards, and/or (4) the extent of contamination in ground water is limited. These release sites are summarized below.

DOE has performed one Five-Year Review for this OU (Buscheck et al., 2013). The next Five-Year Review is scheduled for 2018.

1.7.1. Building 801 Dry Well and the Pit 8 Landfill (OU 8)

The Building 801 Firing Table was used for explosives testing and operations resulting in contamination of adjacent soil with metals and uranium. Use of this firing table was discontinued in 1998, and the firing table gravel and some underlying soil were removed. Waste fluid was discharged to a dry well (sump) located adjacent to Building 801D from the late 1950s to 1984. The dry well was decommissioned and filled with concrete in 1984. VOCs, perchlorate and nitrate are COCs in ground water due to the past releases from the Building 801 Dry Well. VOC concentrations in ground water are currently near or below cleanup standards. Nitrate concentrations in ground water currently exceed the cleanup standard in two wells. Perchlorate is not currently detected in ground water. VOCs are COCs in subsurface soil, but do not pose a risk to human health. The adjacent Pit 8 Landfill received debris from the Building 801 Firing Table until 1974, when it was covered with compacted soil. There is no evidence of contaminant releases from the landfill.

The remedy selected for this area in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was selected as the remedy for VOCs in subsurface soil at Building 801.

No Remedial Design documents were required for this area.

1.7.2. Building 833 (OU 8)

TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinse water disposal, resulting in TCE-contamination of subsurface soil and shallow perched ground water. No contamination has been detected in the deeper regional aquifer. No COCs were identified in surface soil at Building 833.

The selected remedy for Building 833 includes monitoring and risk and hazard management including land use controls. No Remedial Design document was required for this area. Ground water monitoring at Building 833 has shown a decline in total VOC concentrations from a historic maximum of 2,100 µg/L in 1992 to a 2014 maximum of 110 µg/L (March 2014).

1.7.3. Building 845 Firing Table and the Pit 9 Landfill (OU 8)

The Building 845 Firing Table was used from 1958 until 1963 to conduct explosives experiments. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and HMX but no unacceptable risk to human or ecological receptors or threat to ground water was identified. No contaminants have been detected in surface soil or in ground water at the Building 845 Firing Table. Debris generated at the Building 845 Firing Table was buried in the Pit 9 Landfill. There has been no evidence of contaminant releases from the Pit 9 Landfill.

The remedy selected for Building 845 and the Pit 9 Landfill in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was selected as the remedy for uranium and HMX in subsurface soil at Building 845. No Remedial Design documents were required for this area.

1.7.4. Building 851 Firing Table (OU 8)

The Building 851 Firing Table has been used for high-explosives research since 1962. VOCs and uranium-238 were identified as COCs in subsurface soil, and RDX, uranium-238, and metals as surface soil COCs. However, no risk to humans or animal populations, or threat to ground water associated with these contaminants in surface and subsurface soil was identified in the baseline risk assessment. Uranium-238 was identified as a COC in ground water. However, it poses no risk to human or ecological receptors, and uranium activities remain well below cleanup standards and within the range of background levels.

In 1988, the firing table gravel was removed and disposed in Pit 7. Gravel has been replaced periodically since then. The remedy selected for Building 851 in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was selected as the remedy for VOCs and uranium in surface and subsurface soil, and for RDX and metal in surface soil at Building 851. No Remedial Design document was required for this area.

In 2014, DOE/NNSA identified the need for additional investigation of uranium-238 in surface soil at the Building 851 Firing Table to determine if the results of the baseline risk assessment are still valid, given the ongoing use of the firing table after the remedial investigation was completed.

1.7.5. Pit 2 Landfill (OU 8)

The Pit 2 Landfill was used from 1956 until 1960 to dispose of firing table debris from Buildings 801 and 802. Ground water data indicate a discharge of potable water conducted from 1996 to 2005 to support a red-legged frog habitat located upgradient from the landfill may have leached depleted uranium from the buried waste. The frogs were relocated and the water discharge was discontinued, thereby removing the leaching mechanism. No contaminants were identified in surface or subsurface soil at the Pit 2 Landfill. No risk to human or ecological receptors has been identified at the Pit 2 Landfill.

The remedy selected for the Pit 2 Landfill in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. Monitoring data indicate that uranium activities remain below the cleanup standard. There is no evidence of new contaminant releases from the Pit 2 Landfill indicated by the ground water detection monitoring data. No Remedial Design document was required for this area.

1.8. 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 is ongoing. A Final Work Plan for the sampling of surface soil in the Building 812 Firing Table area for PCB and HE compound analysis was submitted to the regulatory agencies on September 1, 2015. A new RI/FS report will be prepared following the completion of 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.

1.9. 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. However, concentrations of Freon 11 and Freon 113 are well below their MCLs; and PCE is only detected in one well at a concentration slightly above its 5 µg/L MCL (6.6 µg/L in well W-865-2004 in January 2014). In July of 2014, DOE/NNSA agreed to conduct additional characterization at Building 865 to add to the degree of certainty that residual contamination is not present in some areas where soil was previously characterized and/or excavated. An RI/FS report will be prepared following the completion of 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.

2. Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 850/Pit 7 Complex OU:

<u>1958</u>

- Building 850 was constructed and hydrodynamic/high explosive experiments began on the overlying firing table.

1958-1967

- Gravel and experimental debris from the Building 850 and 851 Firing Tables were buried in the Pit 3 Landfill.

1962-1972

- A large volume of sand, termed the "sandpile," was stockpiled near Building 850 and was periodically used during large experiments.

1963-1978

- Primary use of tritium at the Building 850 Firing Table occurred.

1964-1967

- An estimated 1,000 PCB-bearing capacitors were destroyed as part of experimental tests at the Building 850 Firing Table.

1968-1974

- Gravel and experimental debris from the Building 850 and 851 Firing Tables were buried in the Pit 4 Landfill.

1968-1979

- Gravel and experimental debris from the Building 850 and 851 Firing Tables were buried in the Pit 5 Landfill.

1978-1988

- Gravel and experimental debris from the Building 850 and 851 Firing Tables was buried in the Pit 7 Landfill. Some gravels from firing tables at Buildings 801, 802, 812, and 845 were placed in Pit 7 in 1988.

1981

- TCE was detected in an onsite water-supply well and remedial investigations began at Site 300. The first monitor wells installed in the Building 850/Pit 7 Complex OU.

1981-1991

- Remedial investigations were conducted at the Building 850/Pit 7 Complex OU.

1988-1994

- Five former water-supply wells were decommissioned and sealed in the Building 850/ Pit 7/East Firing Area

1990

- LLNL Site 300 was placed on the National Priorities List.
- Closure and Post-Closure Plans for the capping of the Pit 4 and 7 Landfills were completed (Rogers/Pacific Corporation, 1990).

1992

- A Federal Facilities Agreement (FFA) was signed for Site 300.
- An engineered cap and interceptor trenches and surface water drainage channels were constructed for the Pit 4 and 7 Landfills (referred to as the Pit 7 Cap) in compliance with RCRA requirements.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued that included the Building 850/Pit 7 Complex OU (Webster-Scholten et al., 1994).

1996

- An Addendum to the Site-Wide Remedial Investigation report for the Building 850/Pit 7 Complex OU provided additional information on the site hydrogeology, contaminant distribution and fate and transport, and potential risk and hazard indices (Taffet et al., 1996).

1998

- The Ground Water Tritium Plume Characterization Summary Report for the Building 850/Pits 3 and 5 Operable Unit further characterized the site hydrogeology, contaminant distribution in ground water, and fate and transport (Ziagos and Reber-Cox, 1998).
- PCB-contaminated shrapnel and debris were removed from the area around the Building 850 Firing Table and disposed at the Envirocare facility in Utah.

1999

- Evaluation of perchlorate and nitrate in Building 850/Pit 7 Complex OU ground water was initiated.

2000

- DOE and the regulatory agencies agreed that additional site characterization and evaluation of cleanup options were necessary prior to selecting a remedy for the Pit 7 Complex.

2000-2003

- Additional site characterization activities were conducted at the Pit 7 Complex.

2001

- An Interim Site-Wide ROD for Site 300 was signed in which a remedy was selected for the Building 850 portion of the Building 850/Pit 7 Complex OU (U.S. DOE, 2001). The Building 850 remedy included monitoring, risk and hazard management including land use controls, and MNA of tritium in ground water. A remedy for the Pit 7 portion of the Building 850/Pit 7 Complex OU was not included in the Interim Site-Wide ROD as additional characterization of this area was still underway. 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., 2001c).

2002

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

2003

- A permeable reactive barrier was installed downgradient of the Pit 7 Complex as part of an *in situ* treatability study to test the effectiveness of this technology in removing uranium from ground water.

2004

- A remedial design was completed for the Building 850 Firing Table (Taffet et al., 2004).

2005

- An area-specific Remedial Investigation/Feasibility Study was completed for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU (Taffet et al., 2005).

2007

- An Amendment to the Interim Site-Wide ROD for the Pit 7 Complex was signed that selected the remedy for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU including monitoring, risk and hazard management including land use controls, MNA of tritium, ground water extraction and treatment, and source control (U.S. DOE, 2007).

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed by DOE, EPA, DTSC, and the RWQCB. The remedies for the Building 850/Pit 7 Complex OU 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.
- High explosive experiments ceased at the Building 850 Firing Table.
- An Engineering Evaluation/Cost Analysis (EE/CA) and Action Memorandum were completed for the Removal Action to remediate PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table (Dibley et al., 2008a and Dibley et al., 2008b).
- The Remedial Design report for the Pit 7 Complex remedy was completed (Taffet et al., 2008).
- A Drainage Diversion System was installed at the Pit 7 Complex to prevent further releases of COCs from the pits and underlying bedrock to ground water.

2009

- The revised Compliance Monitoring Plan/Contingency Plan was issued (Dibley et al., 2009b).
- The Building 850 PCB-soil Removal Action Design was completed (SCS Engineers, 2009).
- A removal action for the excavation, consolidation, and solidification of PCB-, dioxin-, and furan-contaminated soil in a Corrective Action Management Unit (CAMU) at the Building 850 Firing Table was initiated.

2010

- The removal action for the excavation, consolidation, and solidification of PCB-, dioxin-, and furan-contaminated soil in a CAMU at the Building 850 Firing Table was completed in January 2010.
- A Verification Sampling and Analysis Report for the excavation of PCB-, dioxin-, and furan-contaminated soil at Building 850 was submitted and approved by the regulatory agencies (Holtzapple, 2010).
- A ground water treatment system was constructed and began operating at the Pit 7 Complex to remove COCs from ground water.

2011

- A treatability study work plan for the enhanced *in situ* bioremediation of perchlorate in Building 850 ground water was completed (Holtzapple, 2011a).
- A Remedial Action Completion Report for the Building 850/Pit 7 Complex OU was completed (Dibley et al., 2011b).
- An enhanced *in situ* bioremediation treatability study for reduction of perchlorate in ground water immediately downgradient of Building 850 commenced in September 2011 and is ongoing.

2012

- A tracer test was initiated in Building 850 ground water to determine the ground water pathway of water injected into an *in situ* bioremediation injection well NC7-70.

3. Background

3.1. Physical Characteristics

3.1.1. Site Description

LLNL Site 300 is a U.S. DOE experimental test facility operated by the LLNS, Limited Liability Corporation. It is located in the Eastern Altamont Hills 17 miles east of Livermore, California (Figure 1). At Site 300, DOE conducts research, development, and testing associated with high explosive materials. The climate at Site 300 is semi-arid; an average of approximately 10 inches of precipitation falls each year, mostly in the winter. However, during drought years (i.e., during 2012 through 2014), annual precipitation at the site can be significantly below the average. During these recent drought years, annual precipitation was 7 inches in 2012, 8.33 inches in 2013, and 5.25 inches in 2014.

The Building 850/Pit 7 Complex OU is located in the northwestern portion of LLNL Site 300 (Figure 2). Although Building 850 and the Pit 7 Complex are different and separate release sites, they were incorporated into one OU due to the commingling of the downgradient contaminant plumes emanating from these sources. The Building 850 and Pit 7 Complex portions of this OU are described in Sections 3.1.1.1 and 3.1.1.2, respectively.

3.1.1.1. Building 850 Firing Table Site Description

The Building 850 Firing Table is located approximately 2,000 ft south of the Pit 7 Complex (Figure 3). The firing table and the concrete-reinforced bunker, located directly adjacent to and partially under the firing table, were constructed in 1958. The firing table was used to test and develop detonators for prototypical nuclear weapons and armor-piercing projectiles. The bunker was used for diagnostic operations during firing table experiments, such as high-speed photography. The firing table and bunker are located in a topographically low area of the surrounding hills, presumably to reduce air pressure waves and contain debris released during experimental shots.

High explosives experiments were conducted at the Building 850 Firing Table from 1958 to 2008. Over 95% of the approximately 22,670 curies (Ci) of tritium shipped to Site 300 were used in hydrodynamic experiments at the Building 850 Firing Table (Buddemeier, 1985). The vast majority of tritium was used between 1963 and 1978, primarily in gaseous form ($^3H_2$), although some solid lithium tritide was also used. In addition to tritium, the test assemblies used on the firing table contained high explosives and occasionally depleted uranium. No experiments were conducted with fissile materials such as enriched uranium or plutonium.

Some of the explosives and test assemblies contained small quantities of barium, beryllium, copper, lead, and vanadium and utilized a variety of materials including wood-frame structures, tent poles, aluminum, plastic, burlap bags, metal cable, 10-ton rebar-reinforced concrete blocks, lead bricks, copper cylinders, and metal silos.

The firing table and the roof of the bunker were covered with up to 5 ft of gravel to absorb the shock from shot blasts and minimize impacts to bunker occupants. The firing table gravel was routinely rinsed down with 1 to 2 inches of water after each experiment to reduce dust and prevent hazardous material from being re-suspended in the air. This practice was discontinued in 2004. Prior to 1988, the upper 3 inches of gravel were removed from the firing table and disposed of in the Pit 7 Complex landfills on a quarterly basis. After 1988, gravels removed from the firing table were transported to the Nevada Test Site for disposal.

Use of the Building 850 Firing Table for explosives experiments was discontinued in 2008. All utility connections to Building 850 were disconnected in 2009.

3.1.1.2. Pit 7 Complex Site Description

The Pit 7 Complex is located in the northwest part of Site 300 (Figure 2), approximately 2,000 ft south of the site boundary. The Pit 7 Complex is located within a broad northwest-southeast trending valley within the Elk Ravine drainage area that is characterized by a series of northwest-southeast trending ridges and incised valleys (i.e., Doall Ravine). Due to the semi-arid climate (approximately 10 inches of rainfall per year but below average for the last few years), natural surface water in the Pit 7 Complex area is relatively rare, but occurs as surface water runoff during heavy rainfall events. When surface runoff is generated, surface water generally flows southeastward toward Doall Ravine in an ephemeral alluvial drainage channel located just east of the Pit 7 Complex.

The Pit 7 Complex consists of the Pit 3, 4, 5 and 7 Landfills that were constructed by excavating topsoil and alluvial materials within a valley bottom to an average depth of 15 to 20 feet (Taffet et al., 1989). From 1958 to 1988, the Pit 7 Complex landfills were used to dispose of firing table debris and spent gravel. The majority of the waste material in the pits came from the firing tables at Buildings 850 and 851, where aboveground detonations were conducted. The waste placed in the pits included wood, plastic, material and debris from tent structures, pea gravel, and exploded test assemblies, some of which contained tritium, depleted uranium, perchlorate, and nitrate. There is no historical documentation stating VOCs were used at the Building 850 or Building 851 firing tables. Despite detailed records searches and interviews with firing table personnel, the origin of VOCs in Pit 7 Complex waste is still unknown. However, given the low concentrations of VOCs detected in Pit 7 Complex ground water (i.e., individual VOC concentrations all below ground water cleanup standards in 2014), the presence of VOCs could be attributable to residual/incidental contamination of materials placed in the landfill.

The history of each landfill is summarized below:

Pit 3 Landfill

The Pit 3 Landfill was opened in 1958 and closed in 1967 (Taffet et al., 1989). The area and volume of Pit 3 are 6,180 square yards (yd^2) and 26,221 cubic yards (yd^3), respectively (Lindeken and Hieb, 1989).

Pit 4 Landfill

LLNL opened the Pit 4 Landfill in 1968 and closed it in 1974. (Taffet et al., 1989). The area and volume of Pit 4 are 855 yd^2 and 2,796 yd^3, respectively (Lindeken and Hieb, 1989).

Pit 5 Landfill

The Pit 5 Landfill was opened in 1968 and closed in 1979 (Taffet et al., 1989). The area and volume of Pit 5 are 9,100 yd^2 and 29,907 yd^3, respectively (Lindeken and Hieb, 1989).

Pit 7 Landfill

LLNL opened the Pit 7 Landfill in 1968 and ceased depositing waste in it in November 1988 (Taffet et al., 1989). The area and volume of Pit 7 are 2,250 yd^2 and 31,111 yd^3, respectively (Lindeken and Hieb, 1989). Although most of the waste material in Pit 7 was generated at the Building 850 and 851 firing tables, some gravel from the firing tables at Buildings 801, 802, 812, and 845 were deposited in Pit 7.

A map of the Pit 7 Complex area within the Building 850/Pit 7 Complex OU showing the locations of Doall and Elk Ravines, the landfills, drainage diversion system, extraction and monitor wells, and the treatment system is presented on Figure 3.

3.1.2. Hydrogeologic Setting

This section describes the general hydrogeologic setting for the Building 850/Pit 7 Complex OU including surface water, and the unsaturated zone, and the hydrostratigraphic units (HSUs) underlying the area. An HSU is a water-bearing zone that exhibits similar hydraulic and geochemical properties within a particular stratigraphic unit(s).

The spatial and temporal distribution of ground water in the Building 850 and Pit 7 Complex is influenced by several factors, including: (1) episodic El Niño-type rainfall events, (2) hillslope steepness and ground cover, (3) geologic structures (including bedding orientation, fractures, and faults), and the (4) inclined axes of alluvial drainage channels. During heavy rainfall events, hill slopes and alluvial drainage channels transmit surface and shallow ground water within the Building 850 area and Pit 7 Complex toward Doall Ravine, which discharges to Elk Ravine and ultimately to Corral Hollow Creek. The interaction between the alluvial drainage system and the underlying variably-transmissive fractured bedrock influences ground water flow and contaminant transport in the Building 850/Pit 7 Complex OU.

3.1.2.1. Vadose (Unsaturated) Zone

Unsaturated colluvium and unsaturated alluvium occur on hillslopes above Building 850 and west of the Pit 7 Complex landfill and in the stream channel that runs along the northeast side of the Pit 7 Complex Valley and northeastward within Doall Ravine. These materials are typically underlain by unsaturated weathered bedrock and Neroly Formation sandstone. The vadose zone is approximately 10 to 35 ft thick.

3.1.2.2. Saturated Zone

The following HSUs have been identified in the Building 850/Pit 7 Complex OU:

- Quaternary alluvium/weathered bedrock (Qal/WBR) HSU
- Lower Neroly Formation ($Tnbs_1/Tnbs_0$) HSU
- Lower Neroly Formation ($Tnsc_0$) HSU
- Cierbo Formation (Tmss) HSU

In the vicinity of Building 850, the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs are continuous and connected and therefore constitute a single HSU in this area.

Qal/WBR HSU

The Qal/WBR HSU is an unconfined and transmissive water-bearing zone consisting of: (1) clay-rich soil, loosely-consolidated sediment occurring as colluvium on slopes on the west side of Building 850 and the Pit 7 Complex areas and alluvial channel fill in the Pit 7 and Doall Ravine valleys and, (2) the underlying weathered and fractured bedrock strata. The total thickness for the Qal/WBR HSU in the Building 850 area is 40 to 70 ft with depth to water ranging from 30 to 60 ft. In the Pit 7 Complex area, this HSU is 20 to 60 ft thick and depth to water ranges from 20 to 50 ft.

The flow in this HSU is generally ephemeral, with recharge from surface water runoff, direct rainfall infiltration, and base flow from the underlying bedrock HSUs. The saturated thickness of the Qal/WBR HSU is both spatially and temporally variable and dependent on seasonal rainfall. Ground water flow in this HSU is dominated by preferential flow paths, including soil macropores and bedrock fractures, and is generally southeastward. In the Pit 7 Complex area, ground water accumulates in the valley bottom (Figure 4). Figure 4 (and Figure 5) contains water elevation data collected during the fourth quarter 2014. When the Pit 7 Complex valley bottom is continuously saturated, ground water in the Qal/WBR HSU then flows to the southeast in the direction of Doall Ravine. At this point, ground water follows the Doall Ravine drainage into Elk Ravine. The Qal/WBR HSU is also one of the main sources of recharge to the underlying Neroly bedrock HSUs. Water level data indicate that during extended periods of drought, most of the wells completed in the Qal/WBR HSU are either dry or have very little water.

$Tnbs_1/Tnbs_0$ HSU

In portions of the Pit 7 Complex, the Tnbs strata are the first coherent bedrock unit underlying the Qal/WBR and composed of the Lower $Tnbs_1$ and $Tnbs_0$ sandstone units. Locally, the extent of the HSU is limited where it crops out in the canyons immediately west of Building 850 and the Pit 7 Complex, along the northern Site 300 Boundary, and in northeast corner of Site 300. The HSU is unconfined and the saturated thickness exceeds 100 ft east of the Elk Ravine Fault. The HSU is continuous with the overlying Qal/WBR in the immediate vicinity and downgradient of Building 850 area. Depth to water varies from approximately 30 ft near Building 850 and western Doall Ravine to over 200 ft east of the Elk Ravine Fault.

Hydrologic, chemical, and optical televiewer data indicate that fractures and fracture orientation are important flow-controlling features in the $Tnbs_1/Tnbs_0$ HSU. In the northern portion of the Building 850/Pit 7 Complex OU, ground water generally flows east-southeast and in the central and southern portions of the OU, ground water generally flows east and south

(Figure 5). Downgradient (east) of Building 850, a portion of flow in the HSU discharges into Doall Ravine stream channel alluvium (Qal/WBR HSU) as base flow. Under non-drought conditions, the $Tnbs_1/Tnbs_0$ HSU also discharges at Spring 24 (Figure 3), and water from this HSU can be sampled from a shallow pipe inserted into the hillside at a location east of Building 850 (Well 8 Spring). While not a true spring, Well 8 Spring is one of the early sampling points in this area.

***$Tnsc_0$* HSU**

The underlying $Tnsc_0$ HSU is an interbedded and predominately fine-grained unit that serves as the confining layer above the Tmss HSU. The $Tnsc_0$ generally does not yield ground water except where it is fractured. The average thickness of $Tnsc_0$ strata is approximately 30 to 50 ft. Saturation also extends eastward across the Elk Ravine Fault and south within Elk Ravine. One well, W-850-2416, is located immediately downgradient of Building 850 and is screened within the saturated fractures in the upper portion of the $Tnsc_0$ unit.

Tmss HSU

The Tmss HSU is a quartz-rich medium-grained sandstone unit that is unconfined beneath the Pit 7 Complex landfills and under confined artesian and flowing artesian conditions in the Building 850 area. The depth to ground water in the Tmss HSU beneath the Pit 7 Complex is approximately 100 ft. The Tmss HSU is hydraulically separated from the overlying $Tnbs_1/Tnbs_0$ HSU by a 30- to 50-foot thick, fine-grained claystone ($Tnsc_0$). The saturated thickness of the Tmss HSU varies from 30 to over 100 ft. Depth to water varies from 150 ft in the Building 850 area to over 200 ft beneath Elk Ravine. Ground water in the Tmss HSU presumably flows eastward. Recharge to the Tmss HSU presumably occurs in the extensive valley west of Building 850. There are no known discharge areas to surface water from this HSU in the Building 850/Pit 7 Complex OU.

No anthropogenic contaminants have been detected in the Tmss HSU. The lack of contamination in the Tmss HSU is likely due to the overlying $Tnsc_0$ confining layer and the upward hydraulic gradient between the Tmss HSU and the overlying water-bearing zones.

3.1.2.3. Surface Water

Due to the semi-arid climate, natural surface water in the Building 850 and Pit 7 Complex areas is relatively rare. During and following heavy rainfall events, surface water has been observed as surface runoff, ponding in surface depressions, stream flow in active drainages, and discharges from natural springs. Surface runoff is generally observed when greater than one inch of rainfall occurs within a 24-hour period, especially during heavy El Niño-type events. When surface runoff is generated it generally flows southeastward toward Doall Ravine in the ephemeral alluvial drainage channel located just east of the Pit 7 Complex. Ephemeral surface water within Doall Ravine flows to the northeast into Elk Ravine and ultimately into Corral Hollow Creek approximately 1.5 miles east of Site 300. Corral Hollow Creek discharges to the east into the San Joaquin Valley.

Several man-made drainage channels, including diversion trenches and metal culverts, are located within the Building 850/Pit 7 Complex OU. Runoff diversion ditches and culverts are usually located along roads to reduce erosion potential during peak runoff periods. In addition, as part of the RCRA capping of Pits 7 and 4, concrete drainage channels (Figure 3) were installed around these landfills to divert surface runoff away from the landfill caps during heavy rainfall events. The concrete channels are connected to uphill horizontal drains that extend into the hillslope west of Pit 7, and receive flow from two gravel-filled interceptor trenches that run up the center of two prominent depressions on the hillslope. The two main concrete channels discharge to the stilling basins and ultimately the ground surface: one discharges north of the Pit 7 Complex and the other discharges south of Pit 5. These features were originally installed in 1991 when Pits 4 and 7 were covered with a RCRA cap. In 2008, a drainage diversion system was installed on both sides of the Pit 7 Complex valley to capture and divert rainfall runoff and a portion of infiltrating water. The water from this system ultimately discharges into the pre-existing concrete drainage channels. Some of the surface runoff from the hillslope west of the Pit 7 Complex is ultimately discharged to the catchment north of Site 300 and the remainder discharges into the southeast-flowing drainage adjacent to the Pit 7 Complex.

A high-density polyethylene (HDPE) and gravel-lined manmade drainage channel abuts the southern and eastern sides of the Building 850 CAMU. This drainage structure discharges to a culvert that extends under Route 4 and discharges into Doall Ravine. There is also a drainage channel that runs along the south side of the Building 850 access road.

Spring 24 is the only perennial natural surface water within the Building 850/Pit 7 Complex OU and is located approximately 3,000 ft southeast of the Pit 7 landfills, and approximately 750 northwest of where Doall Ravine merges with Elk Ravine (Figure 3). Spring 24 is a likely discharge or leak point from the $Tnbs_1/Tnbs_0$ HSU near the Elk Ravine Fault. As discussed previously, Well 8 Spring is not a true spring, but rather a shallow pipe inserted into the hillside at a location east of Building 850. Well 8 Spring is sampled via this pipe.

3.2. 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 is developed. Land use at Site 300, including the Building 850 and Pit 7 Complex area, is designated as restricted access, federal government industrial (experimental test) use. There have been no changes in land, building, or ground water use in the Building 850/Pit 7 Complex OU during the five year review period or since the Site-Wide ROD was signed in 2008.

The Building 850/Pit 7 Complex OU is entirely surrounded by Site 300 property and does not extend to the site boundary. The OU is accessible only to DOE/LLNL workers.

Site 300 was originally selected as a DOE experimental test site because of the sparsely populated surrounding area. On the basis of residential population, the average density around the perimeter of Site 300 is less than one person per square mile. Land use adjacent to the site boundary closest to the Building 850/Pit 7 Complex OU consists of private rangeland. There is no known planned modification or proposed development of the offsite rangeland closest to (north and west of) the OU. The nearest major population center (Tracy, California) is 8.5 miles to the northeast. There are plans to develop the land parcel east of Site 300 for residential housing, but thus far the development plans have been delayed by city restricted growth initiatives. As part of this development plan, a minimum buffer zone/open space of a mile to 1.5 miles is planned between residential development and the Site 300 boundary. The developer informed DOE/LLNL that ground water would not be used as the water-supply for this development.

The only building located within the Building 850 source area is the bunker at the Building 850 Firing Table that was used to monitor and photograph high explosive experiments conducted on the firing table. Building 850 became relatively inactive after 1988, but experiments continued on a limited basis until 2008 when use of the firing table for high explosives experiments was discontinued. Building 850 was closed and is no longer in use. There are no current plans to reactivate this building or firing table. The four landfills within the Pit 7 Complex, located north of Building 850, were used to dispose of firing table gravels and experimental debris until 1988 when use of the landfills was discontinued.

As the Building 850 bunker and firing table are no longer in use and the Pit 7 Complex area contains only closed landfills, there are no fulltime workers housed in this area. Occasional workers in this area include Environmental Restoration staff conducting monitoring, characterization, and remediation activities; Maintenance and Utility Services Department staff performing maintenance on the landfill caps; and LLNL Fire Department personnel during controlled burns in the area.

There are no active onsite water-supply wells in the Building 850/Pit 7 Complex OU. The nearest active water-supply well (onsite water-supply Well 20) is located approximately 10,000 ft southeast and cross-gradient of the Building 850/Pit 7 Complex OU. Ground water from this well is used for a variety of onsite water-supply needs including cooling towers, HE processing, dust control, drinking water, and fire suppression. Site 300 plans to transition to the Hetch Hetchy water supply in the near future.

Surface water in onsite springs is not used for water-supply or other human uses at Site 300. Some of the springs provide wetland habitat for wildlife.

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, species of special concern, migratory birds, and rare plants). Introduced annual grasslands cover the majority of the Building 850/Pit 7 Complex OU, with limited areas of native grassland and coastal sage scrub scattered throughout the OU (Jones and Stokes, 2002a; Dibley et al., 2014). Small freshwater seeps are associated with Well 8 Spring and Spring 24. As discussed previously, Well 8 Spring is not a true spring, but rather a shallow pipe inserted into the hillside at a location east of Building 850. There is no current surface water or water from the pipe that can be sampled. Spring 24 previously supported a small pool, which is also now largely dry. Three vernal pools/seasonal pools occur north and west of the OU (Jones and Stokes, 2002b). Wildlife within the OU is typical of California grasslands, and includes a variety of small mammals (such as deer mice, ground squirrels, rabbits and skunks), reptiles (such as western fence lizards and rattlesnakes), large mammals such as coyotes and mule deer, passerine birds (such as scrub jays, crows, wrens and towhees) and raptors (such as red-tailed hawks and golden eagles). Amphibians such as frogs and salamanders have been found in areas that can sustain ponded water. A list of vertebrate and rare invertebrate species known to occur at Site 300 can be found in LLNL (2014).

The only special-status plant species known to occur within the boundaries of the Building 850/Pit 7 Complex OU is the big tarplant (*Blepharizonia plumosa*). The big tarplant is an extremely rare late-season flowering plant included on the California Native Plant Society's (CNPS) List 1B, and is found throughout Site 300. In the Building 850/Pit 7 Complex OU, the plant occurs on the ridges south of Doall Road, and in the vicinities of Pit 2 and Buildings 801 and 845 (Dibley et al., 2014). As observed throughout Site 300, while the locations of the various populations are relatively stable, the size of the populations can greatly fluctuate from year to year. Such variations are common in annual plant populations, depending on environmental conditions (Dibley et al., 2014). Three additional special-status plant species (all on the CNPS List 1B), the diamond-petaled California poppy (*Eschscholzia rhombipetala*), the round-leaved filaree (*California macrophylla*) and the adobe navarretia (*Navarretia nigelliformis* ssp. *radians*), occur north and west of the OU (Dibley et al., 2014).

Two special status amphibians are known to occur within the Building 850/Pit 7 Complex OU boundaries, the California red-legged frog (*Rana aurora draytonii*) and California tiger salamander (*Spea Hammondii*). Both are federally threatened, and the California tiger salamander is also state threatened. The entire OU resides within the upland dispersal and critical habitat for the California red-legged frog, and the majority of the OU is within the 1,100 meter buffer area on California tiger salamander breeding sites (Dibley et al., 2014). Breeding by both species has been observed in the pool supported by Spring 24, which is now largely dry. Both species are also known to breed in the pools north and west of the OU. One special status reptile species, the Coast horned lizard (*Phyrnosoma coronatum frontale*), a California Species of Special Concern, has been observed within the Building 850/Pit 7 Complex OU boundaries (Dibley et al., 2009c). Although none have been observed, the southwest corner of the Building 850/Pit 7 Complex OU contains a small amount critical habitat for the state- and federally- threatened Alameda whipsnake (*Masticophis lateralis euryxanthus*).

Three special status bird species may occur within the Building 850/Pit 7 Complex OU. Grasshopper sparrows (*Ammodramus savannarum*) are expected to occur in the grasslands within the OU. The loggerhead shrike (*Lanius ludovicianus*) and burrowing owl (*Athene cunicularia*) have been recorded nesting within the OU. All three species are California Species of Special Concern, and the loggerhead shrike and burrowing owl are also federal Birds of Conservation Concern. Three special status mammal species may occur within the Building 850/Pit 7 Complex OU. The American badger (*Taxidea taxus*), a California Species of Special Concern, has been observed within the OU. Calls of the pallid bat (*Antrozous pallidus*), a California Species of Special Concern, were detected just north of the OU boundary. While the Building 850/Pit 7 Complex OU represents potential habitat for the state- and federally- endangered San Joaquin kit fox (*Vulpes macrotis mutica*), none have ever been observed at Site 300.

3.3. History of Contamination

The history of contamination at the Building 850 Firing Table area and Pit 7 Complex are discussed in Sections 3.3.1 and 3.3.2, respectively.

3.3.1. Building 850 Firing Table Area

As discussed in Section 3.1.1.1, the Building 850 Firing Table was used to conduct high explosives experiments from 1958 to 2008. The test assemblies used in experiments contained tritium, high explosives (i.e., RDX, HMX, and ammonium perchlorate), metals, and occasionally depleted uranium. These constituents were released to the environment during explosives testing. The routine rinsing of the firing table gravel following shots mobilized some experiment constituents (i.e., tritium, uranium-238, perchlorate, nitrate, and HE compounds) that had accumulated in the gravel and subsequently migrated to the underlying bedrock and ground water. This practice was discontinued in 2004.

From 1962 to 1972, a large volume of sand, known as the Building 850 sandpile, was stockpiled near Building 850 and was periodically used during large experiments. The sand became contaminated with tritium after repeated use in experiments. Rainwater infiltrating into the Building 850 sandpile may have contributed to releases of tritium to the subsurface. In 1990, the sandpile was covered with thick plastic to minimize rainwater infiltration.

Prior to PCBs becoming regulated substances, an estimated 1,000 capacitors were used in 10 to 20 experiments (50 to 100 capacitors per experiment) conducted from 1964 to 1967. The capacitors were used to provide a sudden burst of electrical energy during these experiments. During these experiments, PCBs, and dioxins and furans generated by the combustion of PCBs during the shot blast, were released to and contaminated surface soil on the surrounding hillslopes.

3.3.2. Pit 7 Complex

As discussed in Section 3.1.1.2, the Pit 7 Complex landfills were used from 1958 to 1988 to dispose of firing table debris and spent gravel, primarily from the Buildings 850 and 851 firing tables. The source of contamination in the Pit 7 Complex is the firing table debris and gravel buried in these landfills that contained residual VOCs, tritium, depleted uranium, perchlorate, and nitrate from experiments conducted on the firing tables.

In years of normal rainfall (10 inches/year), ground water levels remain well below the landfills. However, during past El Niño years/events, rainfall increased by 50 to 100% and the amount of runoff and recharge increased significantly. During these El Niño events, shallow ground water underlying the landfills rose and inundated the pit waste and underlying bedrock. Contamination contained in the pit waste and underlying bedrock came into contact with and was released to shallow subsurface ground water. The bulk of the water that inundated the landfills was shallow recharge ground water that flows into the landfill area following infiltration on the hillslopes to the east and west of the Pit 7 Complex.

3.4. Initial Response

DOE/LLNL began environmental investigations at the Building 850/Pit 7 Complex OU in 1981 to characterize the extent of contamination in soil, bedrock, ground water and surface water. These characterization efforts included records searches and interviews; the drilling of 341 boreholes and the installation of 180 ground water monitor wells; sampling of soil, soil moisture, bedrock, ground water and surface water; neutron probe measurements; magnetic surveys; soil vapor surveys; hydraulic testing; evaluating observed water level responses to rainfall events; geologic mapping; ground water transport modeling; geologic and hydrogeologic characterization; and risk assessment. The geologic and chemical data from wells and boreholes are used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminant concentrations.

At the Pit 7 Complex, additional site characterization activities included:

- Characterization of residual tritium and uranium sources in Pits 3 and 5, based on samples of pit waste and adjacent soil (1999).

- Performing a surface geophysical survey to corroborate results of other methods (i.e., borehole logs/cone penetrometer data) and independently define pit bottoms and geometry of alluvium/weathered bedrock (2002).
- Conducting a helium-3 soil vapor survey to corroborate results of other methods (soil moisture and soil vapor tritium data) and independently estimate the number of curies of tritium remaining in the pits and the vadose zone (2003).
- Installing monitoring piezometer nests to determine which shallow water-bearing zones may convey water into the valley bottom where the Pit 7 Complex is located (2001).
- Conducting a water budget study to refine the hydrogeological conceptual model for the Pit 7 Complex area, and to support evaluation of remedial alternatives designed to divert water away from the pits (2002-2003).
- Evaluating the Elk Ravine Fault system regarding its potential effects on ground water transport and future plume movement downgradient of the Pit 7 Complex (2002-2003).
- Investigating existing and innovative remedial technologies to be evaluated in the Feasibility Study (2003-2004).

Prior to 1988, when waste disposal in the Pit 7 Complex landfills ceased, the pits were covered with approximately 3 ft of compacted native soil. In 1992, an engineered cap was constructed over the Pit 7 Landfill (referred to as the Pit 7 Cap) in compliance with RCRA requirements. The design included interceptor trenches and surface water drainage channels, a top vegetative layer to prevent erosion, a biotic barrier layer to minimize animal burrowing, and a clay layer of very low permeability to prevent infiltration of precipitation and shallow subsurface interflow that could result in leaching of contaminants. The Pit 7 cap also covers 100% of Pit 4 and approximately 25 to 30% of Pit 3. The original compacted native soil cover material on Pit 3 and Pit 5 remains intact.

In 2002, DOE/LLNL installed a shallow terrace drain composed of three 20-ft long and 3-ft deep gravel-filled trenches to test the efficacy of this technique for capturing shallow flow on the hillslope west of the Pit 7 Complex, diverting it away from and preventing water table rises into the landfills. Two horizontal wells fitted with flow meters at the outfall points were also installed on the western hillslope for the same purpose.

In 2003, a permeable reactive barrier, consisting of 11 closely- spaced boreholes filled with cow bone char (hydroxyapatite) and sand was installed within the Qal/WBR HSU downgradient of the Pit 7 Complex as part of an *in situ* treatability study to test the effectiveness of this technology in removing uranium from ground water. The treatability study results indicated that the *in situ* permeable reactive barrier would not be the most effective treatment technology for removing uranium from ground water. The use of this technology would result in longer cleanup times because it is limited by ground water flow rates to carry the uranium to the reactive barrier for treatment. Additionally, uranium-bearing ground water was found to not preferentially flow into the reactive barrier material.

In 2009, a non-time critical removal action to mitigate the risk to onsite workers and ecological receptors associated with PCB-, dioxin-, and furan-contaminated surface soil at Building 850 was initiated. A total of 27,592 cubic yards of PCB-, dioxin-, and furan-contaminated soil were excavated from the Building 850 Firing Table area, mixed with Portland cement and water, and consolidated in a CAMU. The removal action was completed in

January of 2010. Additional information on the Building 850 Removal Action is presented in the Engineering Evaluation/Cost Analysis for PCB-, Dioxin- and Furan-contaminated Soil at the Building 850 Firing Table (Dibley et al., 2008a) and Building 850 Action Memorandum (Dibley et al., 2008b). Design information for the CAMU is presented in the construction subcontractor's 100% design submittal (SCS Engineers, 2009). A map of the Building 850 area within the Building 850/Pit 7 Complex OU showing the location of the CAMU is presented on Figure 3.

3.5. Contaminants of Concern

Contaminants of concern (COCs) in environmental media at Building 850 and the Pit 7 Complex were determined based on: (1) an unacceptable human health cancer risk ($>10^{-6}$) or noncancer hazard (Hazard Index [HI]>1), (2) an unacceptable hazard (HI>1) to ecological receptors, (3) the potential for soil contaminants to impact ground water at concentrations above MCLs, and/or (4) the presence of ground water contaminants at concentrations above the MCL.

Baseline human health risks and hazards for Building 850 and the Pit 7 Complex were estimated and presented in the Site-Wide Remedial Investigation (SWRI) (Webster-Scholten, 1994) and Pit 7 Complex RI/FS, respectively, using industrial adult onsite exposure and offsite residential exposure scenarios. The adult onsite exposure scenario estimated health risk where an adult is assumed to work in the immediate vicinity of worst-case contamination 8 hours a day, 5 days per week, for 25 years. This exposure scenario further assumed that workers would not dig into the Pit 7 Complex landfills or subsurface soil; excavation will be prevented through institutional/land use controls.

Drinking water MCLs were selected as the cleanup standards for COCs in ground water in the Building 850/Pit 7 Complex OU in the Site-Wide ROD. Therefore, ground water cleanup is driven by the MCL ground water cleanup standards selected in the Site-Wide ROD, rather than by a specific risk number/level. Ground water in the Building 850/Pit 7 Complex OU is not currently used as drinking water and institutional controls will prohibit such use until cleanup standards are achieved.

The baseline ecological risk assessment for the Building 850/Pit 7 Complex OU is presented in the SWRI and the Addendum to the Site-Wide Remedial Investigation Report for the Building 850/Pit 7 Complex Operable Unit (Taffet et al., 1996). Additional ecological modeling is also presented in the 2004 First Semester Compliance Monitoring Report (Dibley et al., 2004). Two five-year ecological reviews have also been completed for Site 300 (including the Building 850/Pit 7 Complex OU), which updated the assessment of ecological impacts from Site 300 contaminants. The 2008 Five-Year Ecological Review is reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), and the 2013 Five-Year Ecological Review is reported on in the 2013 Annual Compliance Monitoring Report (Dibley et al., 2014). An LLNL ecologist reviewed data collected during these two time periods to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors.

The COCs identified for surface soil, subsurface soil, ground water, and surface water and a summary of human health risk and ecological hazard identified in the baseline risk assessment for the Building 850 Firing Table area and Pit 7 Complex are discussed in Sections 3.5.1 and 3.5.2, respectively.

3.5.1. Building 850 Firing Table Area

3.5.1.1. Contaminants of Concern for the Building 850 Firing Table Area

COCs have been identified for impacted environmental media in the Building 850 Firing Table area:

- Surface soil (0 to 6 inches): PCBs, HMX, dioxins, furans, depleted uranium, beryllium, cadmium, and copper.
- Subsurface soil: Tritium and uranium.
- Surface water (Well 8 Spring): Tritium.
- Ground water: Tritium, depleted uranium, nitrate, and perchlorate.

3.5.1.2. Summary of Human Health Risk for the Building 850 Firing Table Area

The baseline human health risk assessment identified a cumulative cancer risk of 5×10^{-4} and 1×10^{-4} to onsite workers for inhalation, ingestion, and dermal contact (8 hrs/day, 5 days/week) of PCBs and dioxin and furan compounds, respectively, in surface soil at the Building 850 Firing Table over a 25-year period.

A cumulative cancer risk of 1×10^{-3} was identified for onsite workers continuously inhaling (8 hrs/day, 5 days/week) tritium vapors volatilizing from surface water in Well 8 Spring and migrating into outdoor air over a 25-year period.

The human health baseline risk assessment also identified a cancer risk of 6×10^{-6} for onsite workers associated with beryllium in surface soil at Building 850. However, while the maximum beryllium concentration detected in Building 850 soil (15 milligrams per kilogram [mg/kg]) exceeded background concentrations, it is well below industrial and residential January 2015 EPA regional screening levels (RSLs) of 2,300 mg/kg and 160 mg/kg.

While HMX was identified as a COC in surface soil at Building 850, this HE compound was detected in only one soil sample and its concentration (2.4 mg/kg) is well below current (January 2015) EPA industrial and residential RSLs for soil of 57,000 mg/kg and 3,800 mg/kg, respectively. HMX was included as a COC in soil because it was detected in more than 2% of the samples collected and there were no HMX soil screening levels in place at the time. As discussed in Section 5.4.1.1.5 of this report, although HMX has been detected sporadically in ground water samples from several wells proximal to the Building 850 firing table, all HMX concentrations were well below the current Regional Tapwater Screening Level for HMX (100 µg/L). There are no state or federal MCLs for HMX. During 2014, samples from four wells located immediately downgradient of the Building 850 Firing Table, contained HMX above the current 1 µg/L reporting limit with the maximum of 6.8 µg/L detected.

There was no unacceptable risk or hazard identified for offsite residents, associated with COCs in any environmental media for the Building 850 Firing Table area.

3.5.1.3. Summary of Ecological Hazards for the Building 850 Firing Table Area

No ecological hazard was identified to vegetation and vertebrate endpoints due to the presence of tritium and/or uranium (both as uranium-238 and as uranium as a metal) in surface and subsurface soil in the OU.

No ecological hazard was identified to aquatic invertebrates due to the presence of tritium in Well 8 Spring. Tritium in Spring 24 was not explicitly evaluated in the baseline risk assessment, but tritium levels in Spring 24 are less than that evaluated for Well 8 Spring, and thus below levels expected to pose an ecological hazard. Spring 6 was evaluated as ground water containing tritium from the Building 850 area could migrate to Spring 6. Projected tritium concentrations in Spring 6 were well below concentrations that could pose an ecological hazard. Aquatic bioassays were conducted on Well 8 Spring. No statistically significant effects were observed on *Ceridophnia dubia* (water flea) survival or reproduction or *Selenastrum capricornutum* (algae) growth on any sample tested. The 2013 Five-Year Ecological Review evaluated the presence of HMX, perchlorate, and nitrate detected in Well 8 Spring. These constituents were found to be below ecological or regional screening levels or Site 300 background. As a result of these ecological assessments, no ecological contaminants of concern were identified in the Building 850/Pit 7 Complex OU surface water.

Hazard indices exceeded 1 for cadmium in surface soil for individual adult ground squirrels and individual adult and juvenile deer in the Building 850 area. Further analysis revealed no population-level effects to these species. A review of the ecological hazard posed by PCBs, dioxins, and furans in surface soil in the immediate vicinity of the Building 850 Firing Table concluded that these constituents were unlikely to pose a risk to soil invertebrates or resident rodent populations, but could pose a risk to higher level avian or vertebrate populations. Modeling presented in the 2004 First Semester Compliance Monitoring Report (Dibley et al., 2004) resulted in a Hazard Quotient of 1 to 2 for individual burrowing owls from potential exposure to the PCB Aroclor 1254 in surface soil. The 2008 Five-Year Ecological Review reported a Hazard Quotient of less than 1 for burrowing vertebrate species (ground squirrel, burrowing owl, and kit fox) from potential exposure to the PCB Aroclor 1260 found in surface and subsurface soil in the vicinity of the Building 850 Firing Table. The differing results reported in the 2004 First Semester Compliance Monitoring Report and the 2008 Five-Year Ecological Review were due to evaluating different PCB congeners with different toxicity reference values. Therefore, cadmium, PCBs, dioxins, and furans in surface soil in the vicinity of the Building 850 Firing Table were identified as ecological contaminants of concern.

Beryllium, cadmium, and copper contributed to a Hazard Index greater than one for the Building 850 sandpile for adult ground squirrels, with cadmium primarily driving the hazard.

3.5.2. Pit 7 Complex

3.5.2.1. Contaminants of Concern for the Pit 7 Complex

COCs have been identified for impacted environmental media in the Pit 7 Complex area:

- Surface soil (0 to 6 inches): None.
- Subsurface soil: Tritium and uranium.
- Surface water: None.
- Ground water: VOCs, tritium, uranium, nitrate, and perchlorate.

3.5.2.2. Summary of Human Health Risk for the Pit 7 Complex

The baseline risk assessment indicated that the only unacceptable risk to human health posed by contaminants in the Pit 7 Complex area was inhalation of tritiated water vapor evaporating from subsurface soil by onsite workers in the vicinity of the Pit 3 Landfill. This risk was estimated to be 4 x 10^{-6} and was calculated based on the assumption that a worker spends 8 hours a day, 5 days a week for 25 years at Pit 3. However, only periodic monitoring activities are conducted at the landfills and no workers actually spend this amount of time in the area. In addition, radioactive decay continues to reduce the mass of tritium in subsurface soil at the Pit 3 Landfill, thereby reducing the flux of tritium vapors to air.

In 2007, the risk to onsite workers for inhalation of tritium vapors from the Pit 3 Landfill was recalculated, accounting for tritium decay that occurred between 1992 and 2007, for the Pit 7 Complex Remedial Design Document (Taffet et al., 2008). An excess cancer risk of 8 x 10^{-7} was estimated for a worker spending 8 hours a day, 5 days a week for 25 years at the Pit 3 Landfill. Therefore, there is no longer an unacceptable risk to onsite worker health posed by contaminants in the Pit 7 Complex area.

There was no unacceptable risk or hazard identified for offsite residents associated with COCs in any environmental media in the Pit 7 Complex area.

3.5.2.3. Summary of Ecological Hazards for the Pit 7 Complex

The SWRI baseline risk assessment determined that there was no unacceptable hazard to ecological receptors identified for the Pit 7 Landfill Complex. This determination was based on estimates of hazard from potential exposure to contaminants that were calculated for mammals, amphibians, and birds that could potentially inhabit this area, including threatened and endangered species.

The 2008 Five-Year Ecological Review reported that subsurface samples collected within Pit 5 during additional characterization activities contained uranium concentrations that resulted in Hazard Indices greater than 1 for burrowing vertebrate species. Therefore, uranium within the Pit 7 Complex (Pit 5) was identified as an ecological contaminant of concern.

3.6. Summary of Basis for Taking Action

The response actions selected in the Site-Wide ROD were necessary to protect human health or the environment from actual or threatened releases of hazardous substances from the Building 850/Pit 7 Complex OU. The baseline risk assessment evaluated potential present and future human health and ecological risks associated with environmental contamination in this OU using the assumption that no cleanup or remediation activities would take place. The risk assessment provided the basis for implementing a remedial action and identified the exposure pathways that that need to be addressed. Selection of the cleanup actions was based in part on the extent to which they could reduce human and ecological risks.

The summary of basis for taking action at the Building 850 Firing Table area and Pit 7 Complex are discussed in Sections 3.6.1 and 3.6.2, respectively.

3.6.1. Building 850 Firing Table Area

Remedial and removal actions were initiated in the Building 850 portion of the Building 850/Pit 7 Complex OU to address:

- An unacceptable human health risk of 5 x 10^{-4} and 1 x10^{-4} to onsite workers for inhalation, ingestion, and dermal contact of PCBs and dioxin/furans, respectively, in surface soil at the Building 850 Firing Table (addressed in 2008 Removal Action).

- An unacceptable human health risk of 1 x 10^{-3} associated with onsite worker inhalation of tritium volatilizing from surface water in Well 8 Spring, located downgradient of Building 850.
- An HI greater than 1 associated with the ingestion/bioaccumulation of PCBs, dioxins, and furans in Building 850 surface soil for individual ground squirrels, the San Joaquin kit fox and the western burrowing owl (addressed in the 2008 Removal Action).
- Tritium and nitrate present in Building 850 ground water at concentrations exceeding cleanup standards.

Although uranium was identified as a ground water COC, uranium activities in Building 850 ground water were below cleanup standards. Therefore, remedial actions were not necessary to mitigate risk for this contaminant pathway. However, monitoring of uranium in ground water to detect any activity increases that could impact human health was included as part of the remedy.

Although perchlorate with concentrations above the (State) MCL cleanup standard was identified in Building 850 ground water, a remedy for perchlorate in Building 850 ground water was not selected in the Site-Wide ROD. As indicated in Section 2.9.5 of the Site-Wide ROD (DOE, 2008), DOE will implement an *in situ* bioremediation treatability study and discuss possible remedial measures with the regulatory agencies. The treatability study is currently underway. Remedial alternatives for perchlorate in ground water will be presented in a Focused Feasibility Study. Public input will be solicited prior to the selection of a remedy and the selected remedy for perchlorate in ground water will be documented in an amendment to the Site-Wide ROD.

3.6.2. Pit 7 Complex

Remedial actions were initiated in the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU to:

- Address VOCs, tritium, depleted uranium, nitrate, and perchlorate present in Pit 7 Complex ground water at concentrations exceeding cleanup standards.
- Prevent further contaminant releases from the Pit 7 Complex landfills to ground water.

As discussed in Section 3.5.2.2, a 2007 recalculation of risk to onsite workers inhaling tritiated water evaporating from subsurface soil in the vicinity of the Pit 3 Landfill determined that there was no longer an unacceptable inhalation risk. Therefore, remedial actions were not necessary to mitigate risk for this pathway.

There was no unacceptable hazard to ecological receptors identified for the Pit 7 Landfill Complex.

4. Remedial Actions

4.1. Remedial Action Objectives

Remedial Action Objectives (RAOs) are included in the Site-wide ROD. The RAOs applicable to the Building 850/Pit 7 Complex OU selected remedies are:

For Human Health Protection:

Building 850 and Pit 7 Complex:

- 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 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).

Building 850 only:

- Prevent human incidental ingestion and direct dermal contact of/with PCB-, dioxin-, and furan-contaminated surface soil at Building 850 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 PCBs, dioxins, and/or furans bound to resuspended surface soil particles at Building 850 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 tritium volatilizing from surface water in Well 8 Spring 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.

For Environmental Protection

Building 850 and Pit 7 Complex:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and 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.

An RAO for human health protection/ARAR compliance for ingestion of surface waters (i.e., water from Site 300 springs) was not included in the Site-Wide ROD because there is not a complete exposure pathway for ingestion of surface waters for humans at Site 300. Humans do not drink water from Site 300 springs. In addition, the springs in which contaminants are detected do not produce a sufficient quantity of water to be used as a water-supply (greater than 200 gallons per day). The tritium activities in Well 8 Spring water have declined from a historical maximum of 770,000 picoCuries per liter (pCi/L) to most recent activity of 15,600 pCi/L (October 20 2010). Well 8 Spring has been dry since 2011.

As discussed in Section 3.5.2, a 2008 recalculation of risk to onsite workers inhaling tritiated water evaporating from subsurface soil in the vicinity of the Pit 3 Landfill determined that there was no longer an unacceptable inhalation risk. Therefore, the RAO for this pathway included in the Site-Wide ROD is no longer applicable.

4.2. Remedy Selection

The remedies selected for Building 850 and the Pit 7 Complex in the Site-Wide ROD are described in Sections 4.2.1 and 4.2.2, respectively.

4.2.1. Building 850 Remedy Selection

In the 2001 Interim Site-Wide ROD, a remedy was selected for the Building 850 portion of the Building 850/Pit 7 Complex OU. The interim remedy was selected as the final remedy in the 2008 Final Site-Wide ROD. The removal action for PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table was selected in an Action Memorandum in 2008, and was initiated in 2009 and completed in January 2010.

The components of the selected remedy for Building 850 include:

1. MNA to reduce tritium activities in ground water and surface water to cleanup standards.
2. Monitoring ground water and surface water COCs to evaluate the effectiveness of the remedy in achieving cleanup standards.
3. Risk and hazard management, including institutional/land use controls, to prevent human exposure to contamination and to protect the integrity of the remedy.
4. Excavation, and onsite solidification and consolidation of contaminated soil and sandpile to mitigate risk to onsite workers and ecological receptors.

Active remediation measures for uranium, HMX, and metals in surface soil around the firing table were not included in the remedy as they were determined to pose no unacceptable risk to human health or ground water quality. However, soil containing these constituents was also incidentally excavated and solidified in the removal action to address PCB-, dioxin-, and furan-contaminated soil.

Active remediation measures for tritium, uranium and nitrate in ground water were not included in the remedy because:

- The source of tritium in the vadose zone was rapidly decreasing in mass, and tritium in ground water will naturally attenuate to meet the cleanup standard in a reasonable timeframe time without migrating offsite.
- Uranium activities in ground water were below the cleanup standard and its extent is limited.
- Data do not indicate the presence of a significant source of nitrate in the Building 850 Firing Table area, and the extent of nitrate with concentrations exceeding the cleanup standard is limited and does not pose a threat to human health or the environment.

As discussed in Section 3.6.1, an *in situ* bioremediation treatability study for perchlorate in Building 850 ground water is underway. Remedial alternatives will be presented in a Focused Feasibility Study and a remedy for perchlorate in Building 850 ground water will be selected in an Amendment to the Site-Wide ROD. Because a remedy has not yet been selected or implemented for perchlorate in Building 850 ground water, it is not considered as part of this Five-Year Review and is not discussed further. The status and progress of this treatability study is reported in the Compliance Monitoring Reports.

4.2.2. Pit 7 Complex Remedy Selection

A remedy for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU was selected in the 2007 Amendment to the (2001) Interim Site-Wide ROD for the Pit 7 Complex. The interim remedy was selected as the final remedy in the 2008 Final Site-Wide ROD.

The components of the selected remedy for the Pit 7 Complex include:

1. Monitoring ground water COCs to determine if the cleanup is adequately protecting human health and the environment and to evaluate the effectiveness of the remedy in achieving cleanup standards.
2. Risk and hazard management, including institutional and land use controls, to prevent human exposure to contamination and to protect the integrity of the remedy.
3. MNA to reduce tritium activities in ground water to cleanup standards.
4. Installing and maintaining an engineered drainage diversion system to hydraulically isolate the contaminant sources in the landfills and underlying bedrock from subsurface water, thereby preventing significant recharge of infiltrating rainwater runoff that can result in ground water rising into Pits 3, 4, 5, and 7 and releasing contaminants.
5. Extracting and treating uranium, VOCs, nitrate, and perchlorate in Pit 7 Complex ground water to reduce contaminant concentrations in ground water to cleanup standards.
6. Inspecting the Pit 7 Complex landfill caps/covers periodically for damage that could compromise their integrity and repairing any damage found.

Active remediation measures for tritium in ground water were not included in the remedy because tritium in ground water will naturally attenuate to meet the cleanup standard in a reasonable timeframe time without migrating offsite. In addition, there is no efficient and effective technology at this scale to remove tritium from ground water.

4.3. Remedy Implementation

Implementation of the selected remedies for the Building 850/Pit 7 Complex OU in the Site-Wide ROD are described in Sections 4.3.1 and 4.3.2, respectively.

4.3.1. Building 850 Remedy Implementation

The monitoring of ground water and surface water in the Building 850 area is ongoing and includes:

- Monitoring of tritium in ground water to evaluate the effectiveness of monitored natural attenuation in reducing tritium activities to meet cleanup standards.
- Monitoring of nitrate and depleted uranium in ground water to ensure that concentrations/activities and/or extent of these COCs in ground water do not change such that they pose a threat to human health or the environment.

- Monitoring of tritium in surface water in the Well 8 Spring to determine if risk and hazard management measures, such as access restrictions, continue to be necessary to prevent tritium inhalation exposure by onsite workers.

Remedial action monitoring requirements are contained in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at LLNL Site 300 (Dibley et al., 2009b).

As discussed in Section 3.4, a non-time critical removal action was conducted to mitigate the risk to onsite workers and ecological receptors associated with PCB-, dioxin-, and furan-contaminated surface soil at Building 850 in 2009. A total of 27,592 cubic yards of PCB-, dioxin-, and furan-contaminated soil were excavated from the Building 850 Firing Table area. The contaminated soil was laid down in 12-inch lifts within the subgrade excavation in the Upper Corporation Yard, mixed with 5% Portland cement and water to solidify it, and consolidated in a CAMU. The top of the CAMU consists of a 5 ft thickness of soil mixed with 10% Portland cement and is composed of at least 1 ft of clean fill, underlain by 4 ft of contaminated soil. As shown in Figure 3, the CAMU is located approximately 100 feet east of Building 850. The applicable or relevant and appropriate requirements (ARARs) that applied to the construction of the CAMU are detailed in Table 2 of the Action Memorandum for the Building 850 Firing Table Removal Action (Dibley et al., 2008b). Drainage features were also enhanced and/or constructed on and around the CAMU that provide for erosion control and reduce sediment discharge. A high-density polyethylene (HDPE) and gravel-lined manmade drainage channel abuts the southern and eastern sides of the Building 850 CAMU. This drainage structure discharges to a culvert that extends under Route 4 and discharges into Doall Ravine. There is also a drainage channel that runs along the south side of the Building 850 access road. This removal action mitigated the risk to onsite workers and ecological receptors associated with PCB-, dioxin-, and furan-contaminated surface soil at Building 850.

A risk and hazard management program, including institutional and land use controls, has been implemented at Building 850. The land use/institutional controls for the Building 850 area are described in Section 4.5 and Table 2. The risk and hazard management program also includes the inspection and maintenance of the Building 850 CAMU to identify and repair any damage to the CAMU that could compromise its integrity.

The results of remedial action ground water, and surface water monitoring, remediation progress, and the status of institutional control implementation for the Building 850 area are reported in the ERD semiannual and annual Compliance Monitoring Reports.

A map of the Building 850 area within the Building 850/Pit 7 Complex OU showing the locations of the CAMU and monitor wells is presented on Figure 3. Photographs of the CAMU are included in Appendix A1.

4.3.2. Pit 7 Complex Remedy Implementation

Monitoring of ground water and surface water at the Pit 7 Complex includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 7 Complex landfills (Pits 3, 4, 5, and 7).
- Remedial action monitoring of VOCs, tritium, depleted uranium, nitrate, and perchlorate in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations to meet cleanup standards.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and downgradient of the Pit 7 Complex landfills and analyzed for potential constituents of concern. Constituents of concern are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the Pit 7 Complex landfills.

As part of the remedial action monitoring program, ground water samples are collected from wells and analyzed for ground water contaminants of concern to evaluate the progress and effectiveness of the remedial action in meeting cleanup standards. Contaminants of concern are constituents detected in ground water above the cleanup standard.

A risk and hazard management program, including institutional and land use controls, has been implemented at the Pit 7 Complex. The land use/institutional controls for the Pit 7 Complex are described in Section 4.5 and Table 3. The risk and hazard management program also includes the inspection and maintenance program for the Pit 7 Complex landfills. The purpose of this program is to identify and repair any degradation or damage to the landfill surfaces or damage or blockage of the drainage ways that could lead to: (1) increased infiltration of precipitation, (2) exposure of the landfill contents, and (3) flow of surface water on or adjacent to the landfills.

In 2008, a drainage diversion system was installed at the Pit 7 Complex to prevent further releases of COCs from the pits and underlying bedrock to ground water. The four components of the drainage diversion system include:

1. A subsurface drainage network on the western hillslope.
2. Upgraded riprap at the end of the existing north-flowing concrete channel for the Pit 7 Landfill cap.
3. A vegetated surface water diversion swale along the base of the eastern hillslope.
4. An upgraded surface water-settling basin at the south end of the existing south-flowing concrete channel for the Pit 7 Landfill cap.

Additional information on the Pit 7 landfill cap and drainage diversion system design is presented in the Remedial Design Document for the Pit 7 Complex (Taffet et al., 2008).

A ground water extraction and treatment system (Pit 7-Source) was constructed and began operation at the Pit 7 Complex in May 2010. Ground water is extracted from Qal/WBR HSU and $Tnbs_1$/$Tnbs_0$ bedrock HSU wells to remove VOCs, uranium-238, nitrate, and perchlorate from the subsurface. The ground water treatment system includes three ion-exchange resin canisters for the removal of uranium followed by three ion-exchange resin canisters containing a perchlorate-selective resin that is also effective in removing nitrate. Ground water that has been treated to remove uranium, perchlorate, and nitrate is then piped through three aqueous-phase granular activated carbon (GAC) canisters to remove VOCs. The treated water, which still contains tritium, is discharged to an infiltration trench, where the tritium naturally attenuates *in situ*. Tritium activities in ground water downgradient of the infiltration trench are monitored to ensure that the infiltrating treatment facility effluent does not accelerate downgradient migration of tritium in ground water.

The results of landfill detection monitoring, and remedial action ground water monitoring, remediation progress, and the status of institutional control implementation at the Pit 7 Complex are reported in the ERD semiannual and annual Compliance Monitoring Reports.

A map of the Pit 7 Complex area within the Building 850/Pit 7 Complex OU showing the locations of the landfills, Drainage Diversion System, extraction and monitor wells, and the treatment system is presented on Figure 3. Photographs of the landfills, drainage diversion system, and the treatment system are included in Appendix A3.

4.4. Operation and Maintenance

The remedies for the Building 850/Pit 7 Complex OU operated as designed during this five-year review period and no significant operational or cost issues were identified. All required documentation is in place, and the inspection, operation, and maintenance procedures for the Building 850 CAMU and the Pit 7 Complex ground water treatment system, engineered drainage diversion system, and landfill covers/cap are consistent with established procedures and protocols. Inspection, operation, and maintenance activities and any operational or compliance issues identified during the five-year review period for the Building 850 area and Pit 7 Complex remedies are discussed in Sections 4.4.1 and 4.4.2, respectively.

4.4.1. Building 850 Remedy Operation and Maintenance

The remedy components for the Building 850 area that require long-term inspection, operation, and maintenance include:

- A CAMU where solidified contaminated surface soil was consolidated.
- A ground water monitoring network to evaluate the effectiveness of cleanup.

Inspection and maintenance procedures for these remedy components are contained in the following documents:

- Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at LLNL Site 300 (Dibley et al., 2009b).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Lorega, 2009 and 2012).
- Inspection and Maintenance Plan for the Building 850 Containment Embankment (CAMU) (SCS Engineers, 2010.)

During the review period, inspections of the Building 850 CAMU were conducted in the rainy season, as required. The major maintenance activities for the Building 850 CAMU included:

- Repair of erosional damage on the hillslope west of Building 850 that occurred during heavy winter/spring rains (2010).
- Weed removal from the CAMU and spraying of a pre-emergent herbicide to prevent creation of an attractive habitat for burrowing animals (2012).
- Removing sediment from the drainage system catch basin to restore water flow (2013).
- Removing vegetative debris and sediment from the CAMU surface water drainage system (as needed).

During the five-year review inspection, it was noted that use of a pre-emergent herbicide in the drainage channels on the perimeter of the CAMU would reduce maintenance labor and enhance the flow of surface water runoff during rain events. This work will be scheduled prior to the start of the rainy season in the fall of 2015.

During the five-year review inspection, it was also noted that non-functional lysimeter NC7-09 continues to exist in the area between the southern engineered drainage channel and the CAMU. A schedule for the decommissioning and proper abandonment of the lysimeter is being developed.

In addition, the ground water monitor well network for the Building 850 area was routinely inspected during semi-annual sampling activities. Maintenance activities for the monitoring network included pump replacements, repairing rodent damage to wiring, and general wellhead maintenance on an as-needed basis. During the five-year review period, pumps were replaced in Building 850 monitor wells W-850-2314, NC-11I, K1-2B, W-PIT1-2620, K2-01C, NC7-17, K1-01C, K1-02B, K1-04, and NC2-10. Additional maintenance activities are described in the semi-annual and annual Compliance Monitoring Reports (1st Semester 2010 through 2014 Annual Compliance Monitoring Reports).

The remedy for tritium, uranium, and nitrate at Building 850 operated as designed during this five-year review period and no significant operations or cost issues were identified. A remedy for perchlorate in Building 850 ground water has not yet been selected, and therefore was not evaluated. The remedy for perchlorate in Building 850 ground water will be determined after completion of additional characterization, the *in situ* bioremediation treatability study, and the Focused RI/FS. Although HE compounds were not identified as COCs in Building 850 ground water in the 2008 Site-Wide ROD, RDX and HMX were detected in Building 850 ground water during the five-year review period. These HE compound detections are discussed in more detail in Sections 5.4.1.1.5, 5.4.1.2, and 5.4.1.3. The recommendations to address the HE compounds detected in Building 850 ground water are discussed in Sections 5.4.1.3 and 8.1, and in the tables for Recommendations 1 and 2 of the Five-Year Review Summary Form.

All required documentation is in place, and the inspection, operation, and maintenance procedures for the Building 850 CAMU are consistent with established procedures and protocols.The budgeted and actual environmental restoration costs for Building 850 are tracked closely and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years (2010 through 2014).

4.4.2. Pit 7 Complex Remedy Operation and Maintenance

The remedy components for the Pit 7 Complex that require long-term inspection, operation, and maintenance include:

- An extraction and treatment system to remove VOCs, uranium, nitrate, and perchlorate from ground water.
- An engineered drainage diversion system to hydraulically isolate the contaminant sources in the landfills and underlying bedrock from subsurface water.
- Landfill covers/cap to prevent exposure to pit waste.
- A ground water monitoring network to evaluate the effectiveness of cleanup.

The remedy for the Pit 7 Complex Landfills operated as designed during this five-year review period and no significant operations or cost issues were identified. All required documentation is in place, and the inspection, operation, and maintenance procedures for the Pit 7 Complex ground water extraction and treatment system, engineered drainage diversion system, and landfill covers/cap are consistent with established procedures and protocols.

The inspection, operation, and maintenance (O&M) procedures for the Pit 7 Complex remedy components are contained in the following documents:

- Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at LLNL Site 300 (Dibley et al., 2009b).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Lorega, 2009 and 2012).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Operations and Maintenance Manual, Volume XVI: Operations and Maintenance Manual for the Pit7-Source Treatment System (Moffitt et al., 2012).
- Inspection and Maintenance Plan in the Remedial Design Document for the Pit 7 Complex (Taffet et al., 2008).
- Integration Work Sheet Safety Procedure #11341: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- Integration Work Sheet Safety Procedure #11314: Environmental Restoration Department (ERD) Site 300 Ion Exchange Resin Replacement.
- Integration Work Sheet Safety Procedure #11313: ERD Site 300 Off-Road Driving for Operations and Training.
- Integration Work Sheet Safety Procedure #11343: ERD Routine Ground Water Sampling & Water Level Monitoring at Site 300.
- Integration Work Sheet Safety Procedure #14984: ERD Routine Electronic Operations at Site 300.
- Integration Work Sheet Safety Procedure #11339: ERD Site 300 Hydraulic Pump Operation.
- Integration Work Sheet Safety Procedure #11346: Removal/Replacement of Spent Aqueous and Vapor-phase Granular Activated Carbon (GAC) at Site 300.
- Substantive Requirements for Waste Water Discharge for the Pit 7 Complex ground water treatment system issued by the California RWQCB.

The applicable inspection, operation, and maintenance activities for the ground water extraction and treatment system, engineered drainage diversion system, landfill covers/cap, and monitoring network are discussed in Sections 4.4.2.1 through 4.4.2.3.

4.4.2.1. Pit 7 – Source Ground Water Extraction and Treatment System O&M

The Pit 7-Source ground water extraction and treatment system began full-time operation on May 16, 2010. Monitoring and optimizing the performance and efficiency of the extraction and treatment system comprised a large portion of the O&M activities at the Pit 7 Complex during the five-year review period.

The major maintenance activities for the Pit7-Source ground water extraction and treatment system included:

- Extraction wells NC7-63 and NC7-64 were shut down during the winter months of 2010, 2011, and 2012 to protect against freeze damage.

- Extraction well W-PIT7-2307 was shut down during the first semester of 2011 to prevent drawing contaminants from the Qal/WBR HSU into the underlying $Tnbs_1/Tnbs_0$ bedrock HSU. During the first semester 2013, the pump intake was raised to target only the Qal/WBR HSU.
- An additional nitrate-specific-ion exchange resin column was added to the treatment train in March 2011. This column was placed in the final treatment position, after the GAC. Shortly after installation, chloroform was detected in an effluent sample prompting intermittent operations for evaluation. The chloroform was believed to be a transient event related to the ion-exchange resin.
- The pipeline to extraction well W-PIT7-2306, NC7-63, and NC7-64 was disconnected from April 16, 2011 to August 2011 to allow access to the drilling locations for new wells W-PIT7-2703 and W-PIT7-2704. The only extraction well in operation until August 23, 2011 was well W-PIT7-2305, at which time wells W-PIT7-2306, NC7-63, and NC7-64 were reactivated.
- The transfer pump and tank switches and extraction well batteries were replaced in April 2011.
- The treatment system was shut down from August 22 to December 10, 2012 due to an effluent detection of methylene chloride associated with VOC contamination of a new resin vessel installed on July 18, 2012. To correct this problem (1) the ion-exchange vessel was moved in front of the GAC vessel, (2) a new nitrate resin vessel was installed, and (3) a pre-installation vessel washing procedure was implemented.
- In 2014, double-check valves were installed in the Pit 7-Source ground water extraction wells to prevent backflow of extracted ground water.
- Spent ion-exchange resin and GAC treatment media were replaced on an as-needed basis. Breakthrough of uranium in the uranium-specific ion-exchange resin vessels was not detected during the five-year review period. However, replacement of two of the uranium-specific ion-exchange resin vessels at the Pit 7-Source facility was conducted twice during the five-year review period solely due to clogging of the uranium-specific ion-exchange resin with sediment. Breakthrough of perchlorate in the perchlorate-specific ion-exchange resin vessels was not detected during the five-year review period. Therefore, replacement of the perchlorate-specific ion-exchange resin at the Pit 7-Source facility was not conducted during the five-year review period. Breakthrough of VOCs in the GAC vessels was not detected during the five-year review period. Therefore, replacement of the GAC at the Pit 7-Source facility was not conducted during the five-year review period. The nitrate-specific ion-exchange resin, located at the end of the treatment train to remove any nitrate released from the perchlorate-specific ion-exchange resin, was replaced 3 times during the five-year review period.

Modifications to the extraction wellfield during the review period included:

- The addition of three new ground water extraction wells W-PIT7-2703, -2704, and -2705, and activation of existing extraction well NC7-25, that were brought on-line in August 2012.
- In 2013, extraction well NC7-63 was converted to a monitor well due to continued lack of ground water for extraction.

The Pit 7-Source ground water treatment system operated in compliance during the review period with the exception of one exceedence of the 5 µg/L maximum daily and 0.5 µg/L monthly median effluent limits for VOCs on August 21, 2012. Methylene chloride was detected in the effluent at a concentration of 5.1 µg/L; the treatment facility was immediately shut down on receipt of the analytical results. Since methylene chloride is not a ground water COC at the Pit 7 Complex, an evaluation was conducted which determined that a newly installed ion-exchange resin column was the source of the methylene chloride detected in the effluent. Because the system remained shut down for the rest of the month while the evaluation was conducted, no additional effluent samples could be collected during that month. Therefore, the methylene chloride effluent limit exceedence represented a non-compliance event for the month of August 2012. Although chloroform was detected in the effluent sample collected in March 2011, it did not exceed the daily maximum of 5 µg/L, and results from additional samples collected during the month were all below the reporting limit of 0.5 µg/L, meeting the median effluent limit of 0.5 µg/L for total VOCs.

Operational and maintenance activities performed for the Pit 7 Complex treatment system during the five-year review period were documented in the semiannual and annual Compliance Monitoring Reports and reported to the regulatory agencies.

4.4.2.2. Engineered Drainage Diversion System Inspection and Maintenance

The major inspection and maintenance activities for the engineered drainage diversion system include:

- Monthly inspections of the engineered hydraulic drainage diversion system during the rainy season for damage and accumulated debris.
- When necessary, clearing the drainage diversion system components of blockage and conducting repairs to maintain the system design capacity.

During the review period, monthly inspections of the drainage diversion system were conducted in the rainy season. Maintenance activities included:

- Removing vegetative debris and sediment from the drainage channels, southern settling basin, and rip-rap areas (as needed).
- Repairing squirrel damage (burrows) in the channel banks (2010, 2011, 2012).
- Replacing rip-rap around pipes at the southern settling basin that had been dislodged (2012).
- Grading of a washed-out fire trail and surrounding area to reduce the amount of sediment entering the southern settling basin (2013).
- Flushing of perforated pipes in the vegetated channels (2013).

The hydraulic drainage diversion system inspection and maintenance activities are reported in the annual ERD Compliance Monitoring Reports.

During the Five-Year Review inspection it was noted that improvements to the surface and slope of the road (Route 4) and the roadside drainage way on the east side of the Pit 7 Complex landfills would minimize erosion and accumulation of sediment, reduce flooding during heavy rain events, and both improve operation and reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system. These improvements include grading and patching the road and grading and flattening the roadside edges of the drainage way to enhance water flow into it.

4.4.2.3. Landfill Inspection and Maintenance

The major inspection and maintenance activities for the Pit 7 Complex landfills include:

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

During the review period, the Pit 7 Complex landfills were inspected at least annually to identify any damage or other issues that could compromise the integrity of the landfills. Maintenance activities included:

- Removing vegetative debris and sediment from the landfill surface water drainages (as-needed).
- Sealing joints between concrete sections of the surface water drainages (2012).
- Filling in shallow animal burrows in the landfill cover (annually).

Annual subsidence monitoring of the landfills was conducted and no subsidence was observed during the review period. The benchmark survey points at the four corners of the landfill cap were inspected during annual subsidence monitoring and were found to be in their proper position. The landfill inspection and maintenance activities are reported in the annual ERD Compliance Monitoring Reports.

In addition, the ground water monitor well network for the Pit 7 Complex was routinely inspected during semi-annual sampling activities. Maintenance activities for the monitoring network included replacement of pumps, level transducers, and solar panels, repairing rodent damage to wiring, and general wellhead maintenance on an as-needed basis.

The budgeted and actual environmental restoration costs for the Pit 7 Complex are tracked and are consistently within or near the allocated budget. Table 1 presents the budgeted and actual costs for the last five fiscal years (2010 through 2014).

4.5. 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.
- 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 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.

Land use controls are necessary to prevent human receptor exposure to contaminants in soil and ground water currently above the MCLs. Land use controls are more effective if they are layered or implemented in series with each other. Layering can involve using different types of land use controls at the same time to enhance the protectiveness of the remedy. DOE/LLNL has implemented multiple layers of protection to prevent human receptor exposure to contaminants in soil and ground water currently above the MCLs.

The land use controls and requirements described herein are only applicable to the Building 850/Pit 7 Complex 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 annually completed checklists are included in the Annual Compliance Monitoring Reports.

Land use controls agreed to in the Site-Wide ROD (DOE, 2008) for the Building 850/Pit 7 Complex OU are described in Table 2 (Building 850) and Table 3 (Pit 7 Complex), which present 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 850/Pit 7 Complex OU. Figure 6 shows the specific areas of the Building 850/Pit 7 Complex OU where the land use controls have been maintained or implemented.

Sections 4.5.1 and 4.5.2 summarize 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 by objective, and the status of the land use controls for the Building 850 Firing Table area and the Pit 7 Complex area, respectively.

4.5.1. Building 850 Land Use Controls

Land use control objectives were established and agreed to for the Building 850 portion of the Building 850/Pit 7 Complex OU in the Site-Wide ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers, associated land use control objectives, and the land use controls to meet these objectives that were identified for the Building 850 portion of this OU are described in Section 4.5.1.1 through 4.5.1.6 below. These sections are organized by the land use control objectives identified for the Building 850 area.

4.5.1.1. Prevent Water-supply Use/consumption of Contaminated Ground Water in the Building 850 Firing Table Area: Governmental Institutional Controls

Risk Driver: Tritium, depleted uranium, perchlorate, and nitrate concentrations in ground water onsite exceed cleanup standards.

Land use control objective: Prevent water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

Land Use Controls: DOE/LLNL has implemented two layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Building 850 Firing Table 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: The construction of water supply wells in the Building 850/Pit 7 Complex OU is prevented through implementation of the dig permit process. The dig permit process is applicable to well construction activities because well construction involves soil-disturbing activities, and no soil disturbance is allowed at Site 300 without a soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group. A LLNL Dig Permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required to drill and install any new onsite wells at Site 300. Prior to a decision to grant any such permit, the LLNL Environment, Safety and Health (ES&H) Team Environmental Analyst (EA) must conduct an evaluation of the proposed well location to determine if the proposed new water-supply well is located in an area of ground water contamination. As part of this evaluation, the EA reviews the LUC maps, such as Figure 6, provided by the LLNL Environmental Restoration Department (ERD) that show areas of contaminated ground water with concentrations of contaminants of concern exceeding drinking water MCL ground water cleanup standards. As water-supply well drilling is prohibited in these areas until cleanup standards are achieved, the Environmental Analyst works with the LLNL entity proposing the well installation and ERD 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 Building 850 Firing Table area.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by ERD 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 850 area.

Contamination in the Building 850 Firing Table area is limited to onsite ground water and modeling indicates the contaminant plumes will not migrate offsite during the time necessary to achieve cleanup standards (Taffet et al., 1996; Taffet et al., 2004). Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.

4.5.1.2. Control Excavation Activities to Prevent Onsite Worker Exposure to Contaminants in Building 850 Subsurface Soil: Government Institutional Controls

Risk Driver: Potential exposure to tritium and depleted uranium at depth in subsurface soil at the Building 850 Firing Table.

Land use control objective: Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that subsurface soil does not pose an exposure risk to onsite workers.

Land Use Controls: Land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to depleted uranium and tritium in subsurface soil at Building 850 until it can be verified that subsurface soil does not pose an exposure risk to onsite workers.

These include:

- 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 soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required prior to any excavation work onsite.

As part of the soil excavation permit process, a preconstruction site evaluation is required for any soil or debris disturbing activities. As soon as it is determined that soil or debris are to be disturbed at a project site, the Responsible Individual/project manager is required to notify the LLNL ES&H Team EA to initiate a preconstruction site evaluation. To document the request, a Site Evaluation Request Form is filled out and given to the LLNL ES&H Team EA with a description of the project attached, including project location, and excavation footprint and depth. The LLNL ES&H Team EA evaluated the proposed project location to determine whether sampling of the project location is required.

The evaluation includes:

- Review of LLNL ERD historical source investigation.
- Review of Environmental Functional Area site evaluation documents.
- Review of current and past operations, and pre-existing soil analytical data.
- Visual inspection to evaluate the project site for possible contamination.

If sampling of the project location is required, the LLNL ES&H Team EA and ES&H technician prepare and implement the sampling plan. The LLNL ES&H Team EA evaluates the results and, if a potential for contaminant exposure is identified, recommends methods to ensure that the original sampling adequately defined the hazards and that the necessary controls are identified and implemented prior to the start of work. These controls are identified through conditions to the soil excavation permit and are implemented by the Responsible Individual/project manager. The ES&H Team, including the LLNL ES&H Team EA, representatives from health and safety disciplines, and LLNL Waste Management will also work with the Responsible Individual/project manager proposing the project to determine if the work plans can be modified to avoid areas of contamination.

During excavation or soil or debris disturbing activities such as well drilling, a Controlled Area (approximately 50 feet radius exclusion zone) is established with regulated access. If potentially contaminated soil or debris is unexpectedly discovered during excavation or soil or debris disturbing activities, the Responsible Individual/project manager is required under LLNL internal procedures to stop work and immediately notify the LNLL ES&H Team EA and the ERD so that the material can be evaluated. Samples are gathered to properly classify the soils and/or debris. After evaluating the results, the proper method of handling any contaminated material is implemented.

During this five-year review period, there were no dig permit applications for excavation or construction activities in the Building 850 Firing Table portion of the Building 850/Pit 7 Complex OU.

Work Induction Board: All proposed excavation activities are submitted to and must be cleared through the LLNL Work Induction Board. 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). If excavation activities are proposed for the Building 850 Firing Table area, the Work Induction Board coordinates with the ERD and the Environmental Analyst to determine if the proposed excavation activity is located in an area where there is a potential for exposure to tritium and depleted uranium in subsurface soil. If a potential for contaminant exposure is identified, Environmental Health and Safety personnel ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work.

During this five-year review period, no excavation activities were proposed in the Building 850 Firing Table area.

4.5.1.3. Maintain Land Use Restrictions to Prevent Onsite Worker Inhalation and Ingestion of and Dermal contact with PCB-, dioxin-, and furan-contaminated surface soil at Building 850

Risk Driver: Potential exposure to PCBs, and dioxin and furan compounds in surface soil at the Building 850 Firing Table.

Land use control objective: Maintain land use restrictions in the vicinity of the Building 850 Firing Table until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}. (These risks were successfully mitigated in 2010 by the removal action in which the PCB-, dioxin-, and furan-contaminated surface soil at Building 850 were excavated, consolidated, and solidified in a CAMU. Therefore this land use control is no longer needed.)

Land Use Controls: Pre-remediation risks of risks of 5 x 10^{-4} and 1 x10^{-4} were calculated for onsite workers from inhalation, ingestion, and dermal contact of PCBs, and dioxin and furan compounds, respectively, in surface soil at the Building 850 Firing Table.

These risks were successfully mitigated in 2010 by the removal action in which the PCB-, dioxin-, and furan-contaminated surface soil at Building 850 were excavated, consolidated, and solidified in a CAMU. Therefore this land use control is no longer needed.

4.5.1.4. Control Excavation and Other Ground-breaking Activities to Maintain CAMU Integrity and Prevent Worker Exposure to Contaminated Soil in the Building 850 CAMU: Government Institutional Controls

Risk Driver: Potential exposure to contaminants in solidified PCB-, dioxin-, and furan-contaminated soil in the Building 850 CAMU.

Land use control objectives: Control excavation and other ground-breaking activities to maintain the integrity of the Building 850 CAMU and prevent worker exposure to contaminated soil in the CAMU for as it remains in place.

Land Use Controls: In 2010, the risks associated with worker exposure to PCBs, dioxins, and furans in surface soil at the Building 850 Firing Table were successfully mitigated by a non-time critical removal action which excavated, consolidated, and solidified contaminated soil at Building 850 in a CAMU. The documentation and approval process for the removal action included an EE/CA that was completed in 2008 (Dibley et al., 2008a), followed by an Action Memorandum that documented approval of the removal action (Dibley et al., 2008b). The Building 850 PCB-soil Removal Action Design was completed in 2009 (SCS Engineers, 2009). In 2010, the removal action was completed, and a Verification Sampling and Analysis Report to document that PCB-, dioxin-, and furan-contaminated soil at Building 850 has been excavated to meet the soil cleanup standards was submitted and approved by the regulatory agencies (Holtzapple, 2010). A Remedial Action Completion Report (RACR) for the Building 850/Pit 7 Complex OU that documented completion of the Building 850 removal action was completed and approved by the regulators in 2011 (Dibley et al., 2011b).

Although the removal action mitigated the risk to onsite workers from exposure to contaminated surface soil in the Building 850 Firing Table area, excavation/ground-breaking activities within the CAMU could compromise its integrity and/or liberate contaminated soil particles to which workers could be exposed during these activities. The 2011 RACR documented the DOE would control construction and other ground-breaking activities on the Building 850 CAMU to prevent damage and/or inadvertent exposure to waste as long as the waste remains in place. Therefore, land use controls have been implemented to maintain the integrity of the CAMU and prevent onsite worker exposures to PCB-, dioxin-, and furan-contaminated soil contained within the CAMU. These land use controls include:

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

Governmental Institutional Controls Implementation Status

Dig Permit Process: A soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required prior to any excavation work onsite. As part of the soil excavation permit process, a preconstruction site evaluation is required for any soil or debris disturbing activities. As soon as it is determined that soil or debris are to be disturbed at a project site, the Responsible Individual/project manager is required to notify the LLNL ES&H Team EA to initiate a preconstruction site evaluation. To document the request, a Site Evaluation Request Form is filled out and given to the LLNL ES&H Team EA with a description of the project attached, including project location, and excavation footprint and depth. The LLNL ES&H Team EA evaluated the proposed project location to determine whether sampling of the project location is required.

The evaluation includes:

- Review of LLNL ERD historical source investigation.
- Review of Environmental Functional Area site evaluation documents.
- Review of current and past operations, and pre-existing soil analytical data.
- Visual inspection to evaluate the project site for possible contamination.

If sampling of the project location is required, the LLNL ES&H Team EA and ES&H technician prepare and implement the sampling plan. The LLNL ES&H Team EA evaluates the results and, if a potential for contaminant exposure is identified, recommends methods to ensure that the original sampling adequately defined the hazards and that the necessary controls are identified and implemented prior to the start of work. These controls are identified through conditions to the soil excavation permit and are implemented by the Responsible Individual/project manager. The ES&H Team, including the LLNL ES&H Team EA, representatives from health and safety disciplines, and LLNL Waste Management will also work with the Responsible Individual/project manager proposing the project to determine if the work plans can be modified to avoid areas of contamination.

During excavation or soil or debris disturbing activities, a Controlled Area (approximately 50 feet radius exclusion zone) is established with regulated access. If potentially contaminated soil or debris is unexpectedly discovered during excavation or soil or debris disturbing activities, the Responsible Individual/project manager is required under LLNL internal procedures to stop work and immediately notify the LNLL ES&H Team EA and the ERD so that the material can be evaluated. Samples are gathered to properly classify the soils and/or debris. After evaluating the results, the proper method of handling any contaminated material is implemented.

During this five-year review period, there were no dig permit applications for excavation or other ground-breaking activities were proposed in the Building 850 CAMU.

Work Induction Board: All proposed excavation activities are also submitted to and must be cleared through the LLNL Work Induction Board. 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). If excavation/ground-breaking activities are proposed in the Building 850 CAMU, the Work Induction Board will coordinate with the ERD and the Environmental Analyst to determine if there is a potential for the activity to damage the integrity of the CAMU or result in worker exposure contaminated soil particles during the activity. If a potential for CAMU damage and/or contaminant exposure is identified, the Work Induction Board will work with ERD and Environmental Health and Safety personnel to ensure that hazards are identified and controlled and CAMU damage is prevented. If appropriate mitigating measures to prevent or repair damage to the CAMU during or following excavation cannot be identified, the activity will be prohibited.

In addition, DOE/LLNL inspects and maintains the CAMU to ensure its long-term integrity. The inspection and maintenance and requirements for the CAMU are specified in the Site 300 Compliance Monitoring Plan and are reported in the annual Compliance Monitoring Reports.

The land use controls for Building 850 will be updated to include the CAMU land use controls in the ROD Amendment to be prepared to document the selection of a remedy for perchlorate at Building 850. In addition, a discussion of the removal action that was conducted to mitigate risk associated PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table will be included in this ROD Amendment. A discussion of the documentation and approval process for this removal action (i.e., EE/CA, Action Memorandum, Design Report, Verification Sampling and Analysis Report, and Remedial Action Completion Report) will also be included in the ROD Amendment. In the interim, DOE/NNSA will continue to implement these institutional/land use control to maintain integrity of and prevent worker exposure to contaminated solidified soil in the Building 850 CAMU that were put in place after completion of the removal action.

During this five-year review period, no excavation or other ground-breaking activities were proposed in the Building 850 CAMU. These land use controls will continue to be implemented for as long as the CAMU remains in place at Building 850.

4.5.1.5. Maintain Land Use Restrictions to Prevent Onsite Work Exposure to Tritium Volatilizing from Surface Water in the Well 8 Spring: Government Institutional Controls

Risk Driver: The baseline risk assessment identified a risk of 1×10^{-3} for onsite workers from inhalation of tritium volatilizing from Well 8 Spring into outdoor air.

Land use control objective: Maintain land use restriction in the vicinity of Well 8 Spring until annual risk re-evaluation indicates that the risk is less than 10^{-6}.

Land use control: The land use restriction/institutional controls implemented in the vicinity of Well 8 Spring to prevent onsite site worker inhalation exposure to tritium at the Well 8 Spring until annual risk re-evaluation indicates that the risk is less than 10^{-6}:

- Governmental Institutional Controls:
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Work Induction Board: Any significant changes in activities conducted in the Well 8 Spring area are submitted to and must be cleared by the LLNL Work Induction Board. 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). The Work Induction Board coordinates with ERD 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 Environmental Health and Safety is notified and determines any necessary personal protective equipment or other controls to prevent exposure. During this five-year review period, no new activities were proposed for the Well 8 Spring area.

Workers do not occupy or plan to occupy the Well 8 Spring area in the near future. Current activities in the vicinity of the Well 8 Spring are restricted to semi-annual spring sampling, when water is present in the spring. 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 the Well 8 Spring. However, the Well 8 Spring has been dry since 2011, and there has been no potential for worker exposure to tritium in surface water at this spring during most of the five-year review period.

DOE conducts annual risk re-evaluations when water is present in the Well 8 Spring to determine when the inhalation risk has been mitigated. The risk re-evaluation results are reported in the Annual Site-Wide Compliance Monitoring Reports.

4.5.1.6. Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls: Proprietary Controls

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.

Land use 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 Site-Wide ROD. The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 Site-Wide 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 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. The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

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 (CCR) Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Site-Wide ROD, and will implement deed restrictions per CERCLA 120(h). No change in ownership of Site 300 will take effect without provision for continued maintenance of any contaminant system, treatment system, monitoring system, or other response action(s) installed or implemented.

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 Site-Wide ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

4.5.2. Pit 7 Complex Land Use Controls

Land use control objectives were established for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU in the Site-Wide ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers, associated land use control objectives, and the land use controls to meet these objectives that were identified for the Pit 7 Complex portion of this OU are described in Section 4.5.2.1 through 4.5.2.6 below. These sections are organized by the land use control objectives identified for the Pit 7 Complex area.

4.5.2.1. Prevent Water-supply Use/consumption of Contaminated Ground Water in the Pit 7 Complex Area: Governmental Institutional Controls

Risk Driver: Tritium, depleted uranium, perchlorate, nitrate, and VOC concentrations in ground water onsite exceed cleanup standards.

Land use control objective: Prevent water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

Land Use 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 Pit 7 Complex 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: The construction of water supply wells in the Building 850/Pit 7 Complex OU is prevented through implementation of the dig permit process. The dig permit process is applicable to well construction activities because well construction involves soil-disturbing activities, and no soil disturbance is allowed at Site 300 without a soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group. A LLNL Dig Permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required to drill and install any new onsite wells at Site 300. Prior to a decision to grant any such permit, the LLNL ES&H Team EA must conduct an evaluation of the proposed well location to determine if the proposed new water-supply well is located in an area of ground water contamination. As part of this evaluation, the EA reviews the LUC maps, such as Figure 6, provided by the LLNL ERD that show areas of contaminated ground water with concentrations of contaminants of concern exceeding drinking water MCL ground water cleanup standards. As water-supply well drilling is prohibited in these areas until cleanup standards are achieved, the EA works with the LLNL entity proposing the well installation and ERD 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 7 Complex area.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by ERD 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 Pit 7 Complex area.

Contamination in the Pit 7 Complex area is limited to onsite ground water and modeling indicates the contaminant plumes will not migrate offsite during the time necessary to achieve cleanup standards (Taffet et al., 2005). Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.

4.5.2.2. Maintain the Integrity of Pit 7 Complex Landfill Covers/Cap and the Drainage Diversion System: Engineered Controls

Risk Driver: Potential exposure to contaminants in waste in the Pit 7 Complex landfills.

Land use control objective: Maintain the integrity of the Pit 7 Complex landfill covers and the hydraulic drainage diversion system as long as the pit waste remains in place.

Land use 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:

- Engineered Controls:
  - Landfill covers/cap.
  - Engineered Hydraulic Drainage Diversion System.

Engineered Controls Implementation Status

The covers/cap on the Pit 7 Complex landfills prevent inadvertent exposure to the waste contained in the landfills. The engineered hydraulic drainage diversion system diverts shallow recharge and surface runoff from the surrounding hillslopes away from the Pit 7 Complex landfills, thereby preventing further contaminant releases. DOE inspects and maintains the landfill covers/cap and drainage diversion system. The inspection and maintenance and requirements for the landfill covers/cap and engineered drainage diversion system are specified in the Site 300 Compliance Monitoring Plan and are reported in the annual Compliance Monitoring Reports.

During this five-year review period, the landfill covers/cap and drainage diversion system were inspected and maintained as required. The integrity of the landfill covers/caps and drainage diversion system was maintained.

4.5.2.3. Control Construction, Excavation, and Other Ground-breaking Activities on the Pit 7 Complex Landfills to Prevent Cap/cover Damage and Inadvertent Exposure to Landfill Waste: Government Institutional Controls

Risk Driver: Potential exposure to contaminants in waste in the Pit 7 Complex landfills.

Land use control objective: Control construction and other ground-breaking activities on the Pit 7 Complex landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.

Land use controls: The land use controls that have been implemented to control construction, excavation, and other ground-breaking activities on the Pit 7 Complex landfills 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 soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required prior to any excavation work onsite. As part of the soil excavation permit process, a preconstruction site evaluation is required for any soil or debris disturbing activities. As soon as it is determined that soil or debris are to be disturbed at a project site, the Responsible Individual/project manager is required to notify the LLNL ES&H Team EA to initiate a preconstruction site evaluation. To document the request, a Site Evaluation Request Form is filled out and given to the LLNL ES&H Team EA with a description of the project attached, including project location, and excavation footprint and depth. The LLNL ES&H Team EA evaluated the proposed project location to determine whether sampling of the project location is required.

The evaluation includes:

- Review of LLNL ERD historical source investigation.
- Review of Environmental Functional Area site evaluation documents.
- Review of current and past operations, and pre-existing soil analytical data.
- Visual inspection to evaluate the project site for possible contamination.

If sampling of the project location is required, the LLNL ES&H Team EA and ES&H technician prepare and implement the sampling plan. The LLNL ES&H Team EA evaluates the results and, if a potential for contaminant exposure is identified, recommends methods to ensure that the original sampling adequately defined the hazards and that the necessary controls are identified and implemented prior to the start of work. These controls are identified through conditions to the soil excavation permit and are implemented by the Responsible Individual/project manager. The ES&H Team, including the LLNL ES&H Team EA, representatives from health and safety disciplines, and LLNL Waste Management will also work with the Responsible Individual/project manager proposing the project to determine if the work plans can be modified to avoid areas of contamination.

During excavation or soil or debris disturbing activities, a Controlled Area (approximately 50 feet radius exclusion zone) is established with regulated access. If potentially contaminated soil or debris is unexpectedly discovered during excavation or soil or debris disturbing activities, the Responsible Individual/project manager is required under LLNL internal procedures to stop work and immediately notify the LNLL ES&H Team EA and the ERD so that the material can be evaluated. Samples are gathered to properly classify the soils and/or debris. After evaluating the results, the proper method of handling any contaminated material is implemented.

During this five-year review period, there were no dig permit applications for excavation or construction activities at the Pit 7 Complex landfills.

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 within the landfills or damage of the Pit 7 Complex landfill covers/cap. 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). If a potential for damage to the integrity of the landfill covers/cap or associated drainage structures is identified, ERD will work with the Environmental Analyst and the entity proposing the activity to ensure that mitigating measures are implemented during the activity and/or after it is completed that will ensure the continued, long-term integrity of the landfill covers/cap and associated drainage structures. If appropriate mitigating measures cannot be identified, the activity will be prohibited. If a potential for contaminant exposure during the construction/excavation/ground-breaking activity is identified, Environmental Health and Safety personnel will ensure that hazards are adequately evaluated and necessary controls identified and implemented for the activity prior to the start of work.

During this five-year review period, no construction, excavation or other ground-breaking activities were proposed on or in the Pit 7 Complex landfills.

4.5.2.4. Maintain Access Restrictions at the Pit 7 Complex to Prevent Exposure to Pit Waste: Physical Barriers

Risk Driver: Potential exposure to contaminants in waste in the Pit 7 Complex landfills.

Land use control objective: Maintain access restrictions to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste in the Pit 7 Complex Landfills remains in place.

Land Use Controls: 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. 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.

There are currently no active facilities located in the vicinity of the Pit 7 Complex, with the exception of the Pit 7 ground water extraction and treatment facility that is located southeast of Pit 5. Periodic maintenance of the treatment facility is performed, but does not require workers to enter the landfills. 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.

4.5.2.5. Maintain access restriction at the Pit 3 Landfill to prevent onsite worker inhalation exposure to tritium

Risk Driver: The baseline risk assessment identified a risk of 4×10^{-6} for onsite workers from inhalation of tritium volatilizing from subsurface soil in the vicinity of the Pit 3 Landfill into outdoor air.

Land use control objectives: Maintain access restrictions and activities at the Pit 3 Landfill to prevent onsite worker inhalation exposure to tritium until annual risk re-evaluation indicates that the risk is less than 10^{-6}. (A recalculation of the tritium inhalation risk for onsite workers in 2007 indicated this risk had been reduced to below a 1×10^{-6} cancer risk due to tritium decay that occurred between 1992 and 2007. Therefore this land use control is no longer needed.)

Land Use Controls: A pre-remediation risk of 4 x 10^{-4} was calculated for onsite workers from inhalation of tritiated water vapor evaporating from subsurface soil by onsite workers in the vicinity of the Pit 3 Landfill. However, radioactive decay continues to reduce the mass of tritium in subsurface soil at the Pit 3 Landfill, thereby reducing the flux of tritium vapors to air.

As discussed in Section 3.5.2.2, the tritium inhalation risk for onsite workers was recalculated in 2007, accounting for tritium decay that occurred between 1992 and 2007. An excess cancer risk of 8 x 10^{-7} was estimated for a worker spending 8 hours a day, 5 days a week for 25 years at the Pit 3 Landfill. Therefore, there is no longer an unacceptable risk to onsite worker health posed by tritium evaporating from the Pit 3 Landfill, and this land use control is no longer needed. However, as discussed in Section 4.5.2.3 and 4.5.2.4, land use controls (i.e., the dig permit and Work Induction Board processes, and physical barriers) are still in place to maintain the integrity of the landfill caps and prevent exposure to pit waste.

4.5.2.6. Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls: Proprietary Controls

Risk Driver: Potential exposure to contaminated environmental media and/or waste.

Land use control objective: Prohibit transfer of lands at Site 300 with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

Land use 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 Site-Wide ROD. The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

The Site 300 Site-Wide 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 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. The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

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 (CCR) Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Site-Wide ROD, and will implement deed restrictions per CERCLA 120(h). No change in ownership of Site 300 will take effect without provision for continued maintenance of any contaminant system, treatment system, monitoring system, or other response action(s) installed or implemented.

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 Site-Wide ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

4.5.3. Summary of the Status of Building 850/Pit 7 Complex OU Land Use Controls

The review of the land use controls for the Building 850/Pit 7 Complex 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 Building 850/Pit 7 Complex OU for as long as necessary to keep the selected remedy protective of human health and the environment.

5. Five-Year Review Process

5.1. 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 the initiation of the Five-Year Review for the Building 850/Pit 7 Complex OU was published in *The Tracy Press* and *San Joaquin Herald* on June 19, 2015. Upon completion of the review, a copy of the final report will be placed in the information repositories, and a notice will appear in the newspapers announcing completion of the Five-Year Review Report. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at https://www-erd.llnl.gov/library/index.html/ or the Environmental Community Relations web page at https://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.

5.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 850/Pit 7 Complex 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.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- John Radyk, Hydrogeologist, Weiss Associates.

5.3. Document Review

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

- Closure and Post-Closure Plans for the capping of the Pit (4 and) 7 Landfills were completed (Rogers/Pacific Corporation, 1990).
- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Addendum to the Site-Wide Remedial Investigation report, Site 300 Building 850/Pit 7 Complex Operable Unit (Taffet et al., 1996).
- The Ground Water Tritium Plume Characterization Summary Report for the Building 850/Pits 3 and 5 Operable Unit (Ziagos and Reber-Cox, 1998).
- 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).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001c).
- Remedial Investigation/Feasibility Study was completed for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU (Taffet et al., 2005).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Amendment to the Interim Site-Wide ROD for the Pit 7 Complex (U.S. DOE, 2007).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Engineering Evaluation/Cost Analysis for PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table, Lawrence Livermore National Laboratory Site 300 (Dibley et al., 2008a).
- Action Memorandum for the Removal Action at the Building 850 Firing Table, Lawrence Livermore National Laboratory Site 300 (Dibley et al., 2008b).
- Remedial Design Document for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300 (Taffet et al., 2008).
- Semi-annual and Annual Site 300 Compliance Monitoring Reports that include evaluations of remediation progress in the Building 850/Pit 7 Complex OU (Dibley et al., 2010a, 2010b, 2011a, 2011c, 2012b, 2012c, 2013a, 2013b, and L. Ferry et al., 2014a and 2014b).
- Remedial Action Completion Report for the Building 850/Pit 7 Complex OU, Lawrence Livermore National Laboratory Site 300 (Dibley et al., 2011b).

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 2014.

5.4. Building 850/Pit 7 Complex 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, (2) identifying performance issues, and (3) mitigating risk associated with COCs.

5.4.1. Building 850 Remediation Progress

The progress of ground water remediation in the Building 850 area of the Building 850/Pit 7 Complex OU was evaluated by:

- Comparing 2010 ground water COC concentrations and spatial distribution to 2014 concentrations and distribution (Figures 7 through 14).
- Reviewing temporal COC concentration trends in ground water.

The results of this evaluation for the Building 850 ground water COCs during this five-year review period are discussed in the following subsections: contaminant concentrations and distribution (Section 5.4.1.1), contaminant remediation progress (Section 5.4.1.2), performance issues (Section 5.4.1.3), and risk mitigation progress (Section 5.4.1.4).

5.4.1.1. Building 850 Contaminant Concentrations and Distribution

In the Building 850 area of the Building 850/Pit 7 Complex OU, tritium and perchlorate are the primary COCs detected in ground water; depleted uranium and nitrate are secondary COCs. The high explosives compounds RDX and HMX have also been detected sporadically in ground water at wells proximal to Building 850. For the purposes of compliance monitoring, ground water COCs were designated as primary or secondary in the Site 300 Compliance Monitoring Plan/Contingency Plan. Primary COCs are those that generally exhibit: (1) higher migration rates than secondary COCs; (2) larger horizontal and vertical extent of contamination than secondary COCs; and (3) any other contaminant- or area-specific consideration that indicates that a more frequent sampling frequency is appropriate (e.g., a highly toxic contaminant). Primary COCs are generally monitored more frequently (semi-annually) than secondary COCs (annually).

Tritium, depleted uranium, nitrate, perchlorate, and HE compound contamination in Building 850 ground water occur in the Qal/WBR and the $Tnbs_1/Tnbs_0$ HSUs. No contamination has been detected above reporting limits or above cleanup standards in the underlying $Tnsc_0$ HSU and the deeper Tmss HSU. Tritium, uranium, and nitrate concentrations, distribution, and remediation are discussed in Sections 5.4.2.1.1 through 5.4.2.1.3.

While perchlorate was identified as a ground water COC in the 2008 Site-Wide ROD, no remedy was selected as it was only recently identified as a ground water contaminant at the time of the ROD. In the ROD, DOE committed to implementing an *in situ* bioremediation treatability study for perchlorate in Building 850 ground water, followed by presentation of remedial alternatives in a Focused Feasibility Study. DOE presented perchlorate characterization information to the regulatory agencies in the November 20, 2014 RPM meeting to identify any outstanding perchlorate characterization issues or data gaps that the regulators might have before proceeding with the Focused RI/FS for perchlorate at Building 850. At this meeting, the regulators agreed that characterization was adequate to proceed with the Focused RI/FS with the exception of the need for additional characterization of perchlorate in soil and ground water beneath the firing table. Review of a work plan for this work is in progress; the work is currently scheduled to be conducted in the late summer/fall of 2015. Because the source of perchlorate to ground water is most likely soil and rock beneath the Building 850 firing table, the characterization work plan focuses on that area. Soil containing PCBs above cleanup standards was removed from the hillslopes above the firing table, reducing the possibility that soils containing perchlorate are present on these hillslopes.

A remedy for perchlorate will be selected in an Amendment to the 2008 Site-Wide ROD at a later date. Therefore, while the perchlorate concentrations and distribution are discussed in Section 5.4.2.1.4 of this Five-Year Review for completeness, remediation progress and performance issues are not yet applicable and are not discussed. The status and progress of the *in situ* bioremediation treatability study for perchlorate in Building 850 ground water are discussed in the Compliance Monitoring reports.

No HE compounds were identified as COCs in Building 850 ground water in the 2008 Site-Wide ROD. In the past, contract laboratory reporting limits for RDX and HMX were higher, varying from 5 to 20 µg/L. Lower reporting limits have enabled detection of RDX and HMX at lower concentrations. In 2008, RDX and HMX were detected in a baseline sample collected from a new monitor well drilled and installed downgradient of Building 850. As a result, DOE initiated monitoring of HE compounds in up to 23 wells from 2008 through 2014 to determine the extent of HE compound contamination in Building 850 ground water. The results of this monitoring are discussed in Section 5.4.2.1.5.

In the vicinity of and immediately downgradient of Building 850, the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs are continuous. Thus, ground water contaminant maps (Figures 7 through 14) show the same wells and associated chemical data in this area on both maps for each COC. Despite the decline in annual rainfall during the last few years, the extent of saturation in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs remains relatively stable and there is no apparent impact to COC extent or concentrations noted during the five-year review period as a result of these recent declines in annual rainfall. As a result of the continuous nature of the HSUs in the vicinity and immediately downgradient of Building 850, the discussion of concentrations and distribution for each COC in the Qal/WBR HSU also applies to the $Tnbs_1/Tnbs_0$ HSU but is not repeated in the corresponding $Tnbs_1/Tnbs_0$ HSU COC sections below.

Primary COC ground water sampling is conducted during the first and second semesters, and secondary COC sampling is conducted during the first semester. Tritium is a primary COC throughout the Building 850/Pit 7 Complex OU. Perchlorate is a primary COC in the Building 850 area and a secondary COC at the Pit 7 Complex. Uranium and nitrate are secondary COCs throughout the Building 850/Pit 7 Complex OU. The maps for tritium are based on the most recent data, which are from the second semester. The maps for perchlorate are based on first semester data, because it is the only semester for which there is a complete data set. Thus, annual tritium and perchlorate data and maxima discussed in the text may be different from data on the ground water COC maps (Figures 7, 8, 13, and 14).

5.4.1.1.1. Tritium Activities, Distribution, and Remediation

Monitored Natural Attenuation (MNA) is the remedy for tritium in ground water at Building 850. Overall, tritium activities at Building 850 have decreased by over one order-of-magnitude from an historic maximum of 566,000 pCi/L in 1985 (well NC7-28), to a 2010 maximum of 58,400 pCi/L (well NC7--70), and to a 2014 maximum tritium activity of

25,100 pCi/L (NC7-70). The highest tritium activities in ground water continue to occur directly downgradient of the Building 850 Firing Table. The extent of tritium with activities exceeding the 20,000 pCi/L cleanup standard ground has significantly decreased in both the Qal/WBR and $Tnbs_1/Tnbs_0$ bedrock HSUs, and currently exceeds the cleanup standard in only one well (Figures 7 and 8). However, the overall extent of tritium above background (100 pCi/L) is also discussed and is shown on the figures. Tritium activities are discussed by HSU below.

Qal/WBR HSU

Tritium was first detected in ground water in the Building 850 area at Well 8 Spring in the early 1970s at a maximum activity of 770,000 pCi/L. Well 8 Spring is a location where a shallow pipe inserted into the slope accesses shallow Qal/WBR ground water. Before the "spring" went dry in October 2010, tritium was detected at an activity of 15,600 pCi/L. Overall, during the five-year review period, tritium activities in Qal/WBR HSU ground water downgradient of the Building 850 Firing Table continued to decline and the spatial extent decreased due to natural attenuation and declining water levels and extent of saturation.

For comparison, maps of the tritium isoconcentration contours in Qal/WBR HSU ground water for 2010 and 2014 are shown on Figure 7. The highest activities of tritium in ground water in the Building 850 area occur proximal and immediately downgradient (east) of the firing table (Figure 7). Well NC7-28, located approximately 100 ft downgradient (east) of the firing table, yielded the historic maximum Qal/WBR HSU tritium activity of 566,000 pCi/L in 1985. The maximum tritium activity detected in a 2010 water sample from Building 850 was 58,400 pCi/L at NC7-70. Well NC7-70 is located approximately 20 ft east of the Building 850 Firing Table. In 2010, tritium above the 20,000 pCi/L MCL cleanup standard was detected in samples from three Qal/WBR HSU wells (NC7-28, NC7-70, W-850-2417). In 2014, tritium activities exceeding the 20,000 pCi/L MCL cleanup standard were detected only in ground water samples collected from Qal/WBR HSU monitor well NC7-70. Samples collected from monitor well NC7-70 collected in April and October 2014 contained 25,100 pCi/L and 23,200 pCi/L, respectively.

Wells W-PIT2-2301 and W-PIT2-2302, located in Elk Ravine downgradient of the Pit 2 Landfill, are monitored to determine the downgradient extent of tritium with activities above background (100 pCi/L) in the Qal/WBR HSU. However, neither well contained sufficient water for sampling during 2014. The most recent (2012) samples from these wells, yielded tritium activities within background range (<100 pCi/L). These wells yielded tritium activities within background range in all samples collected in 2010. Given the background activities of tritium in the Qal/WBR HSU samples from previous years, tritium from Building 850 has not been detected in this HSU downgradient of the Pit 2 Landfill.

The following changes in the extent of tritium in Building 850 Qal/WBR HSU ground water occurred during the five-year review period (Figure 7):

- The extent of tritium with activities greater than the 20,000 pCi/L cleanup standard has been reduced from a length of approximately 650 ft immediately downgradient of Building 850 to one well located within 20 ft of the Building 850 Firing Table source area in 2014.
- The extent of tritium with activities greater than 1,000 pCi/L remains relatively stable.

- Overall, the extent of tritium in ground water with activities above the 400 pCi/L California State Public Health Goal (PHG) remains relatively stable, but has decreased in size due to a declining extent of saturation resulting from low rainfall.
- The extent of tritium in ground water with activities above the 100 pCi/L reporting limit has remained relatively stable.

***$Tnbs_1/Tnbs_0$* HSU**

Maps of the tritium isoconcentration contours in $Tnbs_1/Tnbs_0$ HSU ground water for 2010 and 2014 are shown on Figure 8. During the five-year review period, tritium activity exceeding the 20,000 pCi/L cleanup standard was not detected in any ground water samples collected from wells screened exclusively in the $Tnbs_1/Tnbs_0$ HSU.

The highest tritium activity in the $Tnbs_1/Tnbs_0$ HSU downgradient of the Building 850 Firing Table for the 2010 to 2014 review period occurs near Elk Ravine. In 2010, the maximum tritium activity of 10,200 pCi/L was detected in a ground water sample from well NC2-18, located approximately 3,200 ft east of Building 850. The maximum 2014 tritium activity in ground water collected from a $Tnbs_1/Tnbs_0$ HSU well was 8,560 pCi/L in November 2014 from monitor well W-850-2145, located approximately 3,000 ft downgradient (east) of the Building 850 Firing Table.

Overall, tritium activities in water samples from most $Tnbs_1/Tnbs_0$ HSU monitor wells have decreased since 2010 and the extent of ground water with tritium in excess of background is similar to that of previous years. While tritium activities over the five-year review period continue to decline in most portions of the Building 850 plume (Figure 8), tritium activities above background in wells in the furthest downgradient portion of the plume exhibit a slowly increasing trend. However, the extent of tritium with activities above the 100 pCi/L background has remained stable. Tritium activities in Building 850/Pit 7 Complex ground water will continue to be monitored per the requirements in the Site-Wide Compliance Monitoring Plan, and evaluated and reported in the Annual and Semi-Annual Compliance Monitoring Report.

Figure 15 is a time-series plot of tritium activity in monitor wells immediately downgradient and proximal to the firing table. The time-series plot shows that during the five-year review period, tritium activities have declined below the cleanup standard in all wells except NC7-70. The plot also shows that tritium activities in wells NC7-28, NC7-61, and W-850-2417 have general declined since their installation, while wells NC7-70 and W-850-05 show one or more intermittent rises. Regardless of the past intermittent rises in the latter wells, all wells show marked declines in tritium activity over the period of record.

Figure 16 depicts the extent of tritium in ground water in the Building 850 area in excess of the 20,000 pCi/L cleanup standard in 1985, 1991, 1997, and 2014. The figure shows that the extent of tritium above the cleanup standard has declined markedly over that timeframe. In particular, all tritium activities in ground water had declined to below 500,000 pCi/L by 1991 to below 200,000 pCi/L by 1997. In 2014, the extent of tritium in excess of the cleanup standard is limited to one well immediately downgradient of Building 850.

The following changes in the extent of tritium impacting Building 850 $Tnbs_1/Tnbs_0$ HSU ground water occurred during the five-year review period (Figure 8):

- Tritium activities exceeding the 20,000 pCi/L cleanup standard were not detected in any ground water samples collected from wells screened exclusively in the $Tnbs_1/Tnbs_0$ HSU.

- The portion of the tritium plume with activities greater than the 20,000 pCi/L cleanup standard has been reduced from a length of approximately 750 ft to a distance of approximately 20 ft from the Building 850 Firing Table source area (NC7-70 in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water).
- The portion of the tritium plume with activities greater than the 1,000 pCi/L µg/L remains stable.
- Overall, the extent of tritium in ground water with activities above the 400 pCi/L California State PHG remains stable.
- While tritium activities in wells farthest downgradient exhibit a slowly increasing trend, the extent of tritium in ground water with activities above the 100 pCi/L reporting limit has remained relatively stable.

$Tnsc_0$ HSU

The concentrations of tritium in $Tnsc_0$ HSU monitor well W-850-2416, located within the Building 850 perchlorate treatability study area just east of the Building 850 Firing Table, have remained below the 100 pCi/L reporting limit/background, indicating hydraulic isolation from any tritium sources or tritium-impacted ground water.

Tmss HSU

Tritium has never been detected above background activities in Tmss HSU ground water. Only one well in the area, NC7-69, located approximately 400 ft due east of the Building 850 Firing Table, is completed in the Tmss HSU.

5.4.1.1.2. Uranium Concentrations, Distribution, and Remediation

Monitoring was selected as the remedy for depleted uranium in Building 850 ground water as activities in ground water were historically below the 20 pCi/L MCL.

During the five-year review period, total uranium was detected at an activity (24 pCi/L) exceeding the 20 pCi/L cleanup standard in a 2013 sample from Qal/WBR HSU well NC7-28, located downgradient from the Building 850 Firing Table source area. The cleanup standard was also exceeded in 2014 samples from $Tnbs_1/Tnbs_0$ HSU wells W-850-2315 and NC7-29, located southeast and cross-gradient of Building 850, at activities of 24 pCi/L and 21 pCi/L, respectively.

Uranium analyses are performed primarily by alpha spectroscopy with selected samples analyzed by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS). High precision uranium isotope data (uranium-235/uranium-238 [$^{235}U/^{238}U$] atom ratio) for determining the presence of depleted uranium are only available by ICP-MS analysis. The presence of depleted uranium is indicated by a $^{235}U/^{238}U$ atom ratio of less than 0.007. Historic uranium isotope data indicate that regions of ground water containing some added depleted uranium extend downgradient of Building 850 approximately 1,200 ft within the Qal/WBR HSU, and approximately 700 ft within the $Tnbs_1/Tnbs_0$ HSU, from the Building 850 Firing Table and have remained relatively stable in extent during the five year review period.

Although depleted uranium has been detected in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water downgradient of the Pit 2 Landfill and from wells in the $Tnbs_1/Tnbs_0$ HSU north of the Pit 2 Landfill, total uranium activities in recent years have been well below the 20 pCi/L cleanup standard. The depleted uranium observed arises from releases from Pit 2 and not Building 850 and is discussed in the OU 8 sections of the Compliance Monitoring Report and the OU 3 and 8 five year review report; it is not discussed further in this document.

Qal/WBR HSU

Figure 9 shows a comparison of uranium activities in ground water in the Qal/WBR HSU in the Building 850 area for 2010 and 2014. During the five-year review period, total uranium activities were below the 20 pCi/L cleanup standard in all wells located downgradient of the Building 850 Firing Table source area with one exception. In January 2013, total uranium was detected in Qal/WBR HSU well NC7-28 at an activity of 24 pCi/L. Prior to this sampling event, uranium had been detected in this well at activities above the cleanup standard only once (21 pCi/L in February 2008). By the next sampling event in May of 2013, uranium activities in this well had decreased to 9.8 pCi/L and remained well below the cleanup standard throughout the remainder of 2013 and 2014. Well NC7-28 is located immediately downgradient of the Building 850 Firing Table and ethyl lactate injection wells W-850-2417 and NC7-70. Ethyl lactate was injected into Qal/WBR HSU ground water to promote bacterially-motivated reduction of perchlorate as part of an ongoing treatability study. Its effects on dissolved uranium are discussed below.

Water samples from wells immediately downgradient of Building 850 have consistently exhibited uranium isotope atom ratios indicative of added depleted uranium. Figure 17a is a time-series plot of total uranium activities in ground water for selected wells near the Building 850 Firing Table. Figure 17b is a time series plot of $^{235}U/^{238}U$ atom ratios in ground water samples from these wells. Wells NC7-28, NC7-61, NC7-70, and W-850-2417 are completed in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs. Figure 17a indicates that during the five-year review period, water samples from well NC7-28 have contained uranium in excess of the cleanup standard twice (21 pCi/L, February 2008 and 24 pCi/L, January 2013). Prior to ethyl lactate injection, which began in September 2011, uranium activity in the July 2011 ground water sample from this well was 9.8 pCi/L. After ethyl lactate injection began, uranium activities in samples from this well have ranged between 2 pCi/L and 24 pCi/L, but exceeded the 20 pCi/L cleanup standard only once. The total uranium activities in the January and April 2014 ground water samples collected from well NC7-28 were 9.6 pCi/L and 5.4 pCi/L, respectively. Total uranium activities in well W-850-2417 also declined during the lactate injection period to near-historic lows. The maximum activity was detected in the first sample collected from the well (14 pCi/L, December 2007). The four quarterly samples from the well in 2014 contained a maximum of 1.1 pCi/L of uranium. Injection of ethyl lactate lowers the pH of the ground water and creates reducing conditions. Short-term decreases in total uranium activity in ground water are a product of the reducing conditions that lower the solubility of uranium. Uranium activities rebound as dissolved oxygen concentrations rise, and uranium activities in excess of pre-injection activities may result due to the lowered pH and oxidizing conditions that increase uranium solubility and may mobilize depleted and natural uranium precipitated onto aquifer mineral surfaces.

Figure 17b shows that in general, $^{235}U/^{238}U$ atom ratios in samples from wells NC7-28, NC7-61, NC7-70, and W-850-2417 have been fairly constant during the five-year review period. A significant exception is that the two 2014 samples from well NC7-70 became significantly more depleted, implying that some depleted uranium that was previously mineralized or sorbed near the well was solubilized due to transient pH reduction from neutral to 5 related to ethyl lactate slug. Figure 17b also shows that ground water at wells NC7-28 and W-850-2417 became slightly more natural in $^{235}U/^{238}U$ atom ratio, presumably due to mobilization of some natural uranium to local ground water.

The following changes in the extent and magnitude of uranium in Building 850 Qal/WBR HSU ground water occurred during the five-year review period (Figures 9 and 10):

- With the exception of one sample (24 pCi/L in NC7-28; January 2013), uranium activities in Qal/WBR HSU ground water were below the 20 pCi/L MCL throughout the review period.
- The injection of ethyl lactate into the Qal/WBR HSU in 2011 as part of the perchlorate treatability study temporarily reduced uranium activities by transient mineralization of some uranium under anoxic, reducing conditions.
- Subsequent dissolution of uranium under acidic pH conditions caused uranium activities to increase above the cleanup standard in well NC7-28 in 2013. Uranium activities in this well have since decreased to below the cleanup standard once pH conditions normalized.

$Tnbs_1/Tnbs_0$ HSU

Figure 10 shows a comparison of uranium activities in ground water in the Building 850 area in the $Tnbs_1/Tnbs_0$ HSU in 2010 and 2014. During 2014, total uranium activities in ground water samples from two $Tnbs_1/Tnbs_0$ HSU wells in the Building 850 area exceeded the 20 pCi/L cleanup standard. Samples collected during the first semester 2014 from wells W-850-2315 and NC7-29 had uranium activities of 24 pCi/L and 21 pCi/L, respectively. These wells are located southeast and cross-gradient of Building 850. The total uranium activities of ground water samples collected from these wells during the second semester 2014 decreased to 20 pCi/L and 18 pCi/L for W-850-2315 and NC7-29, respectively. The uranium analyses of the second semester samples were performed using ICP-MS. The $^{235}U/^{238}U$ atom ratios measured with ICP-MS in all samples collected from both wells since monitoring began indicate natural uranium (Figure 17b). Both wells exhibit increasing uranium trends with historic maxima of 24 pCi/L (April 2014) and 22 pCi/L (April 2008) for W-850-2315 and NC7-29, respectively (Figure 17a). The 2010 maximum uranium activity in the $Tnbs_1/Tnbs_0$ HSU was 19 pCi/L measured in an April 2010 sample from well W-850-2315. During 2010, the maximum uranium activity in a sample from well NC7-29 was 18 pCi/L. All Building 850 area wells screened exclusively in unweathered $Tnbs_1/Tnbs_0$ HSU, except those in the Pit 2 Landfill area, have historically yielded samples that contain only natural uranium.

$Tnsc_0$ HSU

Uranium activities in $Tnsc_0$ HSU monitor well W-850-2416, located within the perchlorate treatability study area just east of the Building 850 Firing Table, have remained low (<0.5 pCi/L) since monitoring began in 2008. The $^{235}U/^{238}U$ atom ratios initially exhibited a depleted signature in the 0.004 to 0.005 range, which, over time, have trended toward more natural isotopic ratios. The presence of some depleted uranium in ground water from this well is most likely the result of some unavoidable impacts related to drilling, during which some depleted uranium-bearing ground water from the overlying Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs seeped into the $Tnsc_0$ HSU before installation of the well and the grout seal.

Tmss HSU

Uranium activities in samples collected from Tmss HSU wells are below the cleanup standard, well within the range of natural background levels, and indicate natural atom ratios.

5.4.1.1.3. Nitrate Concentrations, Distribution, and Remediation

Monitoring was selected as the remedy for nitrate in ground water at Building 850 as the extent of nitrate with concentrations above the 45 mg/L MCL cleanup standard was limited and nitrate concentrations were within the range of background. During 2014, ground water samples from four wells (Figures 11 and 12) exceeded the cleanup standard. As part of the site-wide nitrate study, ground water with nitrate concentrations greater than the 45 mg/L MCL has been detected in wells that sample pre-modern ground water that pre-dates Site 300 (e.g., NC7-47, Visser et al., 2014).

The highest nitrate concentrations (> 100 mg/L as NO3) were detected in NC7-29, screened in the $Tnbs_1/Tnbs_0$ HSU. Because this well also contains perchlorate and it is located southeast and cross-gradient of Building 850, this elevated nitrate is from a local source and not Building 850. This local source of nitrate (and perchlorate) in ground water at well NC7-29 is believed to be the corporation yard (and associated equipment stored there in the past) located immediately east of the well as there is no other credible source in the area.

Qal/WBR HSU

Figure 11 shows a comparison of nitrate concentrations in ground water in the Building 850 area in the Qal/WBR HSU in 2010 and 2014. During 2014, two Qal/WBR wells (also screened in $Tnbs_1/Tnbs_0$) located in the vicinity of the Building 850 Firing Table yielded ground water with nitrate concentrations that exceeded the 45 mg/L cleanup standard. The May 2014 sample from monitor well NC7-44, located upgradient of the firing table and the *in situ* bioremediation treatment zone, contained 57 mg/L of nitrate. The April 2014 sample from monitor well NC7-61, located downgradient of the firing table and the *in situ* bioremediation treatment zone, contained 50 mg/L of nitrate. Nitrate concentrations in ground water samples from wells NC7-28, NC7-70 and W-850-2417, located within the *in situ* bioremediation treatment zone, remained below the 0.5 mg/L reporting limit during 2014 as a result of denitrification related to ethyl lactate injection in wells W-850-2417 and NC7-70. The 2010 maximum nitrate concentration in wells located directly downgradient of the Building 850 source area was 58 mg/L in an April 2010 ground water sample collected from well NC7-61, also screened across the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs.

$Tnbs_1/Tnbs_0$ HSU

Figure 12 shows a comparison of nitrate concentrations in ground water in the Building 850 area in the $Tnbs_1/Tnbs_0$ HSU in 2010 and 2014. The 2014 maximum nitrate concentration in the Building 850 area in a well screened exclusively in the $Tnbs_1/Tnbs_0$ HSU was 160 mg/L in the April ground water sample from monitor well NC7-29, located southeast and cross-gradient of Building 850. The historic local maximum nitrate concentration of 190 mg/L was detected in the April 2013 ground water sample collected from this well. The other $Tnbs_1/Tnbs_0$ HSU wells with nitrate concentrations exceeding the 45 mg/L cleanup standard are located southeast of the Pit 2 Landfill (NC2-12S and NC2-20) and east of the Pit 1 Landfill (W-PIT1-2209). In 2010, nitrate was detected in excess of the cleanup standard in four $Tnbs_1/Tnbs_0$ HSU wells in or northeast of Elk Ravine: NC2-10, NC2-11D, W-PIT1-02, and K8-01.

Historic data indicate that nitrate concentrations in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water are limited in extent and relatively stable. Overall, except for the *in situ* bioremediation treatment zone, the distribution and concentrations of nitrate in ground water are generally consistent, or have declined slightly from those observed in previous years and during the five-year review period. The elevated nitrate in some of the downgradient wells east of Elk Ravine (e.g., W-865-2004, NC2-19 and W-PIT1-2209) that do not contain any other anthropogenic contaminants, including tritium, likely reflect elevated background levels.

$Tnsc_0$ HSU

The concentrations of nitrate in $Tnsc_0$ HSU well W-850-2416 are in the lower range of background, ranging from below the reporting limit of 0.5 mg/L to 1.4 mg/L (as NO_3).

Tmss HSU

Nitrate concentrations in samples collected from the Tmss HSU are below the cleanup standard and well within the range of natural background levels.

5.4.1.1.4. Perchlorate Concentrations, Distribution, and Remediation

Perchlorate was identified as a ground water COC in the 2008 Site-Wide ROD due to its presence in Building 850 ground water at concentrations above the 6 µg/L State MCL. However no remedy was selected as it was only recently identified as a ground water contaminant at the time of the ROD. In the ROD, DOE committed to implementing an *in situ* bioremediation treatability study for perchlorate in Building 850 ground water. After completion of the *in situ* bioremediation treatment study and additional source characterization, treatability study results and remedial technologies for perchlorate in ground water will be evaluated in a future Focused Remedial Investigation/Feasibility Study (RI/FS). To date, *in situ* enhanced bioremediation with ethyl lactate has reduced perchlorate concentrations in ground water in the vicinity of the Building 850 Firing Table to below the 4 µg/L reporting limit.

As stated in Section 5.4.1.1, perchlorate concentrations and distribution are discussed in this section for completeness. However, remediation progress and performance issues are not yet applicable and are not discussed in this Five-Year Review. The status and progress of the *in situ* bioremediation treatability study for perchlorate in Building 850 ground water are discussed in the Compliance Monitoring reports.

During the five-year review period, the extent of perchlorate with concentrations exceeding the 6 µg/L MCL cleanup standard decreased from 28 wells downgradient of Building 850 and Pit 1 in 2010 to 16 wells downgradient of Building 850 and downgradient of Pit 1 and Pit 2, and immediately north of Elk Ravine in 2014. Wells downgradient of the Building 850 Firing Table, with the exception of three wells (NC7-28, W-850-2417 and NC7-70) located within the *in situ* bioremediation treatment zone, continue to exhibit the highest perchlorate concentrations in the Building 850 area. Perchlorate concentrations and distribution Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSU ground water in the Building 850 Area are discussed below.

Qal/WBR HSU

Figure 13 shows a comparison of the extent of perchlorate in ground water in the Building 850 area in the Qal/WBR HSU in 2010 and 2014. In 2010, the maximum perchlorate concentration of 79 µg/L was detected in a sample from well W-850-2417, located directly downgradient of the Building 850 Firing Table. In 2011, a treatability study was initiated with the injected of ethyl lactate into well W-850-2417 to facilitate *in situ* bioremediation of perchlorate in Building 850 ground water. By March 2012, perchlorate concentrations in well W-850-2417 had been reduced to below the 4 µg/L reporting limit. In 2013, the maximum perchlorate in Building 850 ground water of 52 µg/L was detected in well NC7-70, located upgradient of W-850-2417 and directly downgradient of the firing table. With regulatory approval, ethyl lactate injection into well NC7-70 began in September 2013. Following ethyl lactate injection into NC7-70, perchlorate concentrations in this well have been below the reporting limit.

The 2014 maximum perchlorate concentration in Building 850 ground water of 44 µg/L was detected in samples collected from well NC7-61. Well NC7-61 is located 500 ft east of the firing table and directly downgradient of the *in situ* bioremediation treatment zone and is screened in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs. During 2014, perchlorate concentrations in ground water samples from all wells located upgradient (west) of well NC7-61, with the exception of one sample from well NC7-28 (4.3 µg/L, May), were below the 4 µg/L reporting limit.

Ground water in the Qal/WBR HSU that contains perchlorate with concentrations in excess of the 6 µg/L cleanup standard extends approximately 2,200 ft downgradient of the Building 850 Firing Table. The extent is similar to that of 2010, with the exception of the wells located upgradient (west) of well NC7-61 where ethyl lactate injection into wells NC7-70 and W-850-2417 has reduced perchlorate concentrations to below the 4 µg/L reporting limit.

$Tnbs_1/Tnbs_0$ HSU

Figure 14 shows a comparison of the extent of perchlorate in ground water in the Building 850 area $Tnbs_1/Tnbs_0$ HSU in 2010 and 2014. The 2014 maximum perchlorate concentration in ground water samples collected from wells screened in the $Tnbs_1/Tnbs_0$ HSU is 11 µg/L, measured in samples from monitor wells NC7-27, and NC7-29. Wells NC7-27 and NC7-29 are located approximately 900 ft east (downgradient) and 1,500 ft southeast (cross-gradient) of the Building 850 Firing Table, respectively. Other $Tnbs_1/Tnbs_0$ HSU wells yielding ground water with perchlorate concentrations exceeding the 6 µg/L cleanup standard during 2014 are located east of the Building 850 Firing Table (NC2-18 and W-850-2145), southeast of the Pit 2 Landfill (NC2-05A, NC2-12I and NC2-17), and east of the Pit 1 Landfill (K1-02B, W-PIT1-2326 and W-PIT1-2620). The migration of perchlorate in in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs may have contributed to perchlorate concentrations observed in the $Tnbs_1/Tnbs_0$ HSU in the Pit 1 area. Pit 1 may have released perchlorate to ground water prior to being capped in 1992. Data indicate that Pit 2 is not a likely source of perchlorate and has not contributed to the distribution of perchlorate observed in the Pit 1 area (Holtzapple, 2011b).

During 2014, the extent of perchlorate in $Tnbs_1/Tnbs_0$ HSU ground water with concentrations above the 4 µg/L reporting limit and downgradient from the perchlorate treatability study remained similar to 2010.

Wells downgradient of the Building 850 Firing Table continue to exhibit the highest perchlorate concentrations in the Building 850 area. Perchlorate concentrations in excess of the cleanup standard in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water extend continuously 2,000 and 1,200 ft, respectively, from Building 850.

$Tnsc_0$ HSU

Perchlorate concentrations in $Tnsc_0$ HSU well W-850-2416 remain below the 4 µg/L reporting limit. The lack of detectable perchlorate in this well supports the hydraulic isolation of the $Tnsc_0$ HSU from the overlying contaminated shallow ground water.

Tmss HSU

In October 2010, perchlorate was detected at a concentration of 10 µg/L in Tmss HSU well NC7-69, located 500 ft downgradient (northeast) of Building 850. This was its first and only detection since sampling of the well for perchlorate began in 2001. Perchlorate concentrations in nine samples collected from the well since that single detection have been below the 4 µg/L analytical reporting limit. It should be noted that false detections are common in perchlorate analyses due to dissolved anion interference.

5.4.1.1.5. HE Compound Concentrations and Distribution

No HE compounds were identified as COCs in Building 850 ground water in the Site-Wide ROD. In the past, contract laboratory reporting limits for RDX and HMX were higher, varying from 5 to 20 µg/L. Lower reporting limits have enabled detection of RDX and HMX at lower concentrations. In 2008, RDX and HMX were detected at concentrations of 4.2 µg/L and 6 µg/L, respectively, in the baseline sample collected from new monitor well W-850-2417 drilled and installed downgradient of Building 850. Baseline sampling conducted for new wells typically includes analysis for an expanded analyte suite in addition to COCs for the area in which the well is drilled.

As a result of the RDX and HMX detections in W-850-2417, DOE/LLNL initiated monitoring for HE compounds in eight wells in the vicinity of and including well W-850-2417 in 2008. Of these eight wells, RDX and HMX were detected in three wells above the 1 µg/L reporting limit. There are no State or Federal MCLs for RDX or HMX. A cleanup standard was selected for RDX in ground water of 1 µg/L based on the Tap Water Preliminary Remediation Goal (PRG) and achievable reporting limit. No cleanup standard has been established for HMX in Site 300 ground water. However HMX concentrations in these three wells were all below the 1,000 µg/L EPA Regional Tap Water Screening Level.

In 2009, monitoring for HE compounds was further expanded to include a total of 20 wells located in the vicinity of and downgradient of the Building 850 Firing Table. RDX was detected at concentrations above the 1 µg/L reporting limit/cleanup standard in five of the twenty wells, with a maximum concentration of 6.7 µg/L detected in well NC7-28 located immediately east of the Building 850 Firing Table. HMX was detected at concentrations above the 1 µg/L reporting limit in five of the twenty wells, with a maximum concentration of 10 µg/L also detected in well NC7-28. The analysis of the samples from the 20 wells defined the lateral extent of RDX and HMX in ground water.

With the exception of detections of nitrobenzene in three wells in 2013, RDX and HMX are the only HE compounds detected in any wells in any the sampling events discussed above.

This enhanced monitoring for RDX and HMX in 19 to 23 wells in Building 850 ground water continued throughout the 2010 through 2014 five-year review period. The results of this monitoring are discussed by HSU below.

Qal/WBR HSU

During the 2010 to 2014 review period, RDX concentrations decreased from the maximum of 9.3 µg/L in 2010 to a maximum of 5.7 µg/L in 2014. The maximum extent of RDX in ground water was observed in 2009 when RDX was detected in five wells (NC7-10, NC7-11. NC7-28, NC7-54, and NC7-61) and extended approximately 800 ft from the firing table. By 2011, the extent of RDX in ground water had decreased to two wells. The extent of RDX in 2014 is still limited to two wells (NC7-28 and NC7-61). Well NC7-28 is located immediately downgradient of the firing table, and NC7-61 is located approximately 500 ft downgradient of the firing table.

During 2014, only ground water samples collected from well NC7-61 (January, April, August, October and November) consistently contained RDX at concentrations exceeding the 1 µg/L reporting limit/cleanup standard. The maximum RDX concentration in NC7-61 in 2014 was 5.7 µg/L. The only other detection of RDX during 2014 that exceeded the reporting limit/cleanup standard was 2.6 µg/L in one (October) sample collected from well NC7-28.

RDX concentrations in ground water samples from wells NC7-28 and W-850-2417 exceeded the 1 µg/L reporting limit/cleanup standard from the time when enhanced monitoring of HE compounds began in February 2008 until September 2011. After September 2011, RDX concentrations dropped below the reporting limit in both wells except for two detections (5.3 µg/L in W-850-2417 in July 2012 and 2.6 µg/L in NC7-28 in October 2014). Well W-850-2417 is located immediately downgradient of the Building 850 Firing Table, and NC7-28 is about 25 ft downgradient of W-850-2417.

The decrease in RDX concentrations at these wells could be related to one or a combination of the following:

- The degradation of RDX caused by reducing conditions created following ethyl lactate injection into well W-850-2417 in 2011 as part of the *in situ* bioremediation treatability study for perchlorate in Building 850 ground water.
- The dilution of RDX concentrations in ground water as a result of the injection of water with the ethyl lactate into well W-850-2417 as part of the *in situ* bioremediation treatability study.
- The solidification/consolidation of 27,592 cubic yards of soil from the Building Firing Table area as part of the 2009 removal action.
- Lack of significant rainfall/recharge in recent years.

During the review period, HMX concentrations decreased from the maximum of 15 µg/L detected in NC-28 in 2011 to a maximum of 6.8 µg/L in 2014 (NC7-61). The maximum extent of HMX in ground water was observed in 2010 when HMX was detected in six wells and Well 8 Spring and extended approximately 700 ft from the firing table. The extent of HMX in 2014 has decreased to three wells W-850-2417, NC7-28, and NC7-61 located within 500 ft of the firing table at concentrations of 4.7 µg/L, 4.8 µg/L, and 6.8 µg/L, respectively. Since regular monitoring of HE compounds began in 2008, HMX concentrations in Building 850 ground water have remained well below the 100 µg/L EPA Regional Tap Water Screening Level.

The only other HE compound detected in Building 850 ground water is nitrobenzene that was detected in wells NC7-28, NC7-61, and W-850-2417 in the first semester (April) 2013 at concentrations of 4.1 µg/L, 3.5 µg/L, and 4.3 µg/L, respectively. The EPA Regional Tap Water Screening Level for nitrobenzene is 0.14 µg/L. During second semester 2013 until the present, nitrobenzene was not detected in ground water samples from any wells in the Building 850 Area.

Nitrobenzene was only detected in the April 2013 samples analyzed by BC Laboratories, Inc. In July 2013, DOE/LLNL requested follow-up EPA Method 8330 analysis of co-located samples by BC Laboratories, Inc. and Curtis & Tompkins, Ltd. The purpose of this follow-up analysis was to evaluate significant differences in collocated sample results and to address an issue from a DOE Consolidated Audit Program audit performed in May 2013 in which it was noted that BC Laboratory was not performing a second column confirmation for explosives analysis. In the July 2013 follow-up sample analyses, each laboratory performed the analysis according to method specifications including a second column confirmation. Both laboratories detected HMX at similar concentrations, but nitrobenzene was not detected in any of the samples.

The limited extent of HE compounds in ground water to the vicinity of the Building 850 firing table and within Qal and weathered $Tnbs_1/Tnbs_0$ can be attributed to the high adsorption capacity of dissolved chemical explosives to reactive sites and clays within the aquifer's solid matrix.

$Tnbs_1/Tnbs_0$ HSU

HE compounds were not detected above the reporting limit in ground water samples collected during 2010 through 2014 or historically from wells screened exclusively in the $Tnbs_1/Tnbs_0$ HSU at or downgradient of Building 850.

$Tnsc_0$ HSU

In October 2010, a sample from the well W-850-2416 that is completed in fractures within $Tnsc_0$ HSU contained 2.7 μg/L of RDX. This well is located about 100 ft downgradient of the Building 850 Firing Table. No HE compounds have been detected in samples from this well before or since the one 2010 detection.

Tmss HSU

HE compounds were not detected in any ground water samples collected from the Tmss HSU.

Summary and Recommendation

Data indicate that except for one sample in a $Tnsc_0$ HSU well (W-850-2416) in 2010, the extent of RDX and HMX in Building 850 ground water is limited to the Qal/WBR HSU near and directly downgradient of the Building 850 Firing Table. With the exception of detections of nitrobenzene in three wells in 2013, RDX and HMX are the only HE compounds detected. The extent of HE compounds in Building 850 ground water has decreased since 2008, when regular sampling and analysis for these compounds commenced, and during 2014 was limited to only three downgradient wells (RDX in two wells and HMX in three wells) located within 500 feet of the Building 850 Firing Table. Concentrations of both RDX and HMX have decreased during the five-year review period. HMX concentrations remain well below the 1,000 μg/L EPA Regional Tap Water Screening Level.

DOE/LLNL recommend continued monitoring of HE compounds in Building 850 ground water to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases. In addition, DOE/LLNL recommends collecting subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water.

5.4.1.2. Contaminant Remediation Progress

Data collected during the five-year review period continue to support that natural attenuation (dispersion and radioactive decay) and a diminishing source term continue to reduce tritium activities in ground water to below the 20,000 pCi/L cleanup standard (Figure 8). As shown on Figure 16, the extent of tritium activities above the 20,000 pCi/L cleanup standard in Building 850 ground water has decreased significantly since 1985. Since 2013, the extent of tritium in ground water with activities above the 20,000 pCi/L cleanup standard has been limited to one well (NC7-70), located immediately downgradient of the firing table source area. Tritium activities have decreased from a historical maximum of 566,000 in 1985 to 23,200 pCi/L in October 2014. The leading edge of the tritium plume with activities above background is stable, within the Site 300 interior, and is expected to completely attenuate within the boundaries of Site 300.

Data collected during the five-year review period indicate that: (1) with several exceptions, total uranium activities in ground water at and downgradient from Building 850 are below the 20 pCi/L cleanup standard, (2) $^{235}U/^{238}U$ atom ratios are indicative of natural uranium, and (3) the areal extent of depleted uranium has not changed during the period of monitoring. The several exceedences of the uranium cleanup standard in two wells downgradient from Building 850 is thought to be the result of temporary immobilization of uranium, followed by re-mobilization, due to ethyl lactate injections as part of the perchlorate treatability study. Temporal trends in $^{235}U/^{238}U$ isotope ratios from past samples have remained stable. The enhanced monitoring of chemical parameters (pH, dissolved oxygen, oxidation potential, and general minerals) outlined in the Treatability Study Work Plan for Enhanced *In Situ* Bioremediation of Perchlorate in Ground water at Building 850 (Holtzapple, 2011a) will continue following future lactate injections. This monitoring will provide more information documenting whether increases in uranium concentrations after initial declines are associated with chemical changes brought about by lactate oxidation and associated initial reduction of dissolved uranium, followed by re-oxidation.

Data indicate that nitrate concentrations in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water near and downgradient of Building 850 are limited in extent and relatively stable. Overall, except for the *in situ* bioremediation treatment zone where nitrate concentrations have dropped below reporting limits, the distribution and concentrations of nitrate in ground water are generally consistent, or have declined slightly from those observed in previous years and during the five-year review period. Of the two Qal/WBR HSU wells in which nitrate was detected above the 45 mg/L cleanup standard, one well is located upgradient of the firing table source area and nitrate concentrations were higher in this well than in the downgradient well. While nitrate was also detected in a $Tnbs_1/Tnbs_0$ HSU well at concentrations above the cleanup standard, the well is located cross-gradient from Building 850 and also contains natural uranium at concentrations above the MCL.

The final remedy for perchlorate in ground water will be determined after completion of additional perchlorate source characterization at the Building 850 Firing Table, the current *in situ* bioremediation treatability study, and the Focused RI/FS. Thus, although current results of the ethyl lactate injection are promising, the information will be published in future documents, and preliminary results are not discussed in further detail here.

Although HE compounds were not identified as COCs in the 2008 Site-Wide ROD, monitoring of RDX and HMX in Building 850 ground water were conducted during the five-year review period as a result of the detection of the HE compounds in a baseline sample for a new well drilled in 2008. Data indicate that, except for one sample in a $Tnsc_0$ HSU well (W-850-2416) in 2010, the extent of RDX and HMX in Building 850 ground water is limited to the Qal/WBR HSU near and directly downgradient of the Building 850 Firing Table. With the exception of detections of nitrobenzene in three wells in 2013, RDX and HMX are the only HE compounds detected. The extent of HE compounds in Building 850 ground water has decreased since 2008, when regular sampling and analysis for these compounds commenced, and during 2014 was limited to only three downgradient wells (RDX in two wells and HMX in three wells) located within 500 feet of the Building 850 Firing Table. Concentrations of both RDX and HMX have decreased during the five-year review period. HMX concentrations remain well below the 100 μg/L EPA Regional Tap Water Screening Level.

5.4.1.3. Building 850 Performance Issues

There were no issues that affect the performance of the MNA cleanup remedy for tritium in the Building 850 area during this five-year review period. The remedy for tritium continues to be effective and protective of human health and the environment, and to make progress toward meeting cleanup standards.

During the five-year review period, there was only one detection of uranium above the cleanup standard in wells at or downgradient of the Building 850 Firing Table source area. This temporary increase in uranium activities in one well (NC7-28) is thought to be the result of temporary immobilization of uranium, followed by re-mobilization, due to ethyl lactate injections as part of the perchlorate treatability study. Therefore, the monitoring remedy for uranium in Building 850 ground water continues to be protective because uranium activities in ground water downgradient of the firing table source area remain below the cleanup standard. However, DOE/LLNL will closely monitor uranium activities within the treatment zone of the *in situ* perchlorate bioremediation treatability study to ensure that the effects of the study on uranium activities and distribution continue to be limited both spatially and temporally.

The remedy for nitrate in Building 850 ground water continues to be effective and protective of human health and the environment as: (1) nitrate concentrations near and downgradient of Building 850 are limited in extent and relatively stable, and (2) of the two wells in which nitrate was detected above the cleanup standard, the highest concentration was detected in an upgradient well indicating a natural source of higher nitrate concentrations.

While both uranium and nitrate were detected at concentrations exceeding cleanup standards in wells W-850-2315 (uranium-only) and NC7-29 (uranium and nitrate) during the five-year review period, these wells are located southeast of and cross-gradient from Building 850. The $^{235}U/^{238}U$ atom ratios measured with ICP-MS in all samples collected from both wells since monitoring began indicate only natural uranium. DOE/LLNL will continue to monitor uranium and nitrate in these wells to determine any changes that could impact human health or the environment, or that indicate a release from this area.

The remedy for perchlorate in ground water at Building 850 will be determined after completion of additional characterization, the *in situ* bioremediation treatability study, and Focused RI/FS. Since no remedy has been selected or implemented, no performance issues are identified for perchlorate at Building 850 in this Five-Year Review. A work plan is currently being prepared for the installation of three boreholes within the footprint of the Building 850 Firing Table to determine if residual perchlorate exists in the unsaturated zone beneath the firing table. Water samples from these boreholes will also be analyzed for perchlorate.

Although HE compounds were not identified as COCs in the 2008 Site-Wide ROD, RDX and HMX were detected in Building 850 ground water during the five-year review period. Data indicate that the extent of RDX and HMX in Building 850 ground water is currently limited to the Qal/WBR HSU near and directly downgradient of the Building 850 Firing Table, and concentrations of both RDX and HMX decreased during the five-year review period. HMX concentrations remain well below the 100 μg/L EPA Regional Tap Water Screening Level. However, DOE/LLNL will continue to monitor HE compounds in Building 850 ground water to verify the continued decrease in RDX and HMX concentrations and extent, and to evaluate the mechanisms driving these decreases. In addition, DOE/LLNL recommends collecting subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water.

5.4.1.4. Building 850 Risk Mitigation Progress

This section summarizes the results of the annual risk re-evaluations conducted for the Building 850 portion of the Building 850/Pit 7 Complex OU to assess the progress of the remedy in mitigating risk associated with PCBs, dioxins, and furans in surface soil at Building 850 and tritium in the Well 8 Spring. The risks from COCs at the Building 850 Firing Table area were summarized in Section 3.5.1 and are discussed in more detail in the 2008 Site-Wide ROD.

The cancer risks and hazard indices identified in the baseline human health and ecological risk assessment for Building 850 and the status/progress of the remedy in mitigating those risks and hazards are as follows:

- Surface Soil at Building 850 - A cumulative cancer risk of 5×10^{-4} and 1×10^{-4} to onsite workers was identified for inhalation, ingestion, and dermal contact (8 hrs/day, 5 days/week) of PCBs and dioxin/furan compounds, respectively, in surface soil at the Building 850 Firing Table over a 25-year period. An HI greater than one was also identified for ground squirrels, deer, kit fox, and burrowing owls associated with PCBs and dioxin/furan compounds in Building 850 surface soil. In 2009, 27,592 cubic yards of PCB-, dioxin-, and furan-contaminated soil were excavated from the Building 850 Firing Table area, mixed with Portland cement and water to solidify it, and consolidated in a CAMU. This removal action mitigated the risk to onsite workers and ecological receptors associated with PCB-, dioxin-, and furan-contaminated surface soil at Building 850. Surface soil with concentrations of cadmium posing a potential ecological hazard in the vicinity of the firing table was also likely addressed as part of the removal action.

  The human health baseline risk assessment also identified a cancer risk of 6×10^{-6} associated with beryllium in surface soil at Building 850. The soil containing beryllium was excavated during the soil removal action to mitigate risk associated with PCBs, dioxins, and furans in surface soil in Building 850. Verification samples were not collected as the maximum beryllium concentrations detected in Building 850 soil (15 mg/kg), while exceeding background concentrations, are well below industrial and residential January 2015 EPA regional screening levels of 2,300 mg/kg and 160 mg/kg.

- While HMX was identified as a COC in surface soil at Building 850, this HE compound was detected in only one soil sample and its concentration (2.4 mg/kg) is well below current (January 2015) EPA industrial and residential regional screening levels for soil of 57,000 mg/kg and 3,800 mg/kg, respectively. Additionally, the volume of soil from which the HMX-bearing soil sample was collected, was excavated, solidified, and consolidated as part of the removal action to address PCB-, dioxin-, and furan-contaminated soil at Building 850. For both these reasons, there is no risk indicated for HMX in surface soil at Building 850.

- Sandpile at Building 850 - Beryllium, cadmium, and copper, contributed to a Hazard Index greater than one for the Building 850 sandpile for adult ground squirrels, with cadmium primarily driving the hazard. The sandpile (800 yd^3) was excavated and solidified as part of the removal action to address PCB-, dioxin-, and furan-contaminated soil at Building 850, thereby mitigating the ecological exposure risk to beryllium, cadmium, and copper in the sandpile.
- Well 8 Spring – A cumulative cancer risk of 1×10^{-3} was estimated for onsite workers, assuming continuous inhalation of tritium vapors volatilizing from the Well 8 Spring into outdoor air over a 25-year period. The 2009 Compliance Monitoring Plan/Contingency Plan required that the inhalation risk to onsite workers associated with tritium in surface water volatilizing into outdoor ambient air in the vicinity of Well 8 Spring be re-evaluated annually when surface water is present 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 tritium inhalation in outdoor air near Well 8 Spring was initiated in 2010. A surface water sample was collected from Well 8 Spring in June 2010. However, this spring has been dry since that time. The surface water sample result from June 2010 indicated that tritium activities had decreased from a historic maximum of 770,000 pCi/L in 1972 to 15,600 pCi/L (October 2010). The tritium activities in the 2010 sample exceeded the EPA tritium inhalation tap water Preliminary Remediation Goal of 144 pCi/L, but indicated a significant decrease in tritium activities over time. Workers do not occupy the Well 8 Spring area and institutional controls described in Section 4.5.2.6 continue to prevent exposure until the risk is mitigated. Since the Well 8 Spring has been dry since 2011, there has been no potential for worker exposure to tritium in surface water at this spring during most of the five-year review period. The spring is and will continue to be monitored for the presence of surface water, and if present, surface water in the spring will be sampled to re-evaluate risk.

5.4.2. Pit 7 Complex Remediation Progress

The progress of ground water remediation in the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU was evaluated by:

- Comparing 2014 ground water COC concentrations and spatial distribution (Figures 7 through 14) to 2010 concentrations and distribution.
- Comparing temporal changes in COC extent and concentration.
- Reviewing extraction well performance.
- Reviewing ground water COC mass removal data for the ground water treatment facility at the Pit 7 Complex.
- Evaluating performance of the drainage diversion system in preventing further contaminant releases from the Pit 7 Complex landfills.

The results of this evaluation for the ground water COCs in the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU during this five-year review period are discussed in the following subsections: contaminant concentrations and distribution (Section 5.4.2.1), contaminant remediation and mass removal (Section 5.4.2.2), capture zone analysis (Section 5.4.2.3), Pit 7 landfill detection monitoring and results (Section 5.4.2.4) performance issues (Section 5.4.2.5), and risk mitigation progress (Section 5.4.2.6).

5.4.2.1. Pit 7 Complex Contaminant Concentrations and Distribution

In the Pit 7 Complex area of the Building 850/Pit 7 Complex OU, tritium is the primary COC in ground water and uranium, perchlorate, nitrate, and VOCs are secondary COCs. These constituents have been identified within the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs. The distribution of the first four COCs in these HSUs for 2010 and 2014 are depicted on Figures 7 through 14. Due to their limited extent, maps of the distribution of VOCs in ground water were not created. Tritium, uranium, nitrate, perchlorate, and VOC concentrations, distribution, and remediation are discussed in Sections 5.4.2.1.1 through 5.4.2.1.5.

Primary COC ground water sampling is conducted during the first and second semesters, and secondary COC sampling is conducted during the first semester. Tritium is a primary COC throughout the Building 850/Pit 7 Complex OU. Perchlorate is a primary COC in the Building 850 area and a secondary COC at the Pit 7 Complex. Uranium and nitrate are secondary COCs throughout the Building 850/Pit 7 Complex. The maps for tritium are based on the most recent data, which are from the second semester. The maps for perchlorate are based on first semester data, because it is the only semester for which there is a complete data set. Thus, annual tritium and perchlorate data and maxima discussed in the text may be different from data on the ground water COC maps (Figures 7, 8, 13, and 14).

5.4.2.1.1. Tritium Activities, Distribution, and Remediation

Monitored Natural Attenuation is the remedy for tritium in ground water at Pit 7 Complex. Overall, tritium activities in Pit 7 Complex ground water have decreased by over one order-of-magnitude from historic maximum of 2,660,000 pCi/L. The highest tritium activities in ground water continue to occur in Qal/WBR HSU ground water directly downgradient of the Pit 3 and Pit 5 landfills. The Pit 7 Landfill does not appear to be a source of tritium to ground water as most of the tritium-bearing experiments at Site 300 were conducted prior to its opening in 1979 (Taffet et al., 2008) and well NC7-48, located directly downgradient of Pit 7 and upgradient of Pit 3, has generally yielded ground water samples that contain tritium activities within background ranges. Ground water samples collected from well NC7-48 contained less than 100 pCi/L of tritium. Although the maximum concentrations have declined significantly from historic values and continued to decrease during the five-year review period, the spatial extent of tritium in Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs above the 20,000 pCi/L MCL cleanup standard has not changed significantly. However, the extent of saturation in both HSUs has decreased due to continued drought conditions. Tritium activities are discussed by HSU below.

Qal/WBR HSU

Figure 7 shows a comparison of the extent of tritium in Qal/WBR HSU ground water in the Pit 7 Complex in 2010 and 2014. Figure 18 presents a time-series plot of tritium activities in selected extraction and monitor wells in the Pit 7 Complex area from 1985 through 2014. As shown in Figure 18, tritium activities in Pit 7 Complex ground water peaked in the years immediately following the 1997-1998 El Niño and have generally decreased since that time. Tritium activities have decreased from a historic maximum of 2,660,000 pCi/L (NC7-63, 1998) to a (January) 2014 maximum activity of 134,000 pCi/L in the sample collected from monitor well NC7-51. Well NC7-63 is located directly downgradient of Pit 3. Well NC7-51 is located approximately 40 ft northeast of Pit 5 and 60 ft east of Pit 3. During the five-year review period, tritium activities continued to decrease from a 2010 maximum of 255,000 pCi/L in a sample from well NC7-63 to 115,000 pCi/L in a sample from well NC7-51 in October 2014. Tritium activities in the Qal/WBR HSU have generally declined in all 2014 ground water samples relative to 2010 measurements.

In the Qal/WBR HSU, the region of ground water containing tritium in excess of the MCL cleanup standard extends approximately 750 ft southeast from the eastern edge of Pit 3 and has remained unchanged from 2010 to 2014.

$Tnbs_1/Tnbs_0$ HSU

Figure 8 shows a comparison of the extent of tritium in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 7 Complex in 2010 and 2014. Tritium activities in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 7 Complex area have decreased from an historic maximum of 770,000 pCi/L in 1999 to 271,000 pCi/L maximum in 2010, and to a 2014 maximum of 182,000 pCi/L (October). The historic, 2010, and 2014 maximum tritium activities were detected in samples from extraction well NC7-25, located approximately 250 ft downgradient (northeast) of the Pit 3 Landfill. Tritium activities in the $Tnbs_1/Tnbs_0$ HSU have declined in all 2014 water samples relative to 2010 measurements. From 2010 to 2014, the extent of tritium in excess of the 20,000 pCi/L cleanup standard in the $Tnbs_1/Tnbs_0$ HSU in the Pit 7 Complex area remained fairly constant; extending approximately 800 ft northeast of Pit 3 and Pit 5. The extent of tritium in $Tnbs_1/Tnbs_0$ HSU ground water with activities in excess of the 100 pCi/L background level remains stable, and is similar to that observed in 2010.

Tritium Summary

As shown on Figure 18 (time-series plot of tritium activities in ground water at selected Pit 7 - Source [PIT7-SRC] extraction and monitor wells immediately downgradient of the Pit 7 Complex, tritium activities in samples from all the wells continue to decline from their 1998-1999 El Nino levels. Although the extent of tritium activities above the cleanup standard remained relatively stable in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs during the review period, tritium activities in both Qal/WBR and $Tnbs_1/Tnbs_0$ HSU wells in Pit 7 Complex have decreased significantly from historic maximum activities, and continued to decrease during the five-year review period.

5.4.2.1.2. Uranium Activities, Distribution, and Remediation

Extraction and treatment was selected as the remedy for depleted uranium in Pit 7 Complex ground water as total uranium activities exceeded the 20 pCi/L MCL cleanup standard. Depleted uranium was previously released to ground water from sources in the Pits 3, 5, and 7 Landfills (Taffet et al., 2008). Uranium activities and distribution in ground water in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs in the Pit 7 Complex Area are discussed below. As is the case for the Building 850 portion of the Building 850/Pit 7 Complex OU, uranium activity analyses for the five-year review period were performed primarily by alpha spectroscopy with selected samples analyzed by ICP-MS.

Qal/WBR HSU

Figure 9 shows a comparison of uranium activities in ground water in the Pit 7 Complex in the Qal/WBR HSU in 2010 and 2014. Uranium activities in Qal/WBR HSU ground water in the Pit 7 Complex area exhibit a similar temporal trend as tritium in that they exhibited peak concentrations following the 1998 El Niño and have steadily decreased since then. For example, monitor well NC7-40 detected an historic maximum of 781 pCi/L in April 1998 and declined sharply to 238 pCi/L in November of that year. Located at the southern end of Pit 5, NC7-40 has exhibited a stable to decreasing trend in uranium activity to less than 100 pCi/L in 2014 and remains highly depleted with an isotopic composition of 0.00237 to 0.00326. Extraction wells NC7-64 and W-PIT7-2703 both located downgradient to Pit 3, exhibit the highest uranium activities among the PIT7-SRC extraction wells, generally in excess of 100 pCi/L but isotopic compositions much closer to natural uranium in the range of 0.0067.

In 2010, uranium activities exceeded the 20 pCi/L cleanup standard in samples from 12 wells in the Qal/WBR HSU. All 12 wells are proximal to the landfills and have historically shown $^{235}U/^{238}U$ isotopic ratios indicating some depleted uranium. In 2010, the maximum uranium activity in the Qal/WBR HSU was 120 pCi/L in former extraction well NC7-63 located adjacent to well NC7-64. Well NC7-63 consistently exhibited elevated uranium activity and a depleted uranium signature until it was discontinued as an extraction well in 2013 due to declining water levels below the screen bottom.

During 2014 uranium activities exceeded the 20 pCi/L cleanup standard in samples from 7 wells in the Qal/WBR HSU. Due to continued declining water levels under drought condition, six wells (W-PIT7-1903, W-PIT7-1904, W-PIT7-1905, W-PIT7-1916, W-PIT7-1917 and W-PIT7-1919) that have consistently yielded ground water with uranium activities exceeding the 20 pCi/L cleanup standard could not be sampled because they had gone dry or did not contain sufficient water for sampling.

In summary, uranium activities exceeding the 20 pCi/L cleanup standard are located proximal to the landfills and have historically shown $^{235}U/^{238}U$ isotopic ratios indicating some depleted uranium fraction. The extent of uranium in excess of the MCL cleanup standard in the Qal/WBR HSU is confined to an area directly east of Pit 3 and another area that extends approximately 500 ft southeast from the center of Pit 5. Despite ground water pumping and treatment during the last five years, the spatial extent of shallow ground water impacted with depleted uranium has been stable since the mid-1990s. Areas of depleted uranium in ground water are bounded by wells that exhibit $^{235}U/^{238}U$ atom ratios indicative of natural uranium. This indicates that the depleted uranium plume is stable within the Qal/WBR HSU ground water. Sorption and ion-exchange processes are likely responsible for retarding the migration of depleted uranium in ground water compared to conservative contaminants such as tritium.

Figure 19 shows a comparison of the extent of uranium in the Qal/WBR HSU in excess of the 20 pCi/L cleanup standard in 2010 and 2014. The figure shows that the extents of the uranium concentrations exceeding the 20 pCi/L cleanup standard are almost the same, with one exception, where well NC7-21 gradually declined to activities below the cleanup standard between 2010 and 2014.

Figure 20a is a time-series plot of uranium activities in ground water at selected wells in the Pit 7 Complex. Figure 20b is a time-series plot of $^{235}U/^{238}U$ atom ratios in ground water at selected wells in the Pit 7 Complex. Figure 20a shows that uranium activities in samples from

Qal/WBR monitor well NC7-51 and Qal/WBR extraction wells W-PIT7-2703 and NC7-64 have remained fairly stable while fluctuating generally within the 50 to 100 pCi/L range since 2002 after they declined from the 1998 El Niño peak levels. During the same period, the $^{235}U/^{238}U$ atom ratios in samples from these wells trended to slightly more natural uranium compositions (Figure 20b). Wells W-PIT7-2305 and W-PIT7-2306, for which data are not shown in Figures 20a or Figure 20b, exhibit fairly stable uranium activities generally at or below the 20 pCi/L cleanup standard and fairly stable, near-natural atom ratios.

$Tnbs_1/Tnbs_0$ HSU

Figure 10 shows a comparison of the uranium activities in ground water in the Pit 7 Complex in the $Tnbs_1/Tnbs_0$ HSU in 2010 and 2014. During 2014, uranium activities in the $Tnbs_1/Tnbs_0$ HSU increased to a historic maximum of 100 pCi/L in the October ground water sample collected from extraction well NC7-25. The previous historic maximum of 51.45 pCi/L (October 1998) was also measured in a sample from well NC7-25. The 2010 maximum activity of 36.5 pCi/L (June) was also detected in a sample from well NC7-25. Well NC7-25 is the only $Tnbs_1/Tnbs_0$ HSU well that historically and currently yields ground water with uranium in excess of the cleanup standard, and all $^{235}U/^{238}U$ atom ratio data, until the October 2014 sample, indicated that the uranium in NC7-25 ground water was natural. The $^{235}U/^{238}U$ atom ratio measured in the October sample was 0.0066, indicating the presence of some depleted uranium. Figures 20a and 20b also show the uranium activity rising to its maximum, after a fairly stable uranium trend, in the most recent sample from well NC7-25 and the accompanying drop in $^{235}U/^{238}U$ atom ratio. After two years of cyclic operation of ground water extraction well NC7-25 (ground water extraction began in August 2012), uranium activities in the extracted ground water have increased significantly and, for the first time, the $^{235}U/^{238}U$ atom ratio data indicate the presence of depleted uranium. The change in isotopic composition and increase in concentration in the recent NC7-25 sample is the result of hydraulic capture of Qal/WBR ground water of largely natural uranium-bearing water with some depleted uranium in the close proximity to this pumping well.

The maximum uranium activity in a 2014 sample from a well screened across the Qal/WBR and $Tnbs_1/Tnbs_0$ contact was 21 pCi/L in the April sample from extraction well W-PIT7-2307. This well is located adjacent to Pit 5. This well was operated as an extraction well in 2010 and 2011 when the decision was made to discontinue pumping since this well contained uranium activity below the cleanup standard (12 pCi/L, October 2010) and exhibited natural uranium isotopic composition (0.007089, October 2010). While shut down, this well has rebounded to the cleanup standard at 20.7 pCi/L and it exhibits a slightly depleted uranium isotopic composition of 0.0067.

Except for the instances discussed above, there are no other wells screened within the $Tnbs_1/Tnbs_0$ HSU that have historically or currently yielded samples with uranium activities in excess of the cleanup standard or $^{235}U/^{238}U$ atom ratios indicative of added depleted uranium.

Uranium Summary

While the extent of uranium activities above the 20 pCi/L cleanup standard remained relatively stable in the Qal/WBR HSU during the five-year review period, uranium activities in the Qal/WBR HSU wells in Pit 7 Complex ground water in 2014 have decreased significantly from historic maximum activities, and continued to decrease during the five-year review period. Uranium activities have decreased from a historic maximum of 781 pCi/L in 1998, to a 2010 maximum of 120 pCi/L, and to a 2014 maximum of 109 pCi/L. Well NC7-25 is the only $Tnbs_1/Tnbs_0$ HSU well in the Pit 7 Complex area that historically and currently yields ground water with uranium in excess of the MCL cleanup standard. Although, locally some wells have exhibited some increase in uranium activity, the isotopic composition has generally changed to a more natural composition.

5.4.2.1.3. Nitrate Concentrations, Distribution, and Remediation

Extraction and treatment was selected as the remedy for nitrate in Pit 7 Complex ground water as nitrate has been detected in Pit 7 Complex ground water at concentrations exceeding the 45 µg/L MCL cleanup standard. During 2014, ground water samples from four wells (Figures 11 and 12) exceeded the 45 mg/L cleanup standard. Two of the wells with nitrate concentrations exceeding the cleanup standard are located near Pits 3 and 5, respectively. The other two are located approximately 1,000 and 1,700 ft northeast of the landfills. During 2010, five wells in the Pit 7 Complex yielded ground water samples containing nitrate in excess of the cleanup standard. From 2010 to 2014, nitrate concentrations for all wells in the Pit 7 Complex generally remained stable.

Qal/WBR HSU

Figure 11 shows a comparison of nitrate concentrations in Qal/WBR HSU ground water in the Pit 7 Complex in 2010 and 2014. Nitrate concentrations in the Qal/WBR HSU have decreased from the historic maximum of 90 mg/L in a sample from well NC7-63 (April 2011) to the 2014 maximum concentration of 45 mg/L (April) in the sample from well NC7-64, located immediately downgradient of Pit 3. This well was the only Pit 7 Complex well screened exclusively in the Qal/WBR HSU that contained nitrate in excess of the cleanup standard in 2014. Well NC7-64 is located 17 ft southwest of well NC7-63 (nearer to Pit 3) and is screened 13 ft deeper. Well NC7-63 was dry during 2014. The 2010 maximum nitrate concentration in Qal/WBR HSU wells in the Pit 7 Complex area was 48 mg/L in the January sample from well NC7-63. This well is located directly downgradient of Pits 3.

$Tnbs_1/Tnbs_0$ HSU

Figure 12 shows a comparison of nitrate concentrations in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 7 Complex in 2010 and 2014. During 2014, nitrate was detected at concentrations at or above the 45 mg/L cleanup standard in samples from $Tnbs_1/Tnbs_0$ HSU wells NC7-47 and W-PIT7-13, both located downgradient and northeast of the Pit 7 Complex area. The 2014 maximum nitrate concentration detected in the Pit 7 Complex area was 66 mg/L in the May sample from well NC7-47. NC7-47 is located approximately 1,500 ft downgradient/northeast of the Pit 7 Complex Landfills. Well NC7-47 is also the location of the historic maximum nitrate concentration detected in the $Tnbs_1/Tnbs_0$ HSU of 85 mg/L (May 2003). The April 2014 sample collected from well W-PIT7-13 contained 55 mg/L. The 2010 maximum $Tnbs_1/Tnbs_0$ HSU nitrate concentration detected in the Pit 7 Complex area was 68 mg/L in a May 2010 sample from well NC7-47. The historic maximum nitrate concentration of 195 mg/L was detected in a September 1993 sample from well K7-01, which is screened in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs.

The maximum nitrate concentration in a 2014 sample from a well screened in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs was 46 mg/L in the April sample from monitor well K7-01. Well K7-01 is located immediately downgradient of Pit 5. The 2010 sample from this well yielded a maximum of 44 mg/L of nitrate.

Nitrate Summary

Historic data indicate that ground water nitrate concentrations in the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs are limited in extent and relatively stable. Nitrate concentrations have decreased from the historic maximum of 195 mg/L in 1993, to a 2010 maximum of 68 mg/L, and to a 2014 maximum of 66 mg/L. The distribution and concentrations of nitrate in ground water during 2014 are generally similar to what was observed in 2010 and in the years between.

5.4.2.1.4. Perchlorate Concentrations, Distribution, and Remediation

Extraction and treatment was selected as the remedy for perchlorate in Pit 7 Complex ground water as perchlorate has been detected in Pit 7 Complex ground water at concentrations exceeding the 6 µg/L MCL cleanup standard.

During 2014, perchlorate was detected in samples from 10 wells, all east and downgradient of the landfills, at concentrations exceeding the cleanup standard. The perchlorate concentrations in ground water samples from several wells containing perchlorate exceeding the 6 µg/L cleanup standard during 2010 were below the cleanup standard in 2014 (NC7-40, NC7-68, W-PIT7-03, and W-PIT7-2141) or were dry or contained insufficient water for sampling (NC7-34 and W-PIT7-2309). Perchlorate concentrations and distribution in ground water in the Qal/WBR and $Tnbs_1$/$Tnbs_0$ HSUs in the Pit 7 Complex Area are discussed below.

Qal/WBR HSU

Figure 13 shows a comparison of the extent of perchlorate in Qal/WBR HSU ground water in the Pit 7 Complex in 2010 and 2014. Perchlorate concentrations in the Qal/WBR HSU ground water in the Pit 7 Complex area have decreased from a historic maximum of 40 µg/L (extraction well W-PIT7-2306, 2009) to a 2014 maximum concentration of 14 µg/L, both in the April sample collected from extraction well W-PIT7-2305, located immediately downgradient of Pit 5 and in the April duplicate sample from monitor well K7-01, located east of the southern end of Pit 5. Well W-PIT7-2306 has not contained sufficient water for sampling since May 2012. Other Qal/WBR HSU wells with samples containing perchlorate at concentrations exceeding the 6 µg/L cleanup standard during 2014 were monitor well NC7-51 and extraction wells NC7-64 and W-PIT7-2703, located immediately downgradient of Pit 3, and monitor well W-PIT7-1918 and extraction wells W-PIT7-2305 and W-PIT7-2705, located immediately downgradient of Pit 5.

The 2010 maximum perchlorate concentration in Qal/WBR ground water was 27 µg/L in a sample from well W-PIT7-2306, located directly downgradient of Pit 3. Twelve other wells completed in the Qal/WBR HSU yielded samples containing perchlorate in excess of the 6 µg/L cleanup standard and defined an area that extended southeast approximately 1,200 ft from the middle of Pit 3. In 2014, perchlorate in the Qal/WBR HSU exceeding the cleanup standard extended approximately 1,100 ft from the middle of Pit 3.

$Tnbs_1$/$Tnbs_0$ HSU

Figure 14 shows a comparison of the extent of perchlorate in $Tnbs_1$/$Tnbs_0$ HSU ground water in the Pit 7 Complex in 2010 and 2014. Perchlorate concentrations in the $Tnbs_1$/$Tnbs_0$ HSU ground water have decreased from the historic maximum of 29 µg/L in a sample from monitor well K7-03 (April 2005) to the 2014 maximum concentration of 10 µg/L, measured in the April sample from extraction well W-PIT7-2307. During 2014, samples collected from monitor well K7-03 and extraction well NC7-25 also contained perchlorate at concentrations exceeding the

6 µg/L cleanup standard. Well NC7-25 is located immediately downgradient of Pit 3, and wells K7-03 and W-PIT7-2307 are located immediately downgradient of Pit 5. During 2010, samples from three $Tnbs_1/Tnbs_0$ HSU wells, K7-03, NC7-25, and NC7-68, contained perchlorate at concentrations in excess of the 6 µg/L cleanup standard and defined an area that extends approximately 1,200 ft southeast along the edges of Pits 3 and 5. The 2010 maximum perchlorate concentration in ground water samples from $Tnbs_1/Tnbs_0$ HSU wells was 11 µg /L in a January sample from well NC7-25 and an April sample from well NC7-68. In 2014, the extent of perchlorate in excess of the cleanup standard remains unchanged from 2010 at approximately 1,200 ft long.

The maximum perchlorate concentration in a 2014 sample from a well screened in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs was 14 µg/L in the April sample from monitor well K7-01. Well K7-01 is located immediately downgradient of Pit 5. The maximum nitrate concentration detected in a sample from this well in 2010 was 12 µg/L.

Perchlorate Summary

Figure 21 is a time-series plot of perchlorate concentrations in ground water at selected wells in the Pit 7 Complex. The plot shows that trends in perchlorate concentrations in samples from the PIT7-SRC extraction wells and two landfill monitoring wells (NC7-51 and NC7-34) are all within the 5 to 15 µg/L range since early 2012 and are all relatively stable or declining slightly.

Perchlorate concentrations have decreased from a historic maximum of 40 µg/L in 2009, to a 2010 maximum of 27 µg/L, and to a 2014 maximum of 14 µg/L. Additionally, the overall footprint of the perchlorate plume downgradient of the PIT7-SRC extraction wellfield has decreased.

5.4.2.1.5. VOC Concentrations, Distribution, and Remediation

The VOC COCs in Pit 7 Complex Area ground water include TCE and 1,1-dichloroethene (DCE).

In 2010, VOCs were detected in ground water samples from seven Pit 7 Complex area wells including one $Tnbs_1/Tnbs_0$ HSU well (K7-03), four Qal/WBR HSU wells, and two wells completed in both HSUs (K7-01 and W-PIT7-2307). The maximum concentrations of VOCs detected in Pit 7 Complex ground water in 2010 included 8.3 µg/L of TCE; exceeding the TCE 5 µg/L cleanup standard, and 3.5 µg/L of 1,1-DCE; below the 1,1-DCE 6 µg/L cleanup standard. This sample was collected in January 2010 from well PIT7-2307, which is screened in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs. By October 2010, the TCE concentration in a sample collected from this well had decreased to the 5 µg/L cleanup standard, and the 1,1-DCE concentration had decreased to 2 µg/L.

VOCs were detected in ground water samples from six Pit 7 Complex area wells during 2014. Individual VOC concentrations were below cleanup standards in the samples from all six wells, and have been so since 2011.

2012 and 2013 were the only years during the review period that a VOC other than TCE or 1,2-DCE was detected in Pit 7 Complex ground water. The December 2012 and October 2013 samples from Qal/WBR HSU well W-PIT7-2703 contained chloroethane at concentrations slightly above the 0.5 µg/L reporting limit. There is no Federal or State MCL cleanup standard for chloroethane.

VOC concentrations and distribution in ground water in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs in the Pit 7 Complex Area are discussed below.

Qal/WBR HSU

TCE concentrations in Qal/WBR HSU ground water in the Pit 7 Complex area have decreased from a historic maximum of 15 µg/L in 1995 (NC7-51) to a 2010 maximum of 5.5 µg/L (W-PIT7-2306) and a 2014 maximum of 0.9 µg/L (NC7-51); below the 5 µg/L TCE cleanup standard. 1,1-DCE concentrations in Qal/WBR HSU ground water decreased from a historic maximum of 11 µg/L in 1985 (well K7-01) to 2.5 µg/L by 2010 (W-PIT7-2306). During 2014, 1,1-DCE was not detected at concentrations above the 0.5 µg/L reporting limit in any samples collected from wells completed in the Qal/WBR HSU. In 2014, chloroform was detected in wells NC7-12 and NC7-21 at concentrations slightly above the 0.5 µg/L reporting limit, but well below the 80 µg/L MCL for total trihalomethanes. In 2014, VOCs were detected in samples from Qal/WBR HSU monitor wells NC7-12, NC7-21 and NC7-51. Well NC7-51 is located immediately downgradient of Pit 3, and wells NC7-12 and NC7-21 are located approximately 1,000 ft and 500 ft southeast (downgradient) of Pit 5, respectively.

$Tnbs_1/Tnbs_0$ HSU

TCE concentrations in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 7 Complex area have decreased from a historic maximum of 11 µg/L in May 1989 (K7-03) to a 2010 maximum of 8.3 µg/L (W-PIT7-2307) and a 2014 maximum of 4.4 µg/L (W-PIT7-2307); below the 5 µg/L TCE cleanup standard. 1,1-DCE concentrations in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 7 Complex area have decreased from a historic maximum of 4.5 µg/L in February 1986 (K7-03) to a 2010 maximum of 3.5 µg/L (W-PIT7-2307) and a 2014 maximum of 1.4 µg/L (W-PIT7-2307); below the 6 µg/L TCE cleanup standard.

During 2014, VOCs were detected in samples from monitor well K7-03 and extraction well W-PIT7-2307, both located immediately downgradient of Pit 5. During 2014, the ground water level in extraction well W-PIT7-2307 remained below the Qal/WBR contact and entirely in the $Tnbs_1/Tnbs_0$ HSU. Well W-PIT7-2307 was the only well with samples in the Pit 7 Complex area that contained concentrations of 1,1-DCE above the 0.5 µg/L reporting limit during 2014. Well K7-03 contained only TCE at a concentration of 0.68 µg/L (April). Monitor well K7-01, which is representative of both HSUs, yielded TCE at concentrations of 0.9 µg/L in the April 2014 sample.

VOC Summary

TCE and 1,1-DCE are the only VOCs historically detected in Pit 7 Complex ground water at concentrations above cleanup standards. Concentrations of TCE and 1,1-DCE have decreased from their historic maximum of 15 µg/L (1995) and 11 µg/L (1985), respectively, to below their 5 µg/L and 6 µg/L cleanup standards in 2014. The data indicate that the extent of VOCs in ground water is limited to the area directly downgradient of Pit 5.

5.4.2.2. Contaminant Remediation and Mass Removal

The performance of and contaminant mass removal by the PIT7-SRC ground water treatment system (GWTS) during the five-year review period are discussed below. During 2014, it was discovered that some extraction wells in the PIT7-SRC area with low-flow cyclic pumps had experienced failures of the check valves built into the pump, resulting in some flow of extracted water back into the well and consequently, an overestimation of flow volume and mass removal in affected wells. This resulted from some volumes of ground water being counted multiple times by the individual well flow totalizers. The discrepancy in flow volume was discovered by comparing the sum of the individual extraction well flow totals to treatment facility influent totalizer volumes. The faulty check valve problem was corrected resulting in a significant decrease in overall extracted flow volumes from all the wells. Please note that the total monthly flow volumes have been corrected back in time to the startup of PIT7-SRC extraction well operations in 2010. This correction is based on the percent difference in monthly individual flow totalizer data to the treatment facility influent totalizer volumes applied to the operating extraction wells. The mass removal results represent the best estimate of the revised flow totals and corresponding COC masses removed. As a result of the flow corrections, the total flow volume treated at PIT7-SRC GWTS since operations began in 2010 decreased from 315,000 gallons using uncorrected flow data to 172,600 gallons using corrected flow data. The discussion below is based on corrected flow data.

Ground water extraction and treatment at the PIT7-SRC GWTS began in March 2010 to: (1) remove uranium, perchlorate, nitrate, and VOCs from ground water immediately downgradient of the landfill source areas, and (2) minimize any plume migration from the source area. Coupled with the source isolation provided by the Drainage Diversion System, designed to divert recharge away from COC sources in the landfills and vadose zone beneath the landfills and prevent any new releases, operation of PIT7-SRC GWTS was intended to remediate pre-existing contamination in ground water. The PIT7-SRC GWTS does not treat tritium in ground water, as there is no cost-effective and efficient method available for the scale of the Pit 7 Complex. The system is designed to remove the other COCs (uranium, perchlorate, nitrate, and VOCs) from the tritium-bearing ground water and inject the treated tritium-bearing effluent into an infiltration trench in the vadose zone overlying the Qal/WBR downgradient of the PIT7-SRC GWTS. To date, this has been done without any significant local tritium increases in ground water in the vicinity of the infiltration trench.

When pumping was initiated in 2010, there were two PIT7-SRC extraction wells that contributed the vast majority (~95%) of ground water for treatment: W-PIT7-2305 and W-PIT7-2307. For example, during 2010, extraction well W-PIT7-2307 contributed over 78% of the volume of ground water to the treatment facility under cyclic pumping with an average long-term rate of <0.1 to 0.14 gallons per minute (gpm). During that same period of time, extraction well W-PIT7-2305 contributed the second-highest volume of water to the facility (over 17%) with a long-term average rate of approximately 0.1 gpm. Ground water extraction from wells NC7-63, NC7-64, and W-PIT7-2306 are significantly limited due to limited recharge under ongoing drought conditions. Ground water extraction from well NC7-63 was discontinued during 2012 due to insufficient water, and this well was converted to a monitor well in 2013. From September 2012 through December 2014, wells W-PIT7-2306 and W-PIT7-2704 also contained insufficient water to sustain even cyclic pumping. However, these wells will continue to be used as extraction wells whenever there is sufficient ground water to pump.

Ground water elevation hydrographs for PIT7-SRC extraction wells are presented and discussed in Appendix C. The hydrographs generally show stable ground water elevations for actively pumping wells, and periods where the water elevations dropped below the pump intake or screen bottom for wells located in portions of the flow system with insufficient water for extraction.

In 2011, an assessment of ground water elevation and COC trends in well W-PIT7-2307, which is completed across the Qal/WBR and $Tnbs_1/Tnbs_0$ HSU contact, indicated that extracted ground water was primarily derived from the $Tnbs_1/Tnbs_0$ bedrock HSU. Additionally, in 2011 well W-PIT7-2307 exhibited uranium activities below the 20 pCi/L cleanup standard and natural isotopic composition. At that time, the decision was made to discontinue pumping this well to eliminate a downward hydraulic gradient that could result in the migration of shallow contaminants into the deeper $Tnbs_1/Tnbs_0$ HSU. Although ground water elevations rebounded after pumping ceased in December 2011, they remained below the Qal/WBR HSU contact. While this well was shut down, the uranium activity rebounded to 20.7 pCi/L and exhibited a slight decrease in isotopic composition to 0.0067. In early February 2013, the pump intake for extraction well W-PIT7-2307 was raised to the base of the Qal/WBR HSU contact and pumping was resumed. Approximately 200 gallons of water were extracted and treated during February and March of 2013 before water levels dropped below the pump intake and have remained below the pump intake. Depending on future water levels and trends in uranium concentration, this well may again be re-activated as an extraction well.

In the second semester of 2012 the PIT7-SRC extraction wellfield was expanded with the addition of three wells: W-PIT7-2703, W-PIT7-2704 and W-PIT7-2705. This wellfield expansion targeted uranium in shallow ground water that exceeded the 20 pCi/L cleanup standard and contained a depleted isotopic composition. However, following this wellfield expansion, overall ground water flow did not increase significantly above pre-expansion levels of up to 3,000 gallons per month, with the majority of the flow coming from extraction well W-PIT7-2305, and two of the 2012 expansion wells, W-PIT7-2703 and W-PIT7-2705. To date, cyclic extraction from expansion well W-PIT7-2703 is contributing 100 to 250 gallons per month and expansion well W-PIT7-2705 is contributing <100 to 600 gallons per month depending on seasonal rainfall. Expansion well W-PIT7-2704 produced about 50 gallons initially and then went dry and has remained dry. In addition to the two 2012 expansion wells, extraction well W-PIT7-2305 continues to provide a significant amount of flow to the PIT7-SRC GWTS; up to 2,400 gallons per month until mid-2014 when it decreased to less than 1,000 gallons per month. This decrease may have been due to the installation of a second check valve, a drop in water levels as a result of continued drought conditions, or both. DOE/LLNL will continue to evaluate the cause of the decreased flow from well W-PIT7-2305. Concentrations of COCs in W-PIT7-2305 ground water have fluctuated since pumping started in 2010, but have shown mainly decreasing trends from pre-pumping conditions to present. Contaminant mass removal at PIT7-SRC GWTS is dominated by the COC trends of these three extraction wells, as summarized here:

- All three extraction wells continue to extract fairly low but stable concentrations of perchlorate in ground water that exceed the 6 µg/L California MCL cleanup standard ranging from 10 to 13 µg/L.
- W-PIT7-2703 and W-PIT7-2705 extract ground water containing uranium that exceeds the 20 pCi/L cleanup standard at 98 pCi/L and 28 pCi/L respectively, however, uranium concentrations in extraction well W-PIT7-2305 are below the cleanup standard at 13 pCi/L.
- Although W-PIT7-2705 is the only extraction well that exhibits a uranium isotopic composition that is significantly depleted at 0.004367, the trend since 2011 has been

toward a more natural composition. W-PIT7-2305 and W-PIT7-2703 exhibit nearly natural isotopic compositions of 0.007152 and 0.006689, respectively.

- VOC concentrations in all three wells have been below analytical reporting limits since 2011.

Also in 2012, extraction from NC7-25, screened in the $Tnbs_1/Tnbs_0$ bedrock HSU, was initiated to increase uranium mass removal. The decision to pump this well was made on the basis that water levels in the adjacent Qal/WBR HSU had declined sufficiently to minimize migration of depleted uranium-bearing ground water from that HSU into this $Tnbs_1/Tnbs_0$ bedrock extraction well. Under cyclic extraction operations, this well initially produced 100 to 150 gallons per month but this flow decreased to below 100 gallons per month in 2014. Until 2014, the uranium in this well exhibited a stable natural $^{235}U/^{238}U$ atom ratio and a uranium activity that exceeded the uranium cleanup standard. After two years of ground water extraction, the October 2014 ground water sample yielded a total uranium activity of 100 pCi/L, a significant increase and historic maximum for this well, with a $^{235}U/^{238}U$ ratio of 0.0066, indicating the presence of some depleted uranium for the first time in a sample from this well. Although the overall volume of ground water extracted from NC7-25 is limited (<160 gallons/month), the uranium concentration and isotopic composition in this well is indicative of the close proximity of the depleted uranium impacted ground water to the underlying Neroly bedrock ground water.

In summary, the COC mass removal performance of the PIT7-SRC extraction wellfield is dominated by three wells: W-PIT7-2305, W-PIT7-2703 and W-PIT7-2705. Prior to the extraction wellfield expansion in 2012, the flow was dominated by W-PIT7-2307 and W-PIT7-2305. However, due to the lack of COC concentrations above cleanup standards in W-PIT7-2307, pumping from this well below the Qal/WBR contact was discontinued in 2011. In the future, if water levels rise above this contact and COCs are present exceeding cleanup standards, pumping from this well will be resumed. To date, about 7.7 grams of perchlorate, 21 grams of uranium and 2.5 grams of VOC mass (mainly TCE) have been removed from a total of 172,600 gallons of treated ground water during five years of operation. Although the maximum COC concentrations have generally declined during this period of ground water remediation, the overall spatial extent of uranium, nitrate, and perchlorate has not changed significantly. However, during the five-year period, concentrations of individual VOC COCs have dropped below cleanup standards. All three wells extract perchlorate at stable concentrations above the 6 µg/L cleanup standard and two of the wells currently extract ground water containing uranium above the cleanup standard (W-PIT7-2703 and W-PIT7-2705). Although the uranium trend in W-PIT7-2705 exhibits a decreasing trend toward the 20 pCi/L cleanup standard, W-PIT7-2703 has exhibited an increasing trend from 66 to 98 pCi/L over the period of ground water remediation. Of the three wells, only W-PIT7-2705 contains ground water with a significant depleted uranium isotopic composition at 0.004367. However, since pumping began from W-PIT7-2705 in 2012, the trend in $^{235}U/^{238}U$ atom ratio has become more natural in composition. Although W-PIT7-2703 exhibits an increasing uranium trend, the $^{235}U/^{238}U$ atom ratio is near natural, indicating primarily natural uranium in the ground water. Therefore, the overall trend in uranium composition in the extracted ground water has become more natural in isotopic composition and the perchlorate trend has remained somewhat stable at low concentrations just above the 6 µg/L cleanup standard.

The overall performance of the PIT7-SRC extraction wellfield since 2010, especially in perchlorate and uranium remediation, can be partially assessed by COC trends in monitor well NC7-51. Monitor well NC7-51 is located down gradient of Pit 3 in an area of elevated perchlorate and uranium and adjacent to 2012 expansion well W-PIT7-2703. During the period 2010 to 2015, perchlorate concentrations in monitor well NC7-51 have declined by over 50% from 15 to 6.6 µg/L and total uranium has slightly decreased from 95 to 85 pCi/L and has become more natural in isotopic composition increasing from 0.0046 to 0.0053. Under declining water levels and continued drought conditions, overall flow and mass removal have significantly declined. Nonetheless, the COC trends in NC7-51 suggest that the highest COC concentrations are being hydraulically captured by the extraction well field.

5.4.2.3. Capture Zone Analysis

Estimating hydraulic capture for the PIT7-SRC extraction wells is difficult due to the low sustainable yield, limited recharge (especially during the past five years), and cyclic pumping. Even with closely-spaced (<50 feet apart) wells outfitted with pressure transducers, the direct hydraulic influence of cyclic pumping on a nearby monitor well has not been observed.

The combined long-term flow rate from the entire extraction well field is less than 2,000 gallons per month (less than 0.05 gpm). In fact, these extraction wells are routinely shut down several days prior to scheduled sampling events to ensure that sufficient water is available to satisfy the ground water sampling requirements. In spite of these conditions, hydraulic influence from cyclic pumping has been observed in the vicinity of wells W-PIT7-2305 and W-PIT7-2705, the two wells providing the majority of the flow from the extraction wellfield. For example, a rapid ground water elevation response of up to 0.7 feet has been observed in monitor well W-PIT7-1918, located 52 feet and 22 feet from extraction wells W-PIT7-2305 and W-PIT7-2705, respectively. The magnitude and rapid timing of this response to pumping indicates that there is some measureable hydraulic connection between these wells.

Given the current low rainfall conditions, the best indicators of hydraulic capture are the COC trends in extraction wells, and more importantly, the COC trends observed in downgradient performance monitoring wells. COC maps and time-series plots of uranium activities and perchlorate concentrations (Figures 20a and 21, respectively) indicate that the extraction wells are removing dissolved COC mass from areas of the highest activities/concentrations (Figures 7 through 14 and 19) in the shallow ground water adjacent to the Pit 3 and Pit 5 source areas. As shown in Figure 20b, uranium isotopic composition in PIT7-SRC area performance monitor wells exhibit a trend toward a more natural composition, suggesting that anthropogenic depleted uranium is adequately captured by the extraction wellfield.

It should also be pointed out that extraction well NC7-25 was activated in 2012 to increase uranium mass removal. After nearly two years of operation, recent analytical results indicate a significant increase in uranium activity and a slight shift in isotopic composition toward a more depleted signature (Figures 20a and 20b, respectively). Prior to the initiation of ground water extraction from NC7-25, the ground water extracted from this well contained only natural uranium. The shift in uranium isotopic composition indicates hydraulic capture of depleted uranium in the shallow ground water in close proximity to this well. To date, all ground water monitoring wells downgradient of NC7-25 continue to exhibit uranium activities that remain significantly below the MCL cleanup standard and isotopic composition indicative of only natural uranium.

The most diagnostic performance monitor wells at PIT7-SRC are NC7-51 and W-PIT7-1918. NC7-51 is located downgradient of the Pit 3 source area and within the area of highest COC concentrations. The long-term uranium trends in this well are indicative of hydraulic capture and extraction wellfield performance from extraction wells NC7-64 and W-PIT7-2703. Although the uranium activity in NC7-51 has remained relatively stable during the period of operation of the PIT7-SRC wellfield, it has declined significantly from the maximum uranium activity observed following the 1998 El Niño. However, during the extraction wellfield operation period, the isotopic composition in this well has exhibited a trend toward more natural composition indicating hydraulic capture and removal of anthropogenic depleted uranium. Additionally, the perchlorate concentrations in NC7-51 exhibit a declining trend indicating hydraulic capture and removal of perchlorate by the upgradient extraction wells. Although perchlorate trends in performance monitoring well W-PIT7-1918 have not significantly decreased during the period of wellfield operation, this well exhibits similar uranium trends to NC7-51 (Figure 19). The COC trends in W-PIT7-1918, located downgradient from the Pit 5 source area, are due to extraction and hydraulic capture from nearby extraction wells W-PIT7-2705 and W-PIT7-2305.

Given the hydraulic properties of the Qal/WBR HSU materials in the PIT7-SRC area and the existing rainfall conditions, the PIT7-SRC extraction wellfield is capturing and removing COC mass from the areas of highest concentrations in the ground water as well as can reasonably be expected.

5.4.2.4. Pit 7 Complex Landfill Detection Monitoring and Results

Detection monitoring of the Pit 7 Complex Landfills is conducted to identify any future releases to ground water in accordance with the requirements of the Site 300 Compliance Monitoring Plan/Contingency Plan. As part of the detection monitoring program for the Pit 7 Complex Landfills, ground water samples are collected from eight monitor wells located upgradient and downgradient of the landfill and analyzed for potential constituents of concern. Wells K7-01, K7-03, K7-06, K7-09, K7-10, NC7-26, NC7-47 and NC7-48 comprise the current detection monitoring well network for the Pit 7 Complex.

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 7 Complex Landfills include VOCs, nitrate, perchlorate, tritium, HE compounds, uranium isotopes, Title 26 metals, lithium, fluoride, and PCBs.

Tritium was detected above the reporting limit in three detection monitor wells during the five-year review period: wells K7-03, K7-01, and NC7-26. Of these wells, the highest tritium activities are currently detected in well K7-03 with an October 2014 activity of 69,300 pCi/L. Tritium activities in this well have decreased from a historic maximum of 216,000 pCi/L in 1993 and from 82,000 pCi/L in 2010. Tritium activities in well K7-01 have decreased from the historic maximum of 72,900 pCi/L in 1999 to 47,200 pCi/L in 2010 and 28,000 pCi/L in October 2014. Tritium activities in well NC7-26 have decreased from its historical maximum of 30,000 pCi/L in 1999 to 2,600 pCi/L and 1,790 pCi/L in October 2014. Data collected during the five-year review period do not indicate any new releases of tritium from the Pit 7 Complex landfills.

Uranium activities were below the 20 pCi/L cleanup standard in all detection monitor wells during the five-year review period. The highest uranium activities in the Pit 7 Complex detection monitor wells are currently detected in well K7-01 with a 2014 activity of 15 pCi/L. Uranium activities in this well have decreased from a historic maximum of 27 pCi/L in 1984 to 19 pCi/L in 2010. The highest historic uranium activities of 105 pCi/L were detected in well NC7-28 immediately following the 1997-1998 El Niño event. Uranium activities in this well have continued to decrease from the historic maximum to 13.3 pCi/L in 2010 and 5.1 pCi/L in 2014. Data collected during the five-year review period do not indicate any new releases of uranium from the Pit 7 Complex landfills.

Nitrate has been historically detected at concentrations above the 45 mg/L cleanup standard in two detection monitor wells: NC7-47 and K7-01. Nitrate concentrations in well NC7-47 have historically been relatively stable, but consistently above the cleanup standard since monitoring of this well began in 1994. During the five-year review period, nitrate concentrations in this well ranged from 64 mg/L to 68 mg/L. NC7-47 is located far downgradient from the Pit 7 Landfill Complex and no other COCs have been detected in this well. Nitrate concentrations in well K7-01 exceeded the cleanup standard in June 2013 (46 mg/L) and April 2014 (46 mg/L). However, concentrations in duplicates for both these samples were below cleanup standards (41 mg/L in June 2013 and 38 mg/L in April 2014). Nitrate concentrations in the other six detection monitor wells are and have been below the cleanup standard and within the range of background concentrations. Data collected during the five-year review period do not indicate any new releases of nitrate from the Pit 7 Complex landfills.

Perchlorate was detected in only two detection monitor wells (K7-01 and K7-03) during the five-year review period. Perchlorate concentrations in samples from these wells have decreased from the historic maximum of 25 µg/L at well K7-01 (July 2006) and 29 µg/L at well K7-03 (April 2005) to 14 µg/L and 9 µg/L of perchlorate in 2014, respectively. Data collected from 2010 to 2014 do not indicate any new releases of perchlorate from any of the landfills.

VOCs (consisting entirely of TCE) were detected in only two detection monitor wells (K7-01 and K7-03) during the five-year review period. TCE concentrations in wells K7-01 and K7-03 have decreased from a historic maximum of 20 µg/L and 15.2 µg/L in 1985 to 0.9 µg/L and 0.68 µg/L in 2014, respectively. Data collected during the five-year review period do not indicate any new releases of VOCs from any of the landfills.

HE compounds, Title 26 metals, lithium, fluoride, and PCBs were not detected in any of the Pit 7 Complex landfill detection monitoring wells at concentrations above their reporting limits during the five-year review period.

In summary, no new contaminant releases have been identified from the Pit 7 Complex Landfill during the five-year review period.

5.4.2.5. Pit 7 Complex Performance Issues

The performance and any associated issues for the MNA of tritium in Pit 7 Complex ground water, the extraction and treatment of VOCs, uranium, perchlorate, and nitrate in ground water, and source control by the engineered drainage diversion system are discussed in Section 5.4.2.4.1 through 5.4.2.4.3.

5.4.2.5.1. MNA of Tritium in Ground Water

There were no issues that affect the performance of the MNA cleanup remedy for tritium in the Pit 7 Complex area during this five-year review period. The remedy for tritium continues to be effective and protective of human health and the environment, and to make progress toward meeting cleanup standards.

5.4.2.5.2. PIT7-SRC Treatment Facility and Extraction Wellfield

The extraction and treatment of VOCs, uranium, perchlorate, and nitrate continue to reduce the concentrations and masses of these contaminants in Pit 7 Complex ground water. It must be noted that this reduction in concentrations and masses of COCs in ground water is quite minimal, especially compared to those of other treatment facilities at Site 300. Continued operation of the PIT7-SRC GWTS and wellfield expansion in 2012 (extraction from four additional wells) have increased the volume of extracted ground water and mass removed, but not as much as previously reported. As mentioned above, during 2014, it was discovered that the check valves in the PIT7-SRC cyclic extraction wells were not functioning properly. These check valves allowed extracted ground water to back-flow into the same well during non-pumping periods. This has resulted in some amount of over-estimates due to "double counting" of extracted ground water volumes and, therefore, over-estimates of total contaminant mass removal. The corrected volume and mass removal estimates for the PIT7-SRC GWTS are presented for the first time in this report. The corrected volumes had the greatest impact on the perchlorate and uranium mass removal estimates, in that both decreased by about 50%. For example, the uncorrected uranium mass removed decreased from 47 to 21 grams and the perchlorate decreased from 15 to 7.7 grams. There was no impact to the VOC mass removal because nearly all the VOCs had been removed prior to the onset of check valve malfunction. Revised volume and contaminant mass removal estimates will also be updated in the 2015 Annual Compliance Monitoring Report.

During 2014, tritium activities in treated effluent from PIT7-SRC GWTS were in the range of 35,800 pCi/L to 53,900 pCi/L. Tritium activities in performance monitor wells K7-01 (2014 maximum of 32,700 pCi/L), NC7-16 (contained insufficient water for sampling in the first semester 2014) and NC7-21 (2014 maximum of 34,000 pCi/L), located near the effluent discharge trench are lower than the treated effluent activities and continue to exhibit decreasing tritium trends. The tritium activities in these wells will continue to be closely monitored to assess any negative impacts to the distribution of tritium in ground water.

The performance summary of the PIT7-SRC ground water extraction and treatment system indicates that:

- Progress has been made in reducing COC concentrations towards cleanup standards. Uranium activities to date have remained relatively stable, and those in excess of the cleanup standard are limited in extent. Individual VOC concentrations have dropped below their cleanup standards. Perchlorate concentrations are stable to decreasing. Nitrate concentrations and distribution have decreased from historic maxima.

- The extent of uranium in excess of the cleanup standard in the Qal/WBR HSU continues to be confined to an area immediately east of Pit 3 and another area that extends from Pit 5 southeast approximately 500 ft. The extent of uranium in both these regions have remained stable and similar to what has been observed over the last few years. The most recent sample results from extraction well W-PIT7-2704, completed at the northeast corner of Pit 5, indicate that the uranium in Qal/WBR HSU ground water in excess of the cleanup level is less extensive than previously depicted.
- Generally, tritium activities in wells downgradient of the infiltration trench are stable or decreasing, indicating that the discharge of tritium-bearing water is not adversely impacting downgradient ground water. Specifically, tritium activities in water samples collected from wells NC7-16 and NC7-21, located immediately downgradient of the infiltration trench in the Qal/WBR HSU, have decreased from 2010 maxima of 42,700 and 64,700 pCi/L respectively to the most recent five-year review period maxima of 20,700 and 32,800 pCi/L, respectively. The most recent sample from NC7-16 was collected on July 10, 2013; the well subsequently went dry. The most recent sample from well NC7-21 was collected on October 14, 2014.
- The extraction and treatment of ground water by the PIT7-SRC GWTS captures minimal volumes of ground water and cannot sustain reasonable pumping rates from any of the extraction wells. This is due to the low permeability and limited saturation in the HSUs. This in turn results in minimal masses of COCs being removed from ground water. Based on previous experience, installation of additional wells will likely not significantly improve this situation because: (1) water available to extract is limited, (2) permeability is limited, and (3) areas of elevated COC mass in ground water are limited. It is not clear if the current trends and distribution of COCs in local ground water have been appreciably affected by operation of the PIT7-SRC GWTS, or will be noticeably affected by its continued operation.

5.4.2.5.3. Landfill Cap and Cover Performance

During the five-year review period, LLNS Maintenance and Utilities Services Department staff annually inspected the Pit 7 Complex landfills 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 removed vegetative debris and sediment from the landfill surface water drainages, sealed joints between concrete sections of the surface water drainages, and filled animal burrows. Otherwise, no significant issues (including subsidence) were reported during annual inspections of the landfill surface.

5.4.2.5.4. Drainage Diversion System Performance

As discussed in the Remedial Design (RD) for the Pit 7 Complex (Taffet et al., 2008), the drainage diversion system was designed to divert excess surface water runoff and shallow subsurface recharge from the hillslopes to the west and east of the Pit 7 Complex landfills during high intensity storms and periods of extreme rainfall (i.e., the 1997-1998 El Niño) to minimize ground water rises into the pit waste and underlying contaminated bedrock. Thus, the drainage diversion system performance can best be evaluated during a future El Niño season or other period of extended intense rainfall (e.g., several continuous days with >1 inch of daily rainfall).

Criteria specified in the Pit 7 Complex Remedial Design that would indicate that the drainage diversion system is not operating as intended and corresponding recent performance evaluations are presented below.

Criterion 1: Ground water elevation responses to rainfall events observed in key monitoring wells are similar to those observed before the installation of the drainage diversion system would indicate the drainage diversion system is not performing as designed.

Evaluation:

- Drainage diversion system performance is evaluated by 22 monitor wells outfitted in April 2010 with dedicated pressure transducers that measure ground water elevations.
- Review of these data indicates that ground water elevation responses to rainfall are less than those observed prior to drainage diversion system installation in one of the key performance monitor wells, NC7-17, located downgradient of the drainage diversion system at the south end of Pit 7. For example, in 2005, prior to installation of the drainage diversion system, ground water elevation in well NC7-17 increased 5 inches per inch of rain received. In 2011, after installation of the drainage diversion system, ground water elevation increased less than 4 inches per inch of rain received for the same time period during the water year. These data indicate a 20% reduction in ground water elevation response to rainfall in well NC7-17 after installation of the drainage diversion system. Total precipitation received during water years 2004-2005 and 2010-2011 was greater than average and almost identical at 13.7 inches and 13.5 inches, respectively. Precipitation received during rainfall years 2011-2012, 2012-2013, and 2013-2014 was below average and therefore, water elevation response evaluations have not been performed for these time periods.

Criterion 2: Maximum ground water rises into the pit waste and underlying contaminated bedrock as indicated by ground water elevation data would indicate the drainage diversion system is not performing as designed.

Evaluation:

- Ground water levels have remained generally at least 10 ft the bottoms of the Pit 7 Complex Landfills. Ground water elevations in the Qal/WBR HSU have decreased since spring 2011 due to below average rainfall (average is approximately 10.2 inches for Site 300) received during rainfall years 2011-2012 (approximately 7 inches), 2012-2013 (approximately 8 inches), and 2013-2014 (approximately 5 inches). During 2013, the ground water elevation in NC7-17 increased about 4 inches per inch of rain during that water year. Ground water elevation hydrographs for selected drainage diversion system performance monitoring wells are presented and discussed in Appendix C.

Criterion 3: Increasing trends in tritium, uranium, VOCs or perchlorate activities/concentrations are observed over a period of at least four quarters in ground water samples from key wells downgradient of the landfills would indicate the drainage diversion system is not performing as designed.

Evaluation:

- COC trends in Pit 7 Complex ground water are generally decreasing:
  - Tritium activities decreased from a historic maximum of 2,660,000 pCi/L in 1998 to a 2010 maximum tritium activity of 255,000 pCi/L, and to a 2014 maximum tritium activity of 182,000 pCi/L.
  - Uranium activities have decreased from a historic maximum of 781 pCi/L in 1998, to a 2010 maximum of 120 pCi/L, and to a 2014 maximum of 109 pCi/L. Although, locally some wells have exhibited some increase in uranium activity, the isotopic composition has generally changed to a more natural composition. As noted above, the one exception to this is NC7-25 where the October 2014 sample indicated an increase in uranium activity and a corresponding shift toward a more depleted isotopic composition.
  - Nitrate concentrations have decreased from the historic maximum of 195 mg/L in 1993, to a 2010 maximum of 68 mg/L, and to a 2014 maximum of 66 mg/L.
  - Perchlorate concentrations have decreased from a historic maximum of 40 µg/L in 2009, to a 2010 maximum of 27 µg/L, and to a 2014 maximum of 14 µg/L. Additionally, the overall footprint of the perchlorate plume downgradient of the PIT7-SRC extraction wellfield has decreased.
  - Total VOC concentrations have decreased from a historic maximum of 21.2 µg/L in 1995, to a 2010 maximum of 11.8 µg/L, and to a 2014 maximum of 5.8 µg/L, with concentrations of all VOC COCs below cleanup standards.

Based on the evaluation of ground water elevation and contaminant activity/concentration data collected from Pit 7 Complex area wells against the performance criteria, the drainage diversion system appears to be operating as intended. However, it is important to note that the drainage diversion system is designed to divert recharge during peak events and has not yet been tested under the above-average annual rainfall conditions for which it was designed.

5.4.2.6. Pit 7 Complex Risk Mitigation Progress

This section summarizes the progress of the remedy in mitigating risk associated with contaminants in the Pit 7 Complex area. These risks were summarized in Section 3.5.2 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 Pit 7 Complex and the status/progress of the remedy in mitigating those risks and hazards are as follows:

- Pit 3 Landfill - A cumulative cancer risk of 1×10^{-3} was estimated for onsite workers, inhaling tritium vapors volatilizing from the subsurface soil in the vicinity of the Pit 3 Landfill and migrating into outdoor air over a 25-year period. As discussed in Section 3.5.2.2, the tritium inhalation risk for onsite workers was recalculated in 2007, accounting for tritium decay that occurred between 1992 and 2007. An excess cancer risk of 8×10^{-7} was estimated for a worker spending 8 hours a day, 5 days a week for 25 years at the Pit 3 Landfill. Therefore, there is no longer an unacceptable risk to onsite worker health posed by tritium evaporating from subsurface soil in the vicinity of the Pit 3 Landfill.

- Pit 5 Landfill - A Hazard Indices greater than 1 associated with uranium in subsurface soil in the Pit 5 Landfill was estimated for burrowing vertebrate species. To mitigate the ecological hazard posed by uranium within the Pit 5 Landfill, the 2009 Compliance Monitoring Plan/Contingency Plan (Dibley et al., 2009b) requires the integrity of the Pit 7 Complex landfill covers/cap be maintained to prevent exposure to burrowing animals to uranium buried within Pit 5. The annual compliance monitoring reports discuss the results of all inspections and maintenance of the landfill covers/cap.

5.5. Interviews and Site Inspection

DOE/NNSA and LLNL meet approximately 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. LLNL routinely inspects the Building 850 CAMU, and the Pit 7 Complex landfill covers/cap and associated drainage ways and drainage diversion system components to identify any damage or blockage of the drainage systems that could impact the integrity or impair the operation of these remedy components. The LLNS treatment facility operator regularly inspects the Pit 7 Complex ground water extraction and treatment system to identify system components needing repair or replacement to ensure the effective and compliant operation of the system. Additional details of routine inspections of remedy components are discussed in Section 4.4.

LLNL conducts self-assessment inspections and DOE/NNSA conducts inspections of remediation activities at Site 300. The RWQCB Remedial Project Manager (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 July 12, 2010, and the Remedial Action Completion Report for the Building 850/Pit 7 OU was finalized in September 2011. The Five-Year Review Inspection was performed by DOE/NNSA and LLNS on March 24, 2015. The Five-Year Review Inspection Photographs and Checklists for Building 850 and the Pit 7 Complex are included as Appendices A1/A2 and A3/A4, respectively.

Operational issues and resulting corrective actions identified during routine inspections associated with the Building 850 CAMU; the Pit 7 Complex landfills, drainage diversion system, and ground water treatment system; and the OU 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.

6. 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.

6.1. 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, except when extra costs were incurred to address unanticipated problems, work scope, or regulatory requests.
- The remedies for Building 850/Pit 7 Complex OU are functioning as intended by reducing COC concentrations/activities towards cleanup standards, preventing further contaminant releases through source control, and mitigating risk to human health and ecological receptors.
- MNA has been effective in reducing tritium activities in Building 850 and Pit 7 Complex ground water towards the cleanup standard.
- At Building 850, uranium activities in ground water are only sporadically detected above the cleanup standard in one well and the extent of nitrate with concentrations exceeding its cleanup standard are limited to three wells. Ground water monitoring of these constituents will provide an early indication of changes in the concentrations/activities and/or extent of these constituents that could impact human health or the environment.
- The Building 850 CAMU is performing as designed to isolate soil containing PCBs, dioxins, and furans, thereby mitigating risk to onsite workers and ecological receptors, and its integrity has been maintained through the inspection and maintenance program, and institutional controls.
- The ground water extraction and treatment system at the Pit 7 Complex are performing as designed and will continue to be operated and maintained to reduce the concentrations of VOCs, uranium, nitrate and perchlorate in ground water. While DOE/LLNL continue to evaluate opportunities to optimize the efficiency and effectiveness of the ground water extraction and treatment system to improve operations and expedite cleanup, optimization of the PIT7-SRC GWTS is limited by the hydraulic characteristics of the HSUs and the availability of water to treat. There may be little-to-no optimization worth the returns on investment that could be achieved. For example, the existing extraction wells are already operating at maximum flow rates, and the installation of additional extraction wells will likely not appreciably increase volume or mass of contaminants removed.
- The Pit 7 Complex landfill covers/cap are performing as designed, their integrity has been maintained through the inspection and maintenance programs, and no new releases from the landfills have been detected by the detection monitoring program. Exposure to pit waste is prevented through institutional/land use controls that prohibits excavating or otherwise disturbing the landfill covers/cap.
- The Engineered Hydraulic Drainage Diversion System is performing as designed to prevent further contaminant releases from the Pit 7 Complex landfills, and its integrity

has been maintained through the inspection and maintenance programs, and institutional controls.

- No early indicators of potential interim remedy failure were identified.
- 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.

Overall, analytical data indicate that the remedial action objectives of the remedies in the Building 850/Pit 7 Complex OU will be met including: (1) ongoing MNA of tritium and monitoring of other COCs in ground water emanating from Building 850 to ensure that concentrations and extents are stable-to-decreasing, (2) continued mitigation of the risk from PCBs in soil at Building 850 by inspecting and maintaining the CAMU, (3) ongoing removal of contaminant mass in ground water from immediately downgradient of the Pit 7 Complex source area, (4) continued inspection and maintenance of the Pit 7 Complex drainage diversion system to ensure it maintains effectiveness in preventing ground water from entering COC vadose zone sources, and (5) preventing further migration of ground water contaminants in the $Tnbs_1/Tnsbs_0$ HSU.

Despite success in all other intended goals, continuing optimization efforts would have questionable impact in improving the performance of the PIT7-SRC extraction wellfield, in increasing hydraulic capture, and in increasing contaminant mass removal. However, because the area where COCs in ground water exceed cleanup standards is limited in extent and the extent of the COCs in the Qal/WBR HSU were not increasing before treatment began, protectiveness is maintained by the treatment facility's current operation and because the COC sources in the vadose zone are isolated by the drainage diversion system.

6.2. 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 have been identified. While the 2008 Five-Year Ecological Review reported that subsurface samples collected within Pit 5 during additional characterization activities contained uranium concentrations that resulted in Hazard Indices greater than 1 for burrowing vertebrate species, landfill inspection and maintenance procedures (i.e., inspecting for and filling animal burrows), prevent exposure of burrowing species to subsurface soil in Pit 5.
- There have been no changes in land, building, or water use.
- No new contaminant 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 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 Building 850/Pit 7 Complex OU remedies.
  - The EPA industrial soil Preliminary Remediation Goal that was used as the cleanup standard for PCBs, dioxins, and furans in the Building 850 soil removal action have been replaced by EPA RSLs. However, the current EPA industrial soil RSL (June 2015) for the PCB Aroclors that were remediated at Building 850 is 0.97 mg/kg; higher than the 0.74 mg/kg PRG cleanup standard that was selected in the Action Memorandum and used in the removal action. The current EPA industrial soil RSL (June 2015) for dioxins and furans (as tetrachloro-di-benzodioxin [TCDD]) that were remediated at Building 850 is 2.2×10^{-5} mg/kg; higher than the 1.6×10^{-6} mg/kg PRG cleanup standard that was selected in the Action Memorandum and used in the removal action. Therefore, the soil cleanup standard and removal action for PCBs, dioxins, and furans in Building 850 soil remains protective.
- The review found that the remedy is making progress toward meeting the RAOs.

Although HE compounds were not identified as COCs in the 2008 Site-Wide ROD, RDX and HMX were detected in Building 850 ground water during the five-year review period. Data indicate that: (1) the extent of RDX and HMX in Building 850 ground water is currently limited to ground water near and directly downgradient of the Building 850 Firing Table, (2) the concentrations and extent of these HE compounds are decreasing, and (3) HMX concentrations remain well below the 100 µg/L EPA Regional Tap Water Screening Level. DOE/LLNL will continue to monitor HE compounds in Building 850 ground water to verify the continued decrease in RDX and HMX concentrations and extent, and to evaluate attenuation mechanisms driving these decreases. In addition, DOE/LLNL recommends collecting subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water. In the interim, existing institutional/land use controls prevent exposure to HE compounds in ground water.

6.3. 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) 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 850/Pit 7 Landfill OU.

7. Issues

No deficiencies or issues were identified with the remedy selected to address tritium, uranium, or nitrate in ground water or the removal action that addressed PCB-, dioxin-, and furan-contaminated soil at the Building 850 portion of the Building 850/Pit 7 Complex OU. As mentioned previously, characterization and a treatability study are underway for perchlorate in Building 850 ground water after which remedial alternatives will be proposed and a remedy selected. As discussed in Section 5.4.1.1.5 and 6.2, RDX and HMX were detected in Building 850 ground water during the five-year review period. Recommendations are presented in Section 8.1 to determine if further actions need to be taken to address these HE compounds in Building 850 ground water.

No deficiencies or issues were identified associated with the remedy selected for the Pit 7 Complex portion of the Building 850/Pit 7 Complex OU during this evaluation. However, recommendations are presented to optimize the operation and maintenance of the PIT7-SRC ground water extraction wellfield and the drainage diversion system in Section 8.2.

8. Recommendations and Follow-Up Actions

DOE/NNSA developed recommendations/follow-up actions during the review process for the Building 850 and Pit 7 Complex portions of the Building 850/Pit 7 Complex OU that are presented in Sections 8.1 and 8.2, respectively.

8.1. Building 850 Recommendations and Follow-up Actions

Although HE compounds were not identified as COCs in the 2008 Site-Wide ROD, RDX and HMX were detected in Building 850 ground water during the five-year review period. While data indicate that the extent of RDX and HMX in Building 850 ground water is currently limited, the concentrations and extent of these HE compounds are decreasing, and existing institutional/land use controls prevent exposure, the following recommendations were developed to determine if further actions need to be taken:

1. Monitor HE compounds in Building 850 ground water semi-annually from monitor wells NC7-10, NC7-11, NC7-14, NC7-15, NC7-19, NC7-27, NC7-28, NC7-44, NC7-54, NC7-55, NC7-60, NC7-61, NC7-70, NC7-71, NC7-73, W-850-05, W-850-2313, W-850-2314, and W-850-2417 to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases.
2. Collecting subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present

in the vadose zone underlying the Building 850 Firing Table that could impact ground water above cleanup standards.

8.2. Pit 7 Complex Recommendations and Follow-up Actions

Although no deficiencies or issues were identified with the Pit 7 Complex remedy, the following recommendations were developed to optimize the operation and/or maintenance of the ground water extraction and treatment and the drainage diversion system components of the Pit 7 Complex remedy:

1. Convert current extraction well NC7-25 to a monitor well and drill and install a larger diameter extraction well nearby to optimize ground water extraction of uranium in ground water at this location.
2. Implement improvements to the surface and slope of the road and the roadside drainage way on the east side of the Pit 7 Complex landfills to minimize erosion and accumulation of sediment, reduce flooding during heavy rain events, and both improve operation and reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system. These improvements include grading and patching the road and grading and flattening the roadside edges of the drainage way to enhance water flow into it.

A schedule for implementing the recommendations for the Pit 7 Complex will be discussed with the regulatory agencies.

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

9. Protectiveness Statement

The remedies at the Building 850/Pit 7 Complex 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 land use controls, the Health and Safety Plan, and the Contingency Plan.

The remedies protect human health in the short-term because:

1. Tritium activities in Building 850 and Pit 7 Complex ground water have significantly decreased from their historical maximum, and natural attenuation will continue to reduce tritium activities in ground water and surface water (Well 8 Spring) to meet the cleanup standard in a reasonable timeframe. Modeling indicates that the tritium plume will not migrate offsite in the period of time it takes to natural attenuate to cleanup standards, and monitoring of the tritium plume is conducted to validate these modeling results (Taffet et al., 1996; Taffet et al., 2004; Taffet et al., 2005). In addition, institutional controls described in Sections 4.5.1.1, 4.5.2.1, and 4.5.1.5 are in-place to prevent exposure to tritium in ground water and surface water at Well 8 Spring until cleanup standards are achieved.
2. The risk to onsite workers and ecological receptors associated with PCB-, dioxin-, and furan-contaminated surface soil at the Building 850 Firing Table has been mitigated by the soil excavation and solidification removal action. Institutional/land use controls and

inspection and maintenance procedures prevent further exposure by protecting the integrity of the CAMU.

3. Ground water monitoring of uranium and nitrate in Building 850 ground water will provide an early indication of changes in the concentrations/activities and/or extent of these constituents that could impact human health or the environment. As indicated in the Site-Wide Contingency Plan (Dibley et al., 2009), if ground water contaminant concentrations (i.e., uranium activities and/or nitrate concentrations in Building 850 ground water) increase in a consistent and significant manner for reasons not attributable to remediation efforts (e.g., cyclic pumping), or natural aquifer or laboratory variables, DOE will notify the regulatory agencies and modifications to the remedial action will be considered as necessary to protect human health.
4. The engineered drainage diversion system at the Pit 7 Complex will continue to control the contaminant source in the Pit 7 Complex landfills by preventing ground water level rises into the pit waste, thereby releasing contaminants to ground water.
5. VOC concentrations in Pit 7 Complex ground water have been reduced to below cleanup standards and are decreasing toward background levels, and ground water extraction and treatment continues to reduce uranium activities and perchlorate and nitrate concentrations in Pit 7 Complex ground water to cleanup standards.
6. The Pit 7 Complex landfill covers/caps, coupled with institutional/land use controls, prevents inadvertent exposure of onsite workers to contaminants in the pit waste.
7. Natural attenuation (radioactive decay) has mitigated the tritium inhalation risk to onsite workers at the Pit 3 Landfill.
8. No new contaminant releases have been identified for the Pit 7 Complex landfill, and continued detection monitoring will provide an indication of any future releases.
9. Ground water monitoring will provide an early indication of migration of contaminants towards the site boundary.
10. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of land use/institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Building 850/Pit 7 Complex 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.

However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure long-term protectiveness:

1. Monitor HE compounds in Building 850 ground water to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases.
2. Collect subsurface soil samples for HE compound analysis from the boreholes to be drilled as part of the Building 850 perchlorate characterization effort. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone underlying the Building 850 Firing Table that could impact ground water above cleanup standards.

3. Complete the characterization of perchlorate in subsurface soil at Building 850, present and evaluate remedial alternatives, and select and implement a remedy to address perchlorate in Building 850 ground water.

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 because:

- Some tritium and uranium may remain in subsurface soil following the achievement of ground water cleanup standards.
- Waste that may still contain contaminants will remain in place at the Pit 7 Complex landfills.
- Solidified and consolidated soil contaminated with PCBs, dioxins, and furans will remain in place in the Building 850 CAMU.

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 Site-Wide 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.

10. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2020).

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12. Acronyms and Abbreviations

ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
CAMU	Corrective Action Management Unit
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Ci	Curies
CNPS	California Native Plant Society
COC	Contaminant of concern
DCE	Dichloroethene or Dichloroethylene
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EA	Environmental Analyst
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency
ERD	Environmental Restoration Department
ER	Environmental Restoration
ES&H	Environmental Safety & Health
FFA	Federal Facilities Agreement
ft	Feet
GAC	Granular activated carbon
gpm	Gallons per minute
GSA	General Services Area
GWTS	Ground water treatment system
HDPE	High-density polyethylene
HE	High explosives
HI	Hazard Index
HMX	High-Melting Explosive
HSU	Hydrostratigraphic unit
ICP-MS	Inductively Coupled Plasma – Mass Spectrometry
LFO	Livermore Field Office
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
MSL	Mean sea level
NNSA	National Nuclear Security Administration

NPDES	National Pollution Discharge Elimination System
O&M	Operation and maintenance
OU	Operable unit
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene or Tetrachloroethylene
pCi/L	PicoCuries per liter
PHG	Public Health Goal
PRG	Preliminary Remediation Goal
Qal	Quaternary alluvium
Qal/WBR	Quaternary alluvium/weathered bedrock
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
SWRI	Site-Wide Remedial Investigation
TBOS/TKEBS	Tetrabutyl orthosilicate/ Tetrakis (2-ethylbutyl) silane
TCDD	Tetrachloro-di-benzodioxin
TEIMS	Taurus Environmental Information Management System
TCE	Trichloroethylene
TFRT	Treatment Facility Real Time
Tmss	Miocene Cierbo Formation—lower siltstone/claystone member
$Tnbs_0$	Neroly silty Sandstone
$Tnbs_1$	Tertiary Neroly Lower Blue Sandstone
$Tnsc_0$	Tertiary Neroly Formation—lower siltstone/claystone member
$^{235}U/^{238}U$	Uranium-235/uranium-238 (atom ratio)
U.S.	United States
USFWS	United States Fish and Wildlife Service
VOCs	Volatile organic compounds
yd^3	Cubic yards
µg/L	Micrograms per liter

Figures

List of Figures

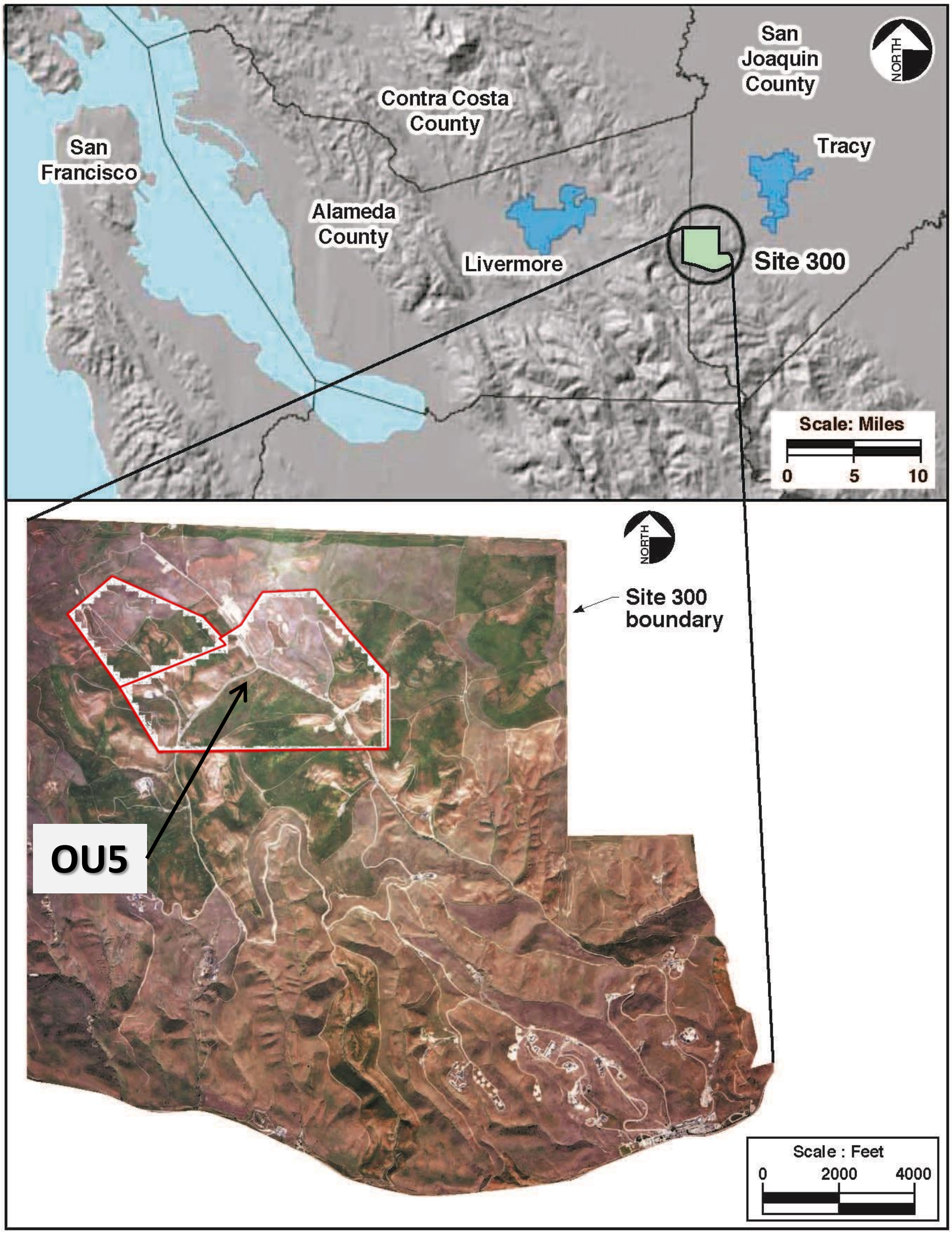


Figure 1. Location of LLNL Site 300.

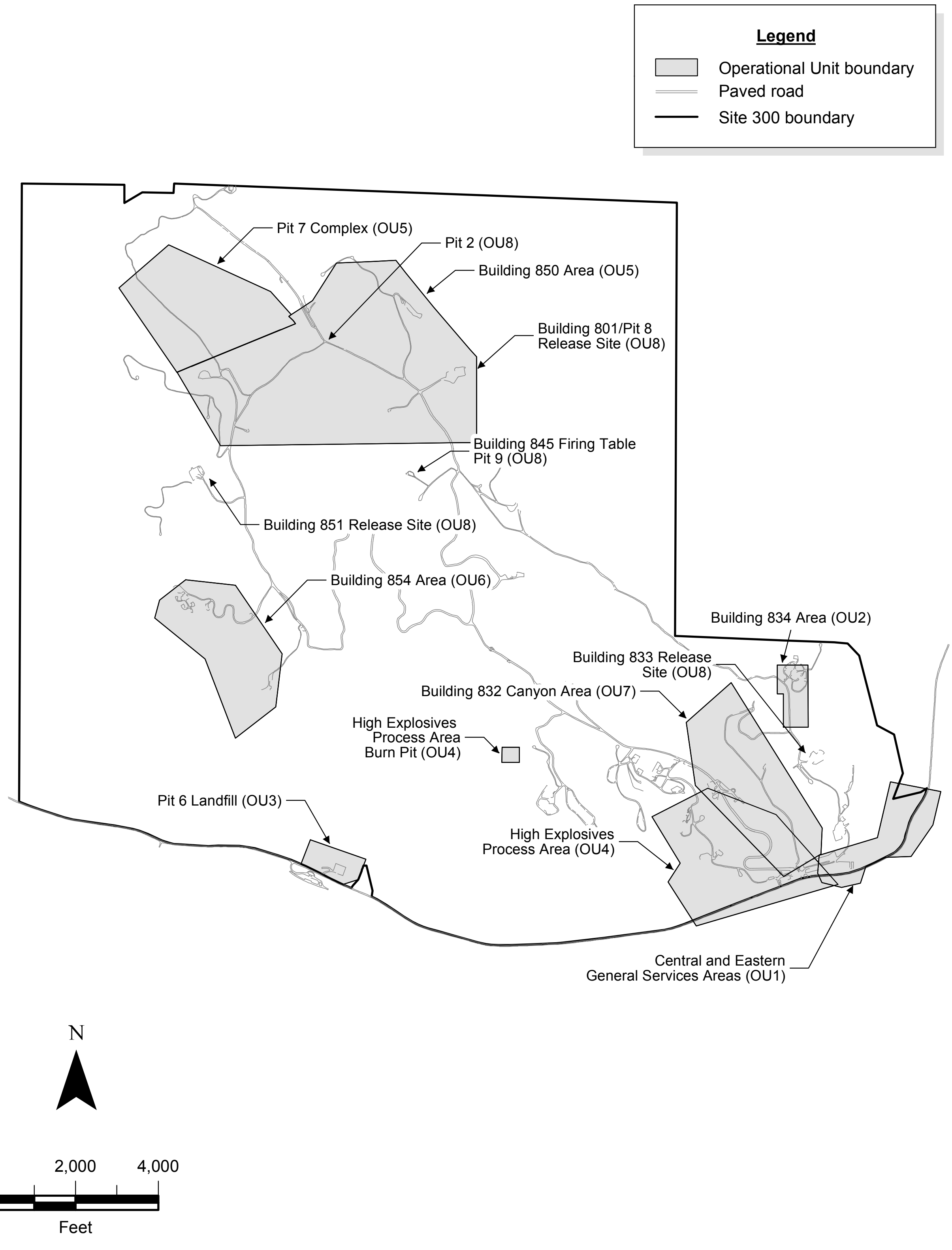


Figure 2. Site 300 map showing Operable Unit locations.

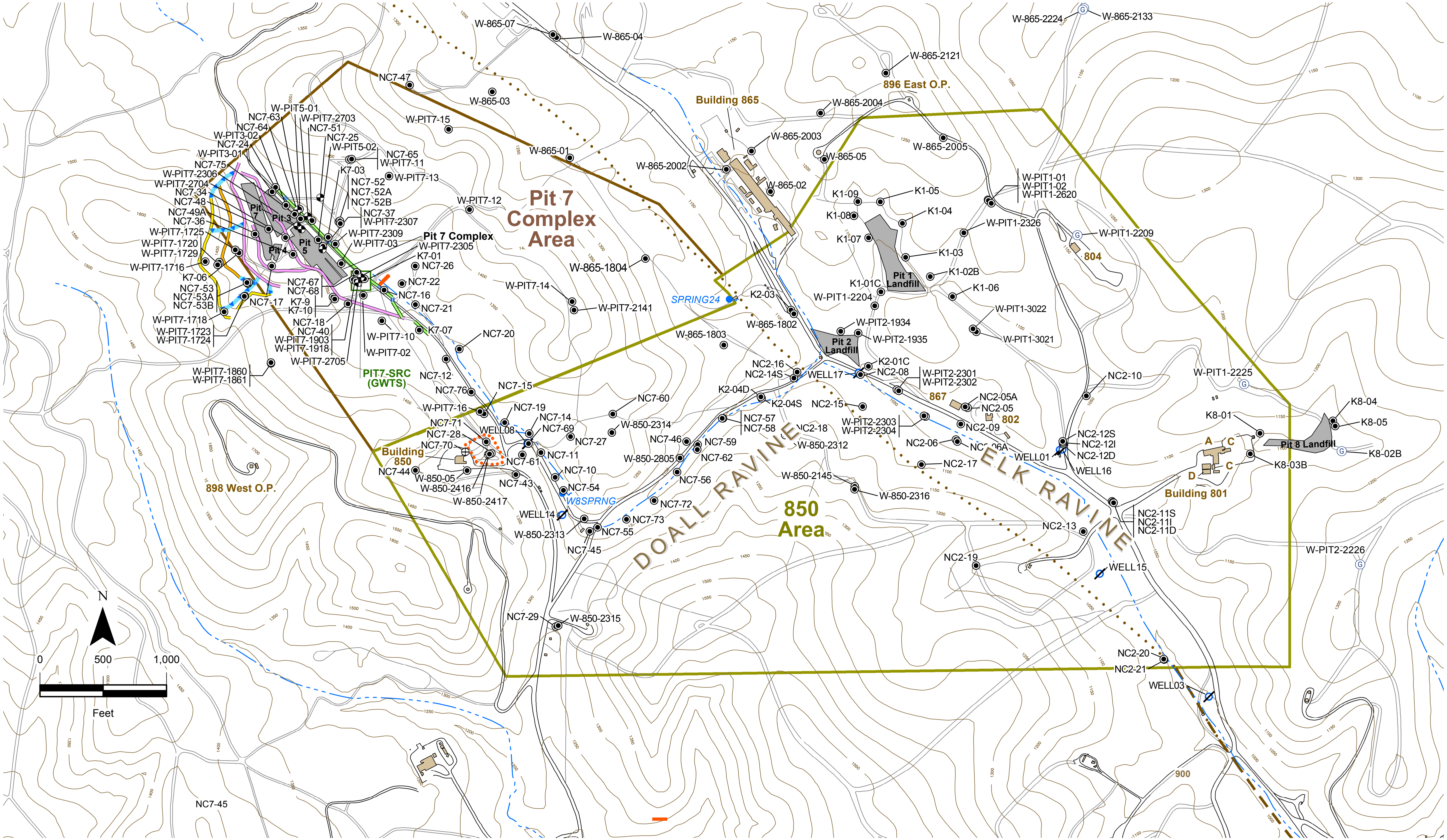


Figure 3. Building 850 and Pit 7 Complex area site map showing monitor, extraction, and injection wells, springs, treatment facility and other remediation features.

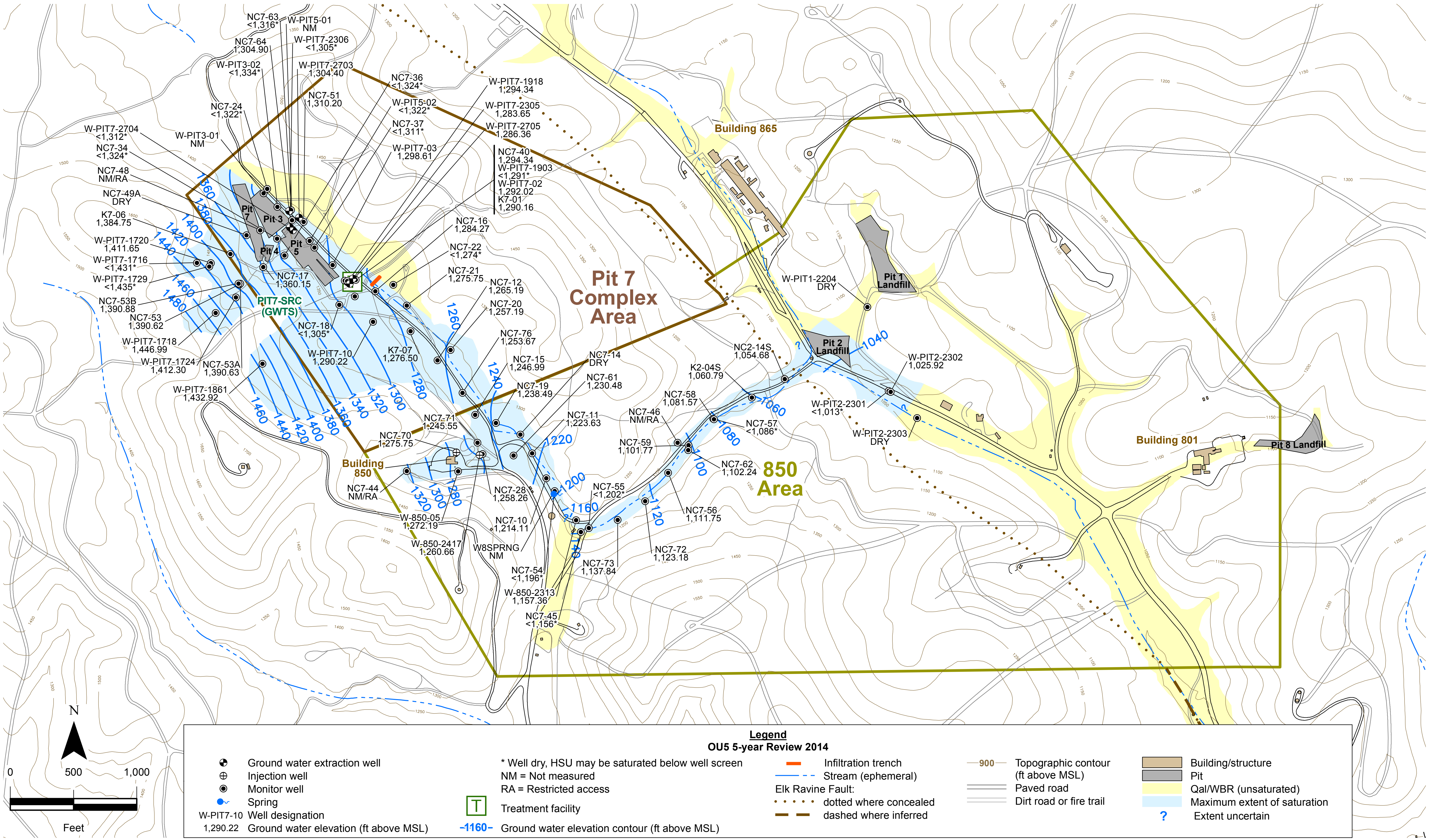


Figure 4. Building 850 and Pit 7 Complex area ground water potentiometric surface map for the Qal/WBR hydrostratigraphic unit, 4th Quarter 2014.

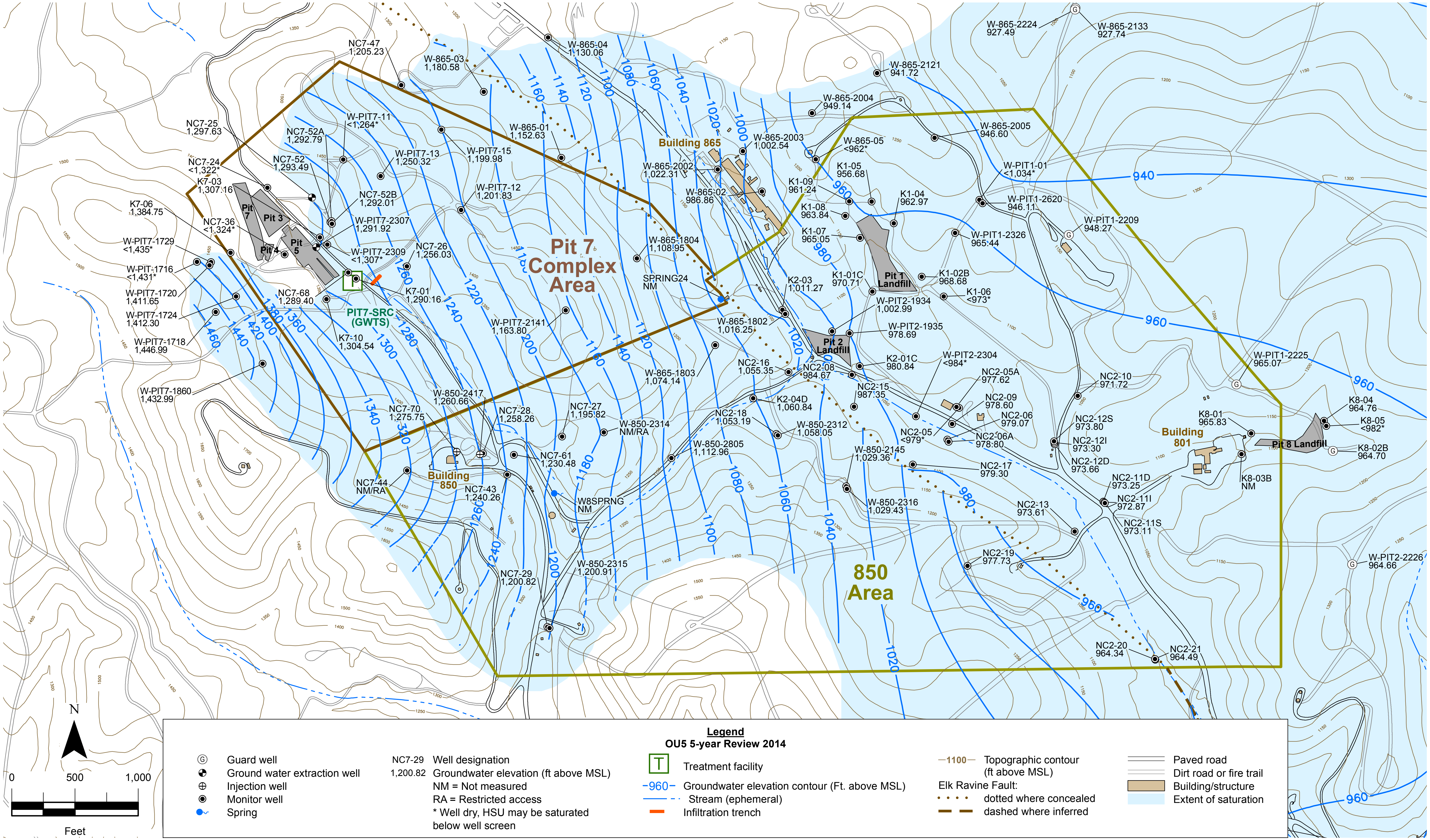


Figure 5. Building 850 and Pit 7 Complex area ground water potentiometric surface map for the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit, 4[th] Quarter 2014.

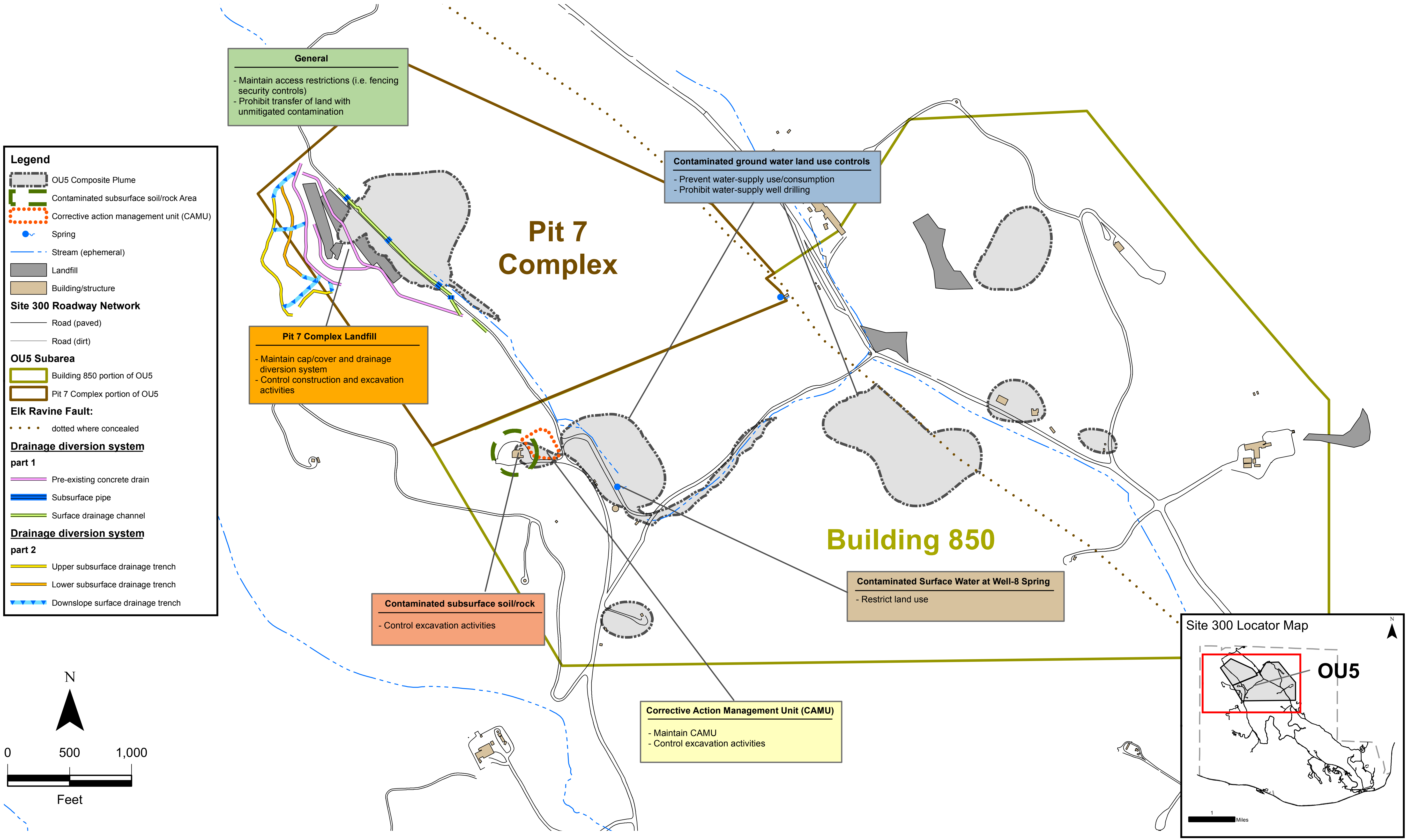


Figure 6. Building 850/Pit 7 Complex land use controls.

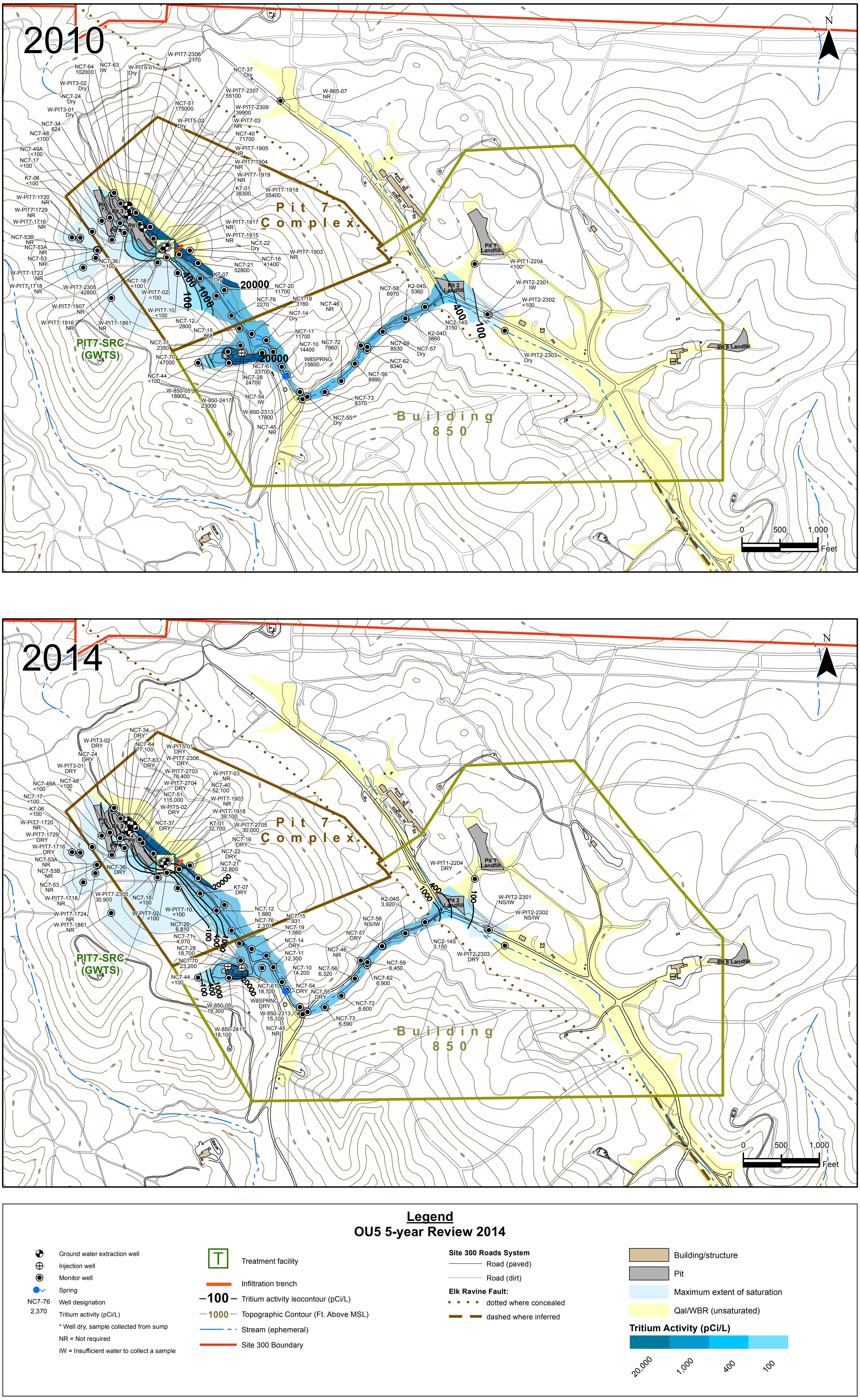


Figure 7. Building 850 and Pit 7 Complex area tritium activity isocontour maps (second semester 2010 and 2014) for the Qal/WBR hydrostratigraphic unit.

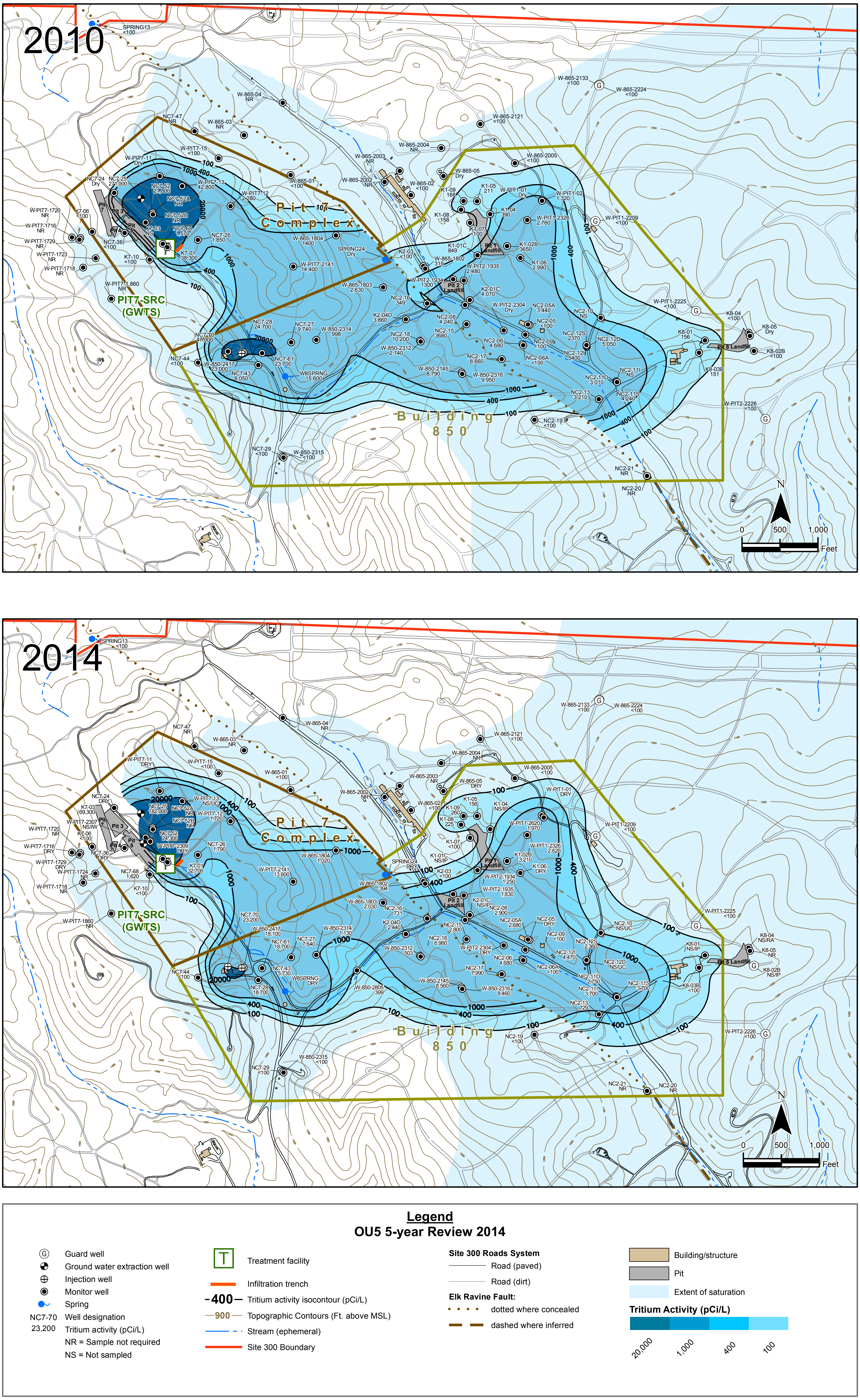
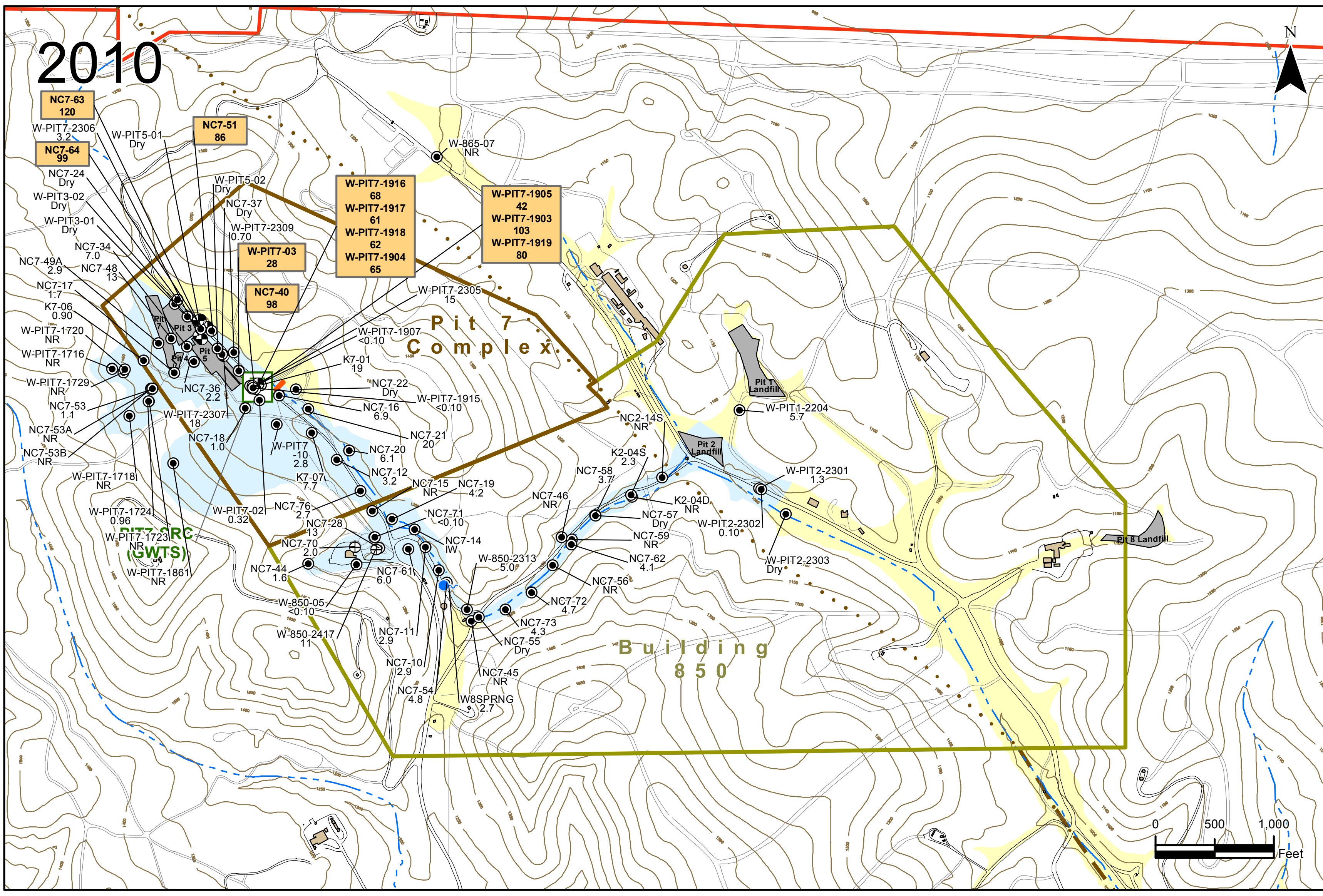
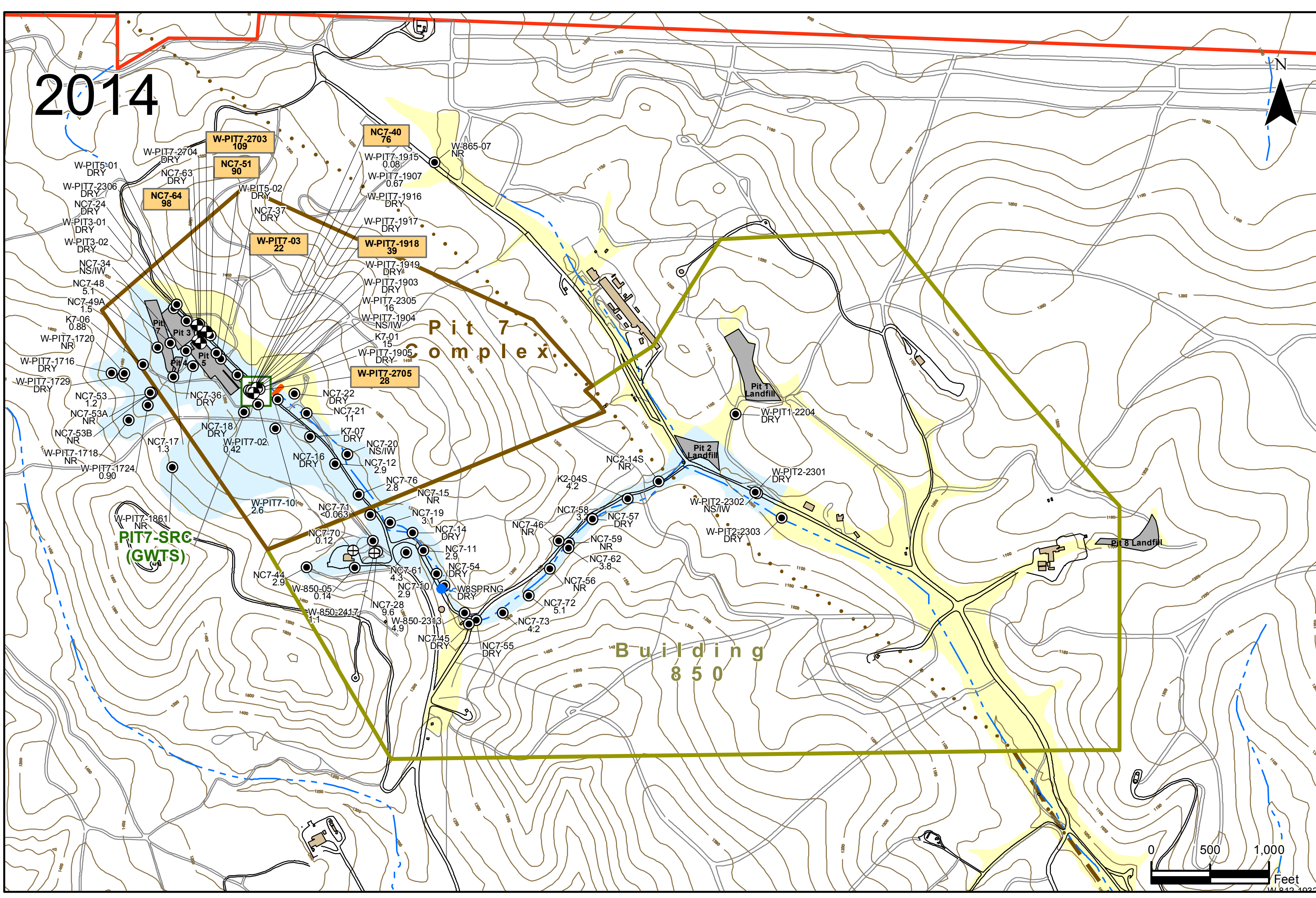


Figure 8. Building 850 and Pit 7 Complex area tritium activity isocontour maps (2010 and 2014) for the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.





Legend

OU5 5-year Review 2014

- Ground water extraction well
- Ground water injection well
- Monitor well
- Spring
- K7-10 Well designation
- 0.25 Total Uranium activity (pCi/L)
- NC7-25 38 Total uranium activity >20 pCi/L is shown highlighted
- IP = Inoperable pump
- IW = Insufficient water to collect a sample
- NR = Not required
- NS = Not sampled
- Treatment facility
- Infiltration trench
- Stream (ephemeral)
- 900 Topographic contour (Ft. above MSL)
- Site 300 Boundary

Elk Ravine Fault:
- dotted where concealed
- dashed where inferred

Site 300 Roads System
- Road (paved)
- Road (dirt)

- Building/structure
- Pit
- Maximum extent of saturation
- Qal/WBR (unsaturated)

Figure 9. Building 850 and Pit 7 Complex area maps (first semester 2010 and 2014) showing ground water uranium activities for the Qal/WBR hydrostratigraphic unit.

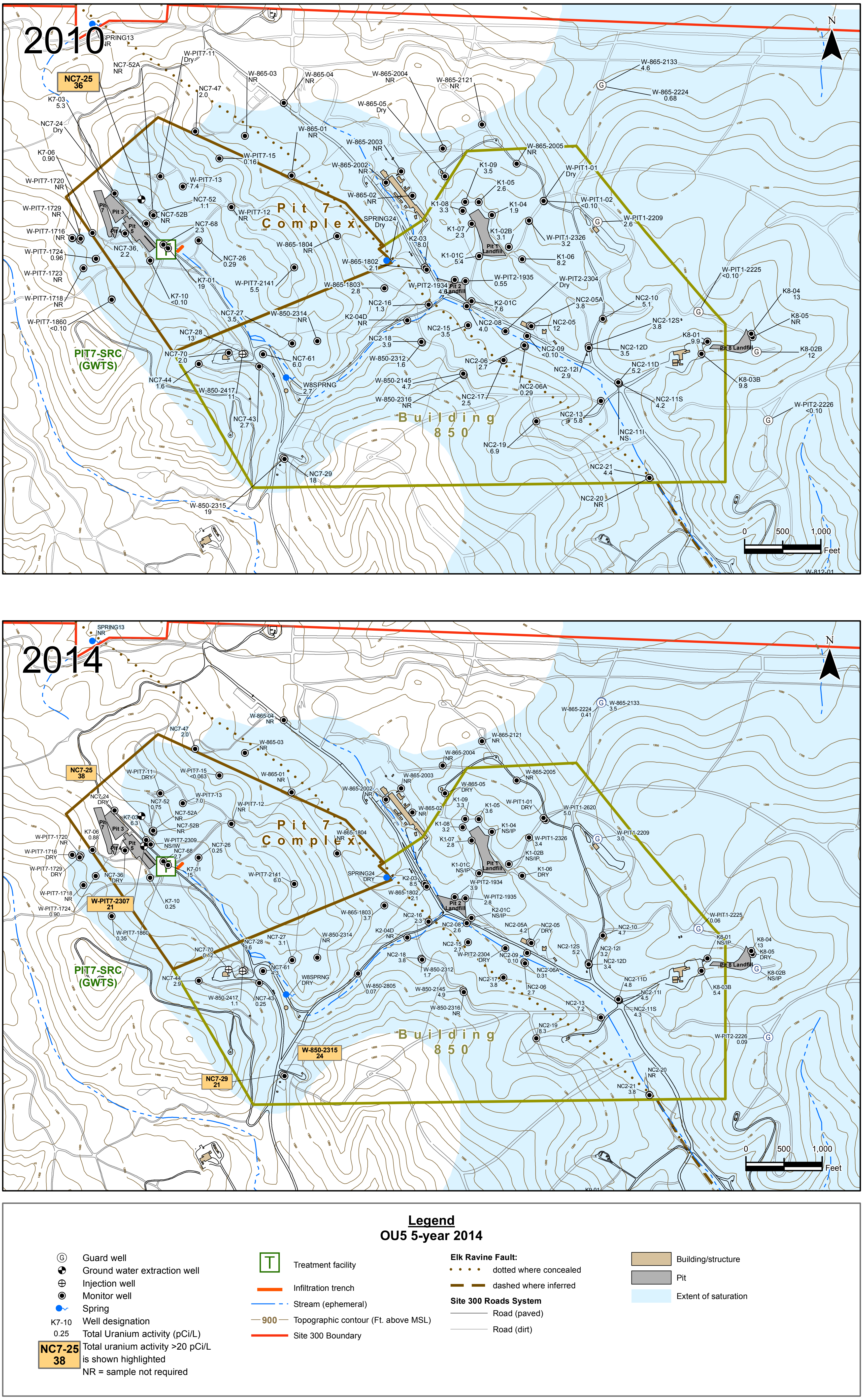


Figure 10. Building 850 and Pit 7 Complex area maps (2010 and 2014) showing ground water uranium activities for the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

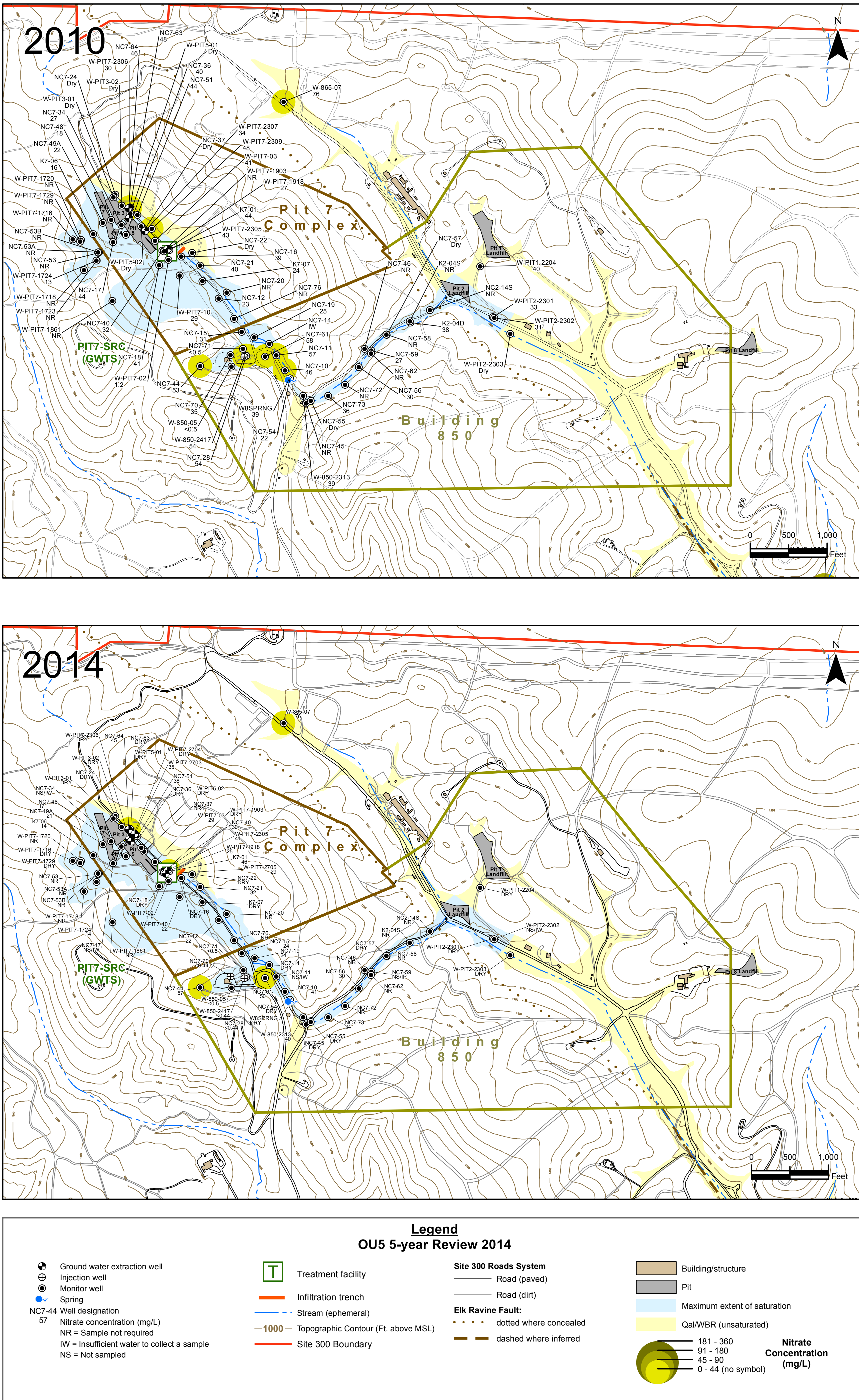


Figure 11. Building 850 and Pit 7 Complex area maps (first semester2010 and 2014) showing nitrate concentrations for the Qal/WBR hydrostratigraphic unit.

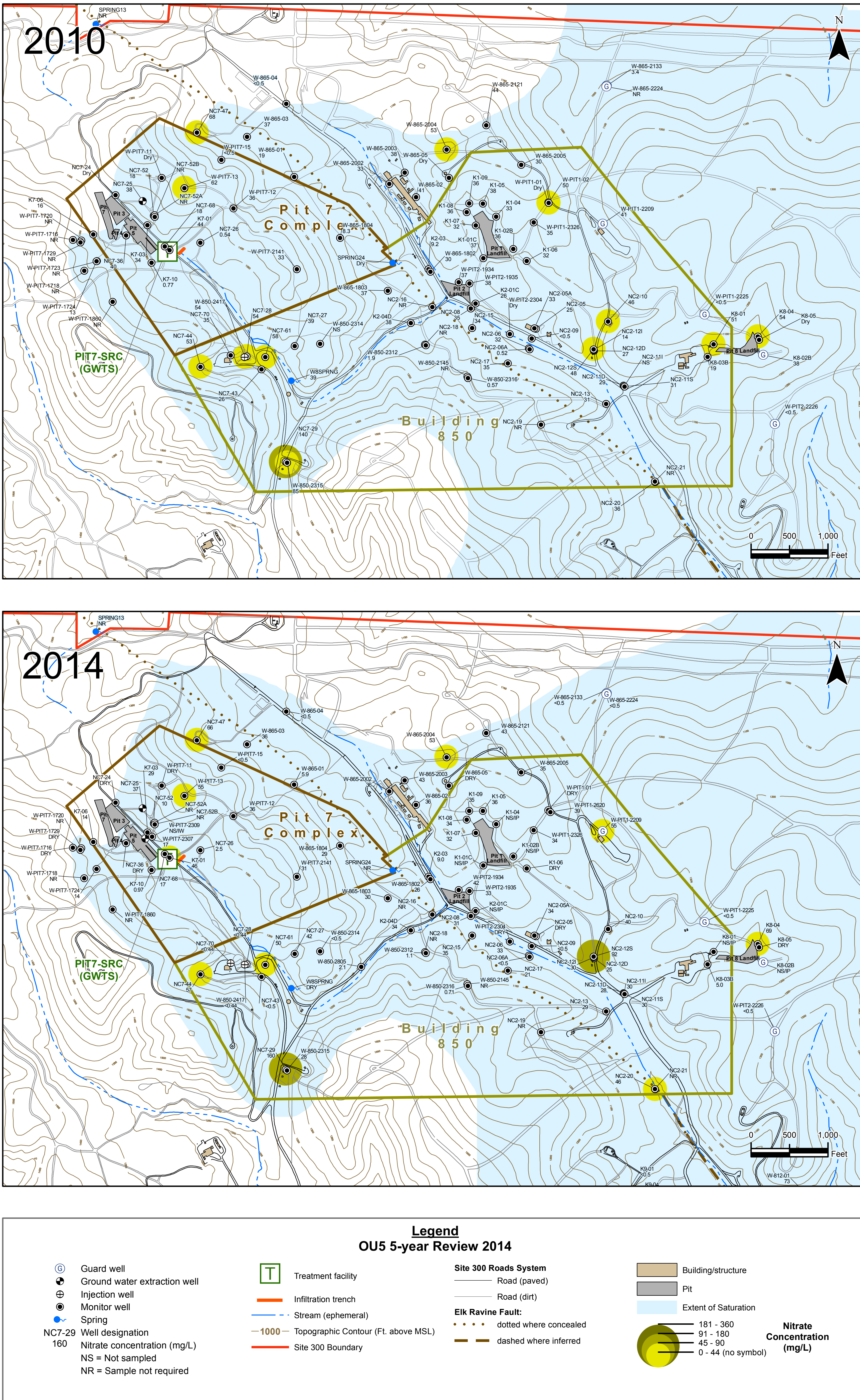


Figure 12. Building 850 and Pit 7 Complex area maps (2010 and 2014) showing nitrate concentrations for the $Tnbs_1/Tnbs_0$ hydrostratigraphic unit.

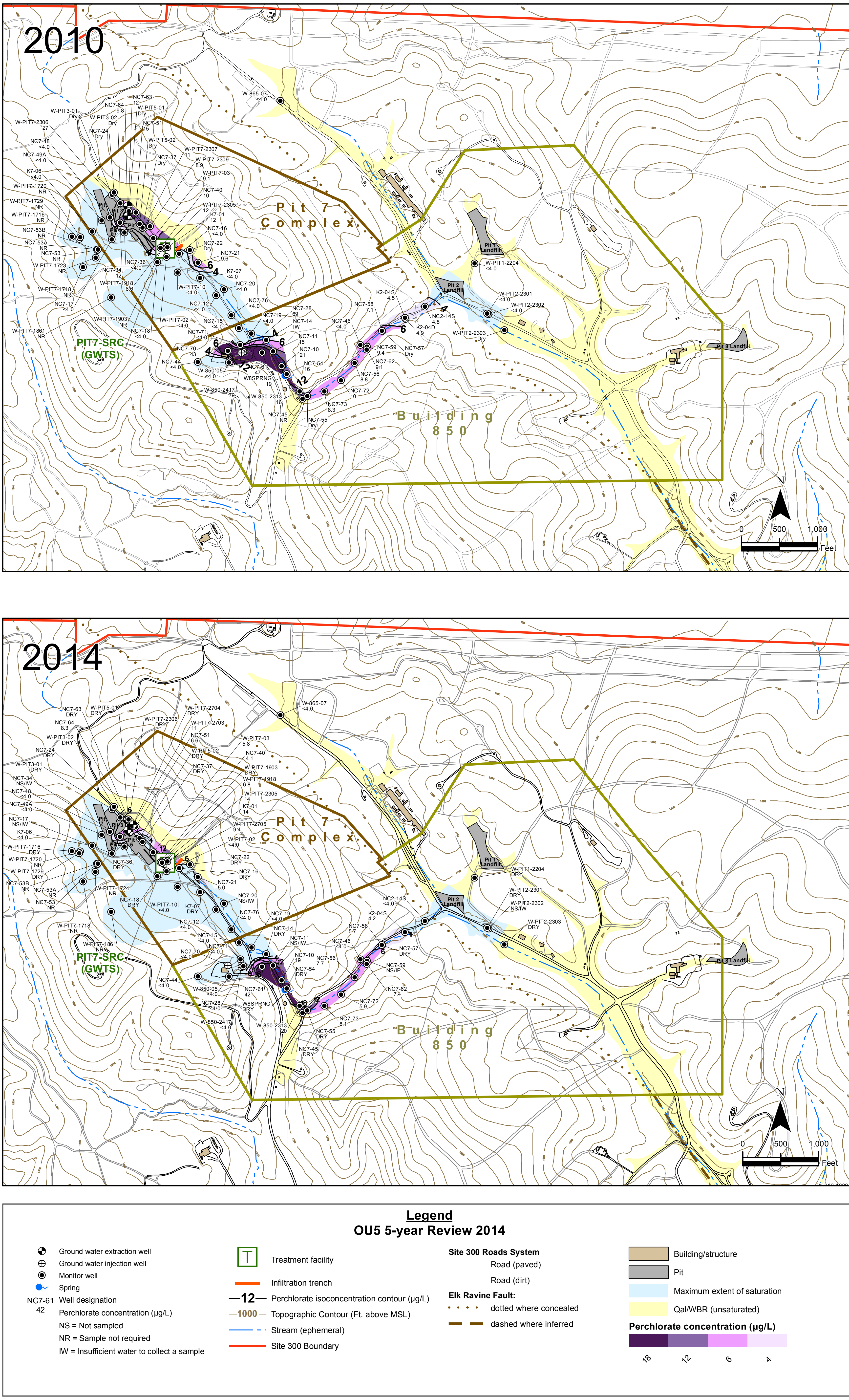


Figure 13. Building 850 and Pit 7 Complex area perchlorate isoconcentration contour maps (first semester 2010 and 2014) for the Qal/WBR hydrostratigraphic unit.

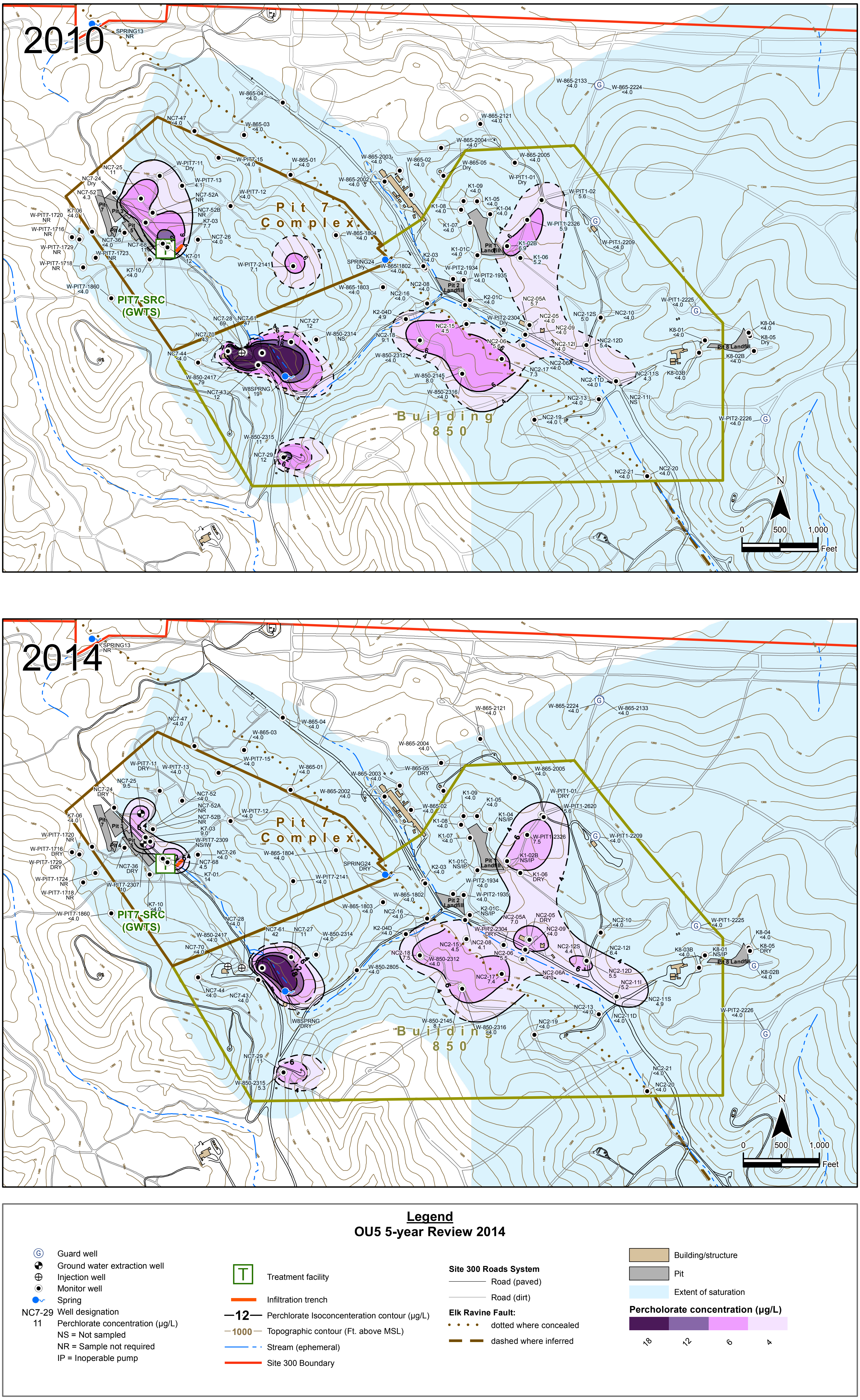


Figure 14. Building 850 and Pit 7 Complex area perchlorate isoconcentration contour maps (2010 and 2014) for the Tnbs$_1$/ Tnbs$_0$ hydrostratigraphic unit.

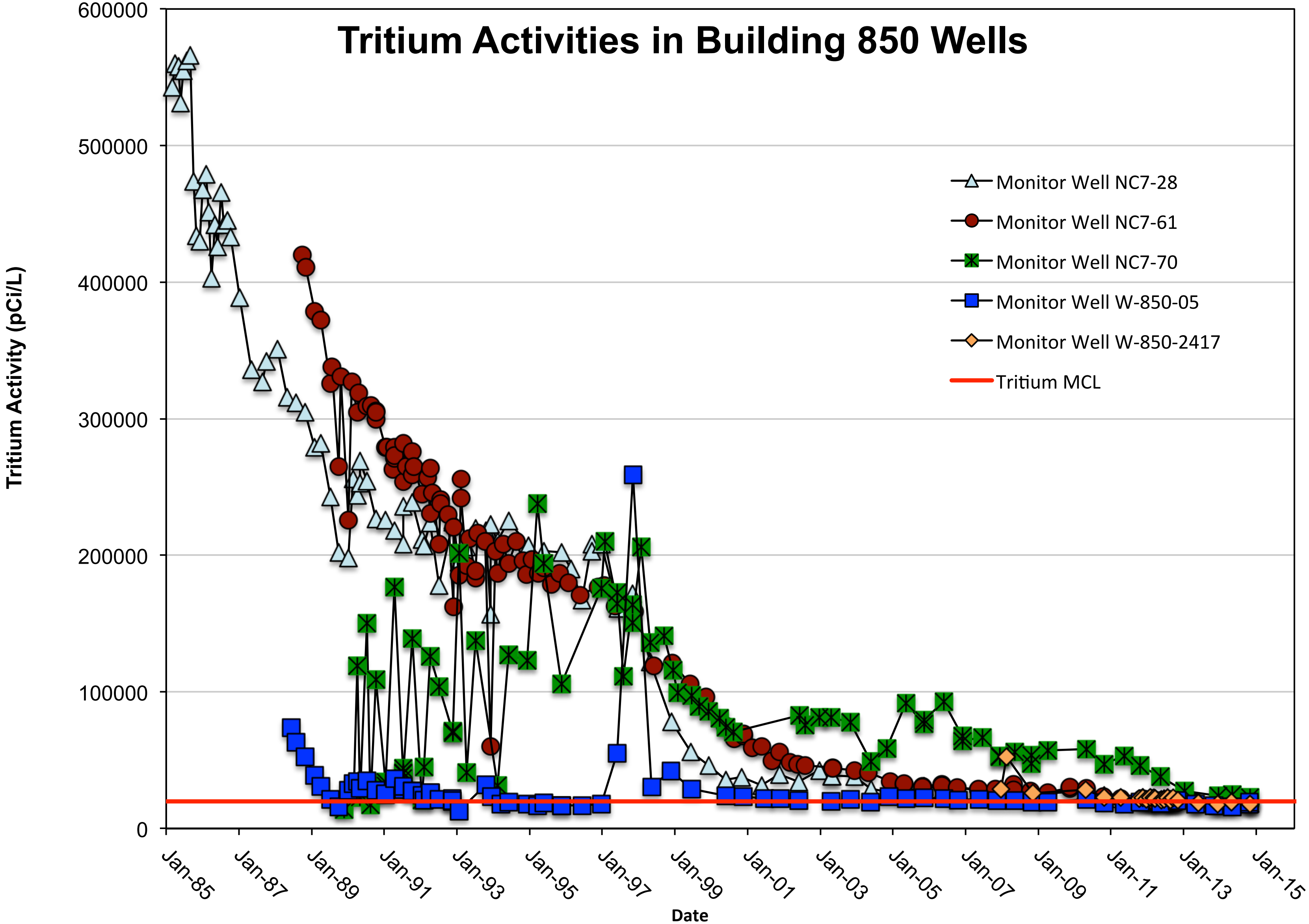


Figure 15. Time-series plot of ground water tritium activities (pCi/L) for wells in the Building 850 area.

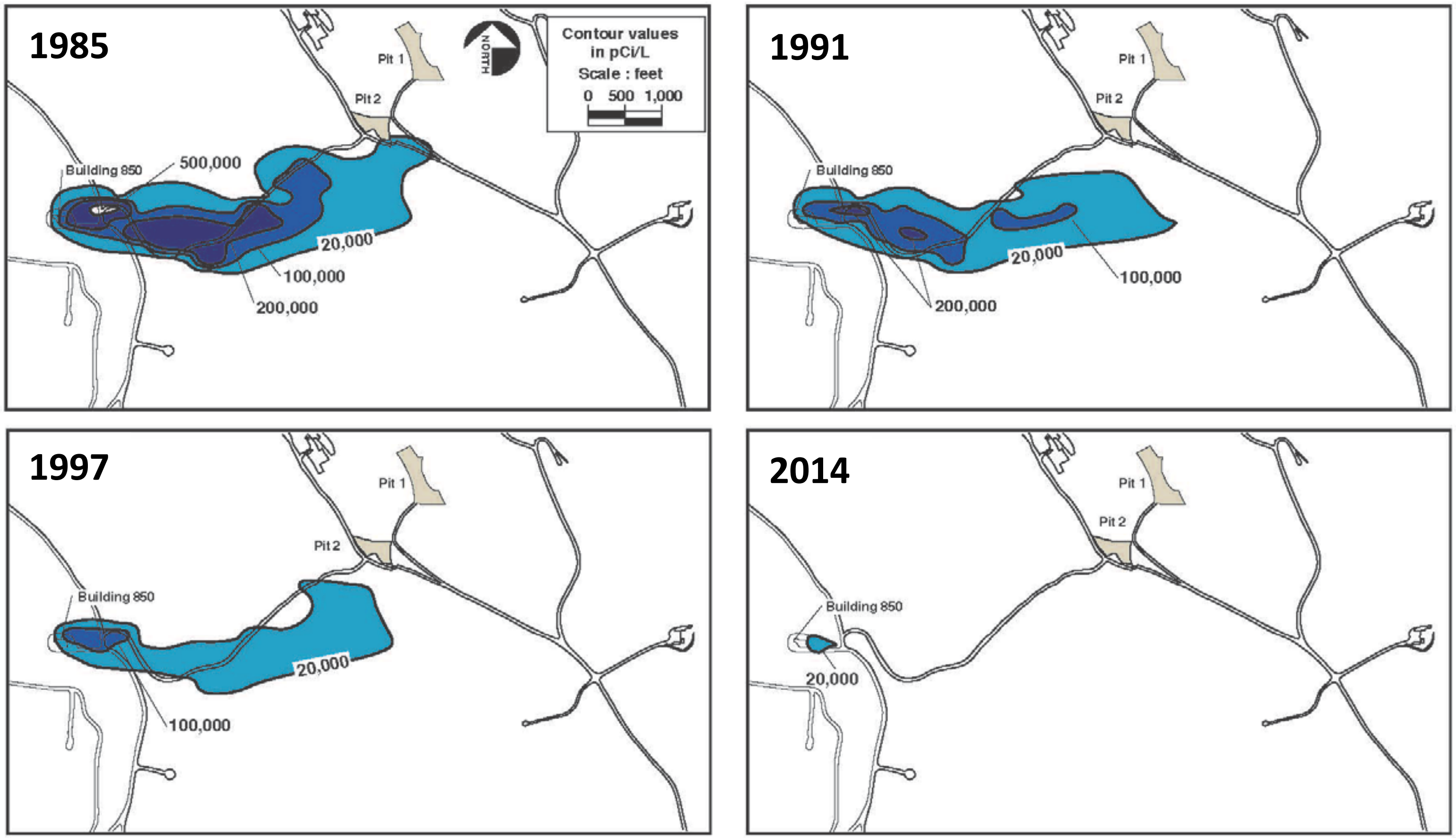


Figure 16. Comparison of the distribution of tritium activities in the Building 850 $Tnbs_1/Tnbs_0$ hydrostratigraphic unit in 1985, 1991, 1997 and 2014.

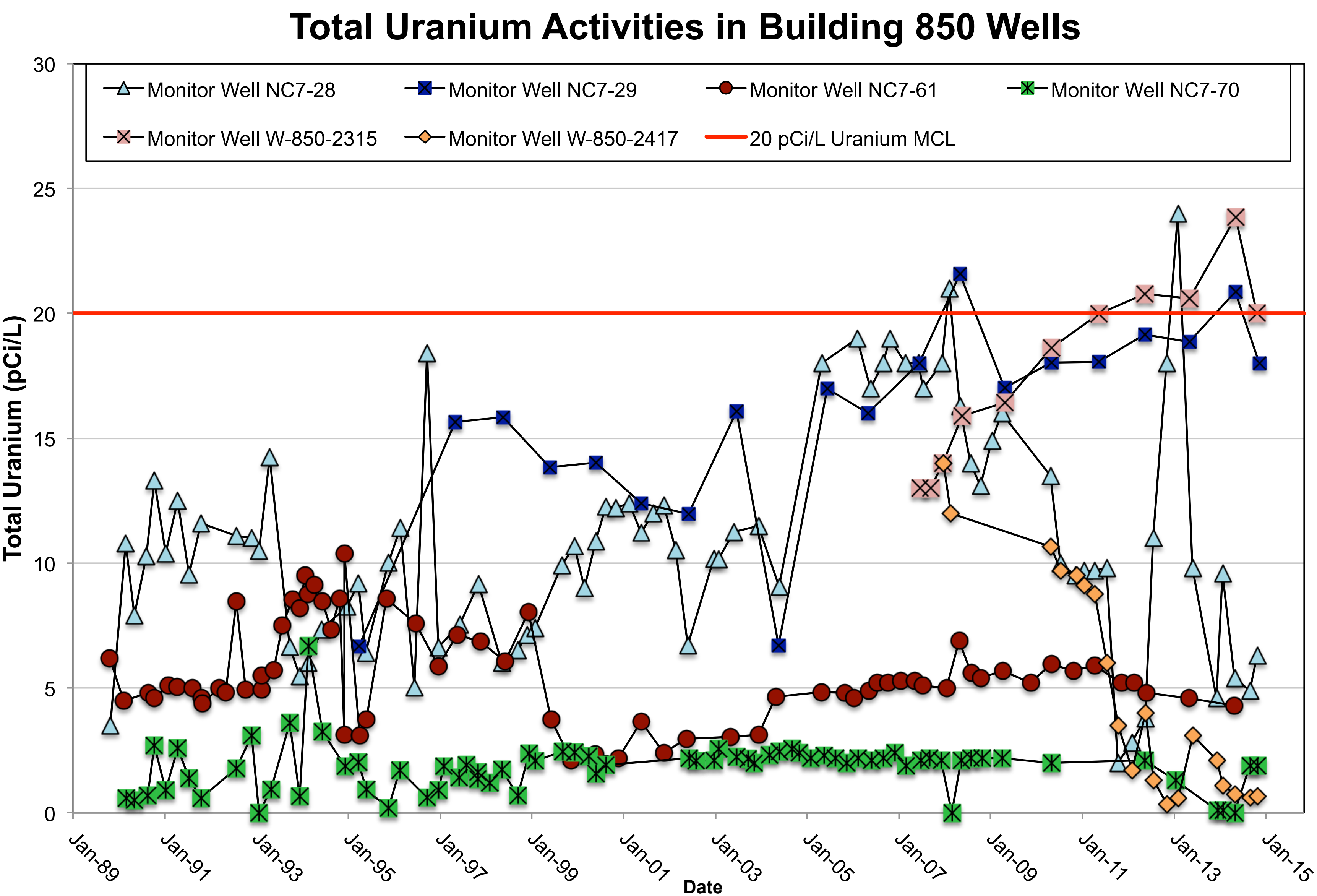


Figure 17a. Time-series plots of ground water uranium activities (pCi/L) for wells in the Building 850 area.

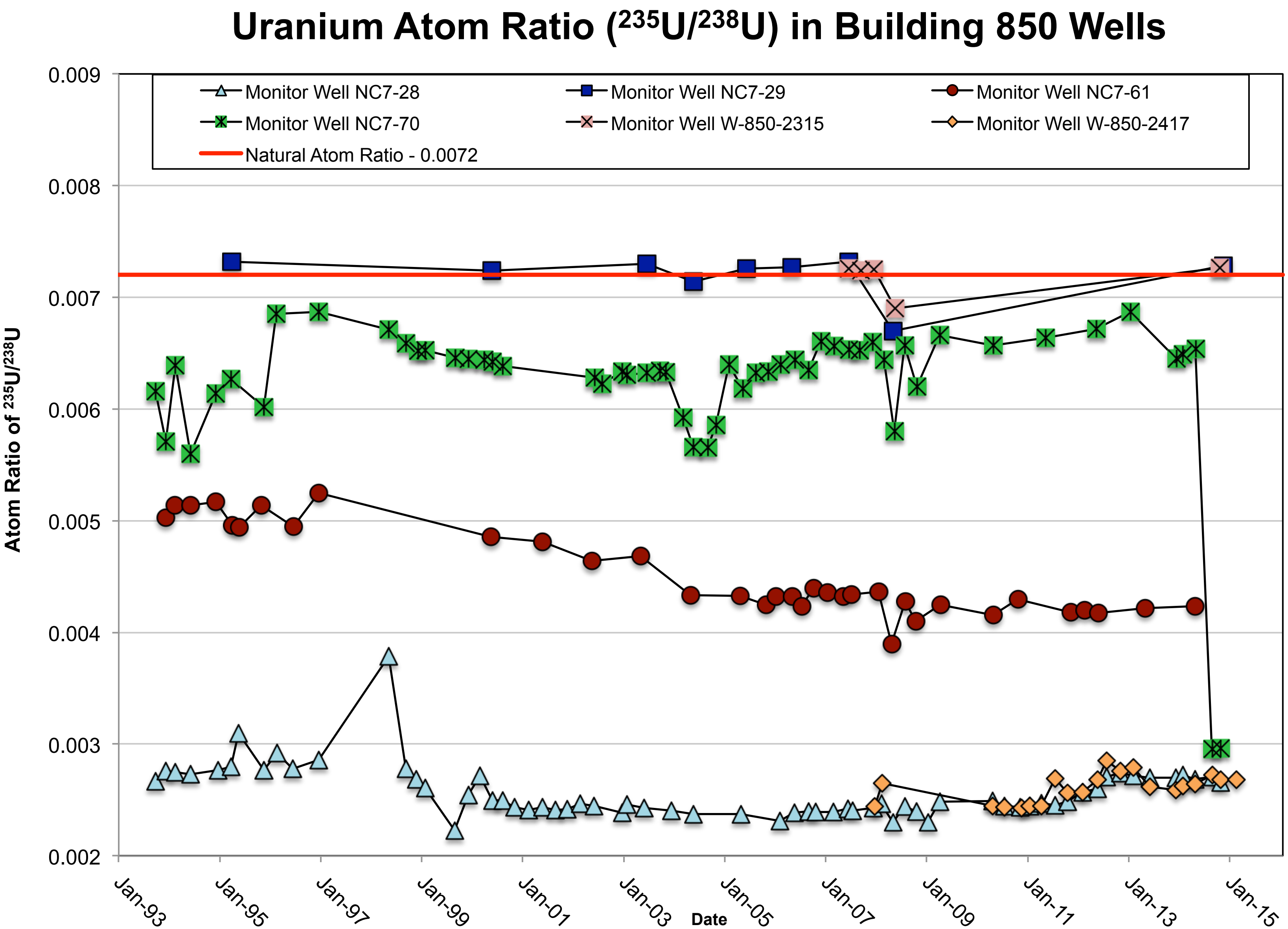


Figure 17b. Time-series plots of ground water $^{235}U/^{238}U$ atom ratios for wells in the Building 850 area.

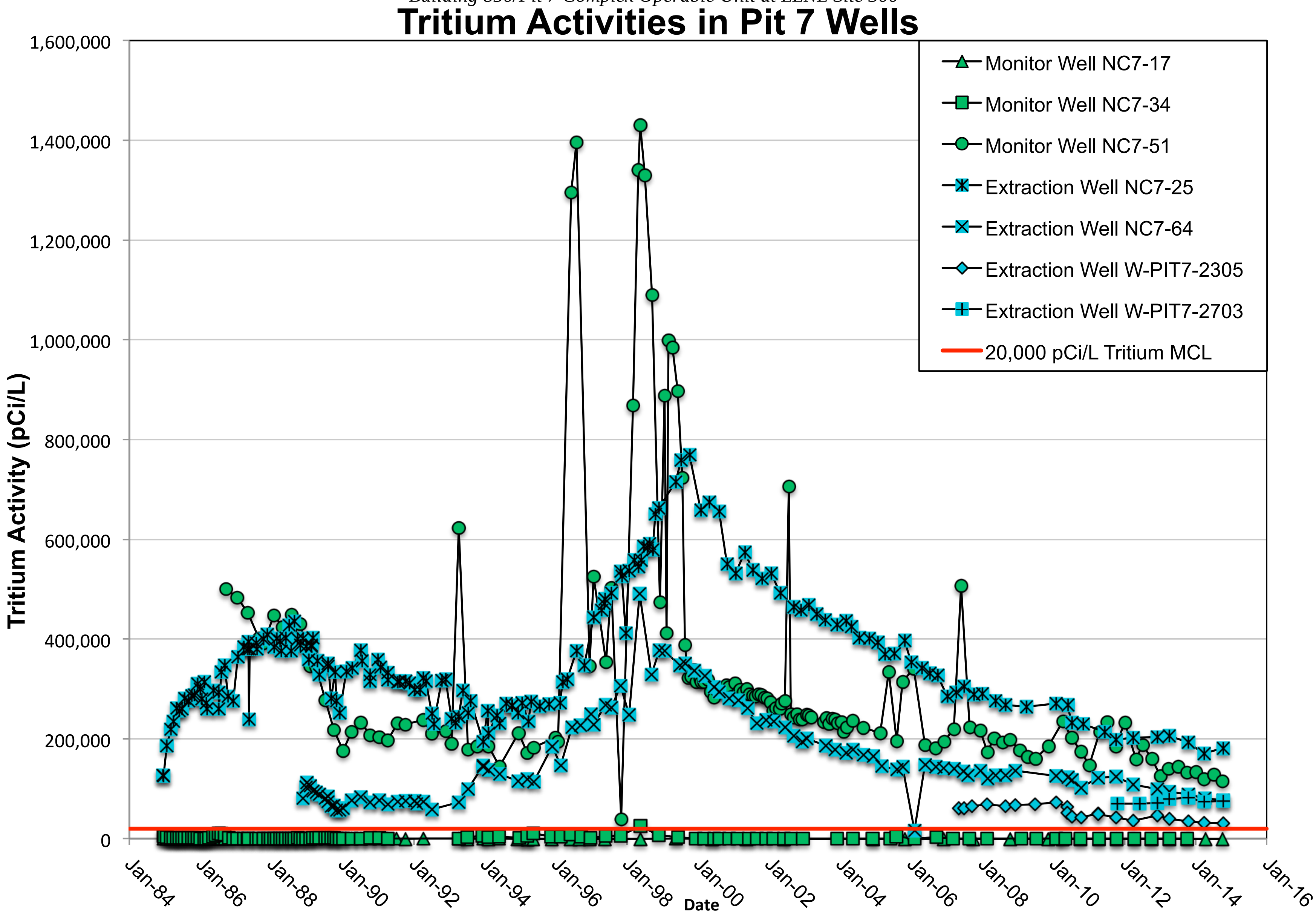


Figure 18. Time-series plots of tritium activities in Pit 7 Complex ground water for selected extraction and monitor wells.

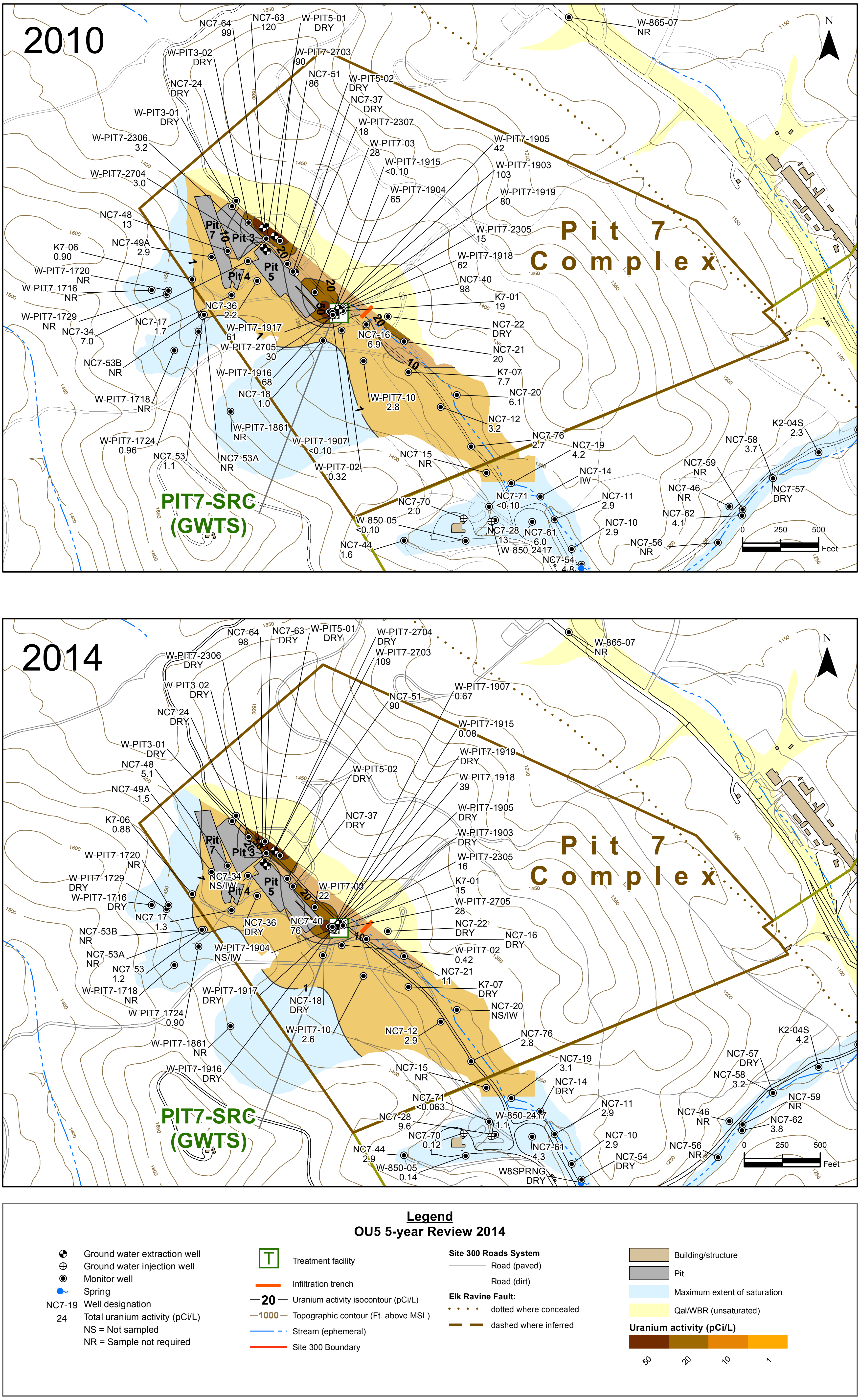


Figure 19. Comparison of the extent of uranium in ground water in the Pit 7 Complex Qal/WBR hydrostratigraphic unit in first semester 2010 and 2014.

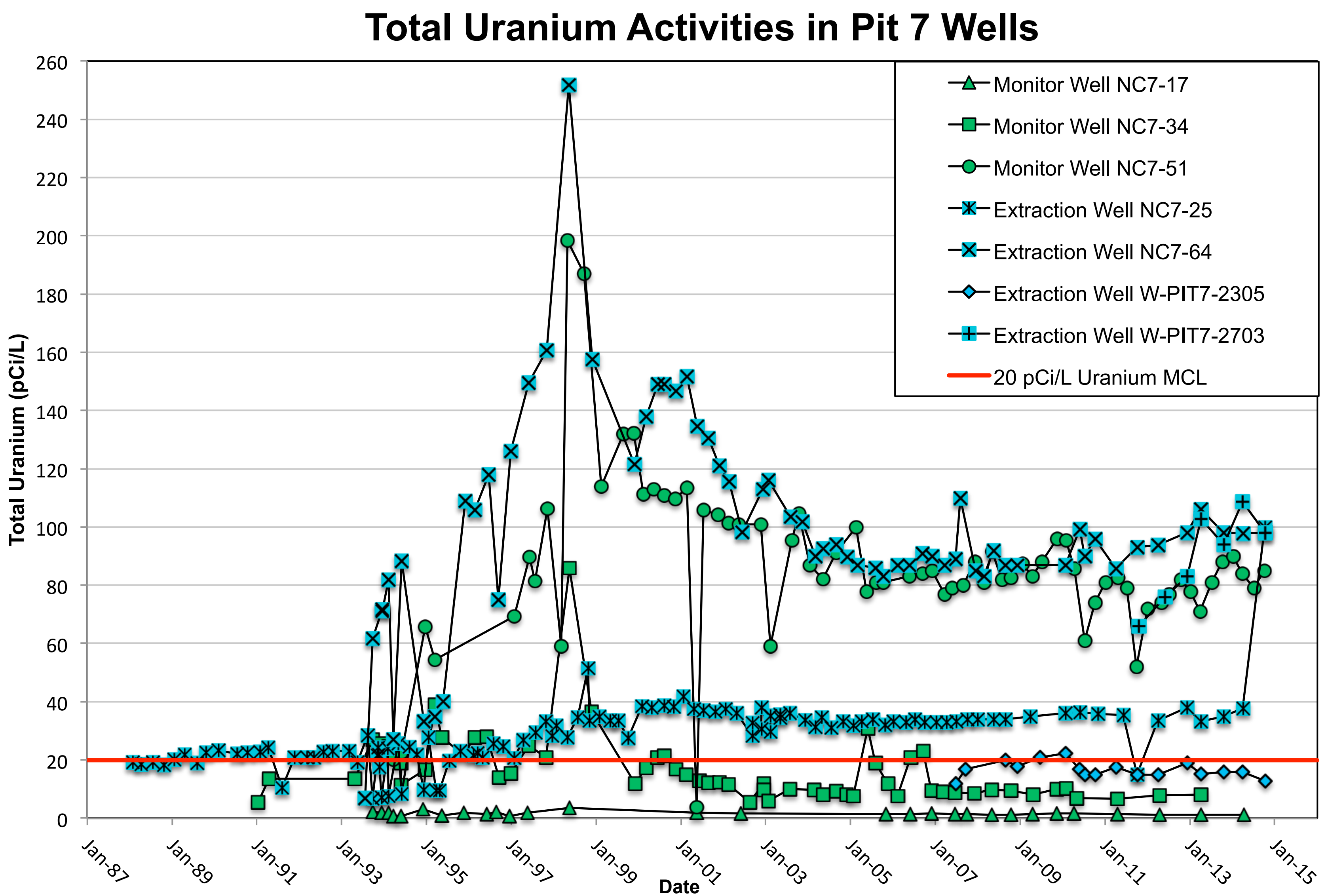


Figure 20a. Time-series plots of uranium activities (pCi/L) in Pit 7 Complex ground water for selected extraction and monitor wells.

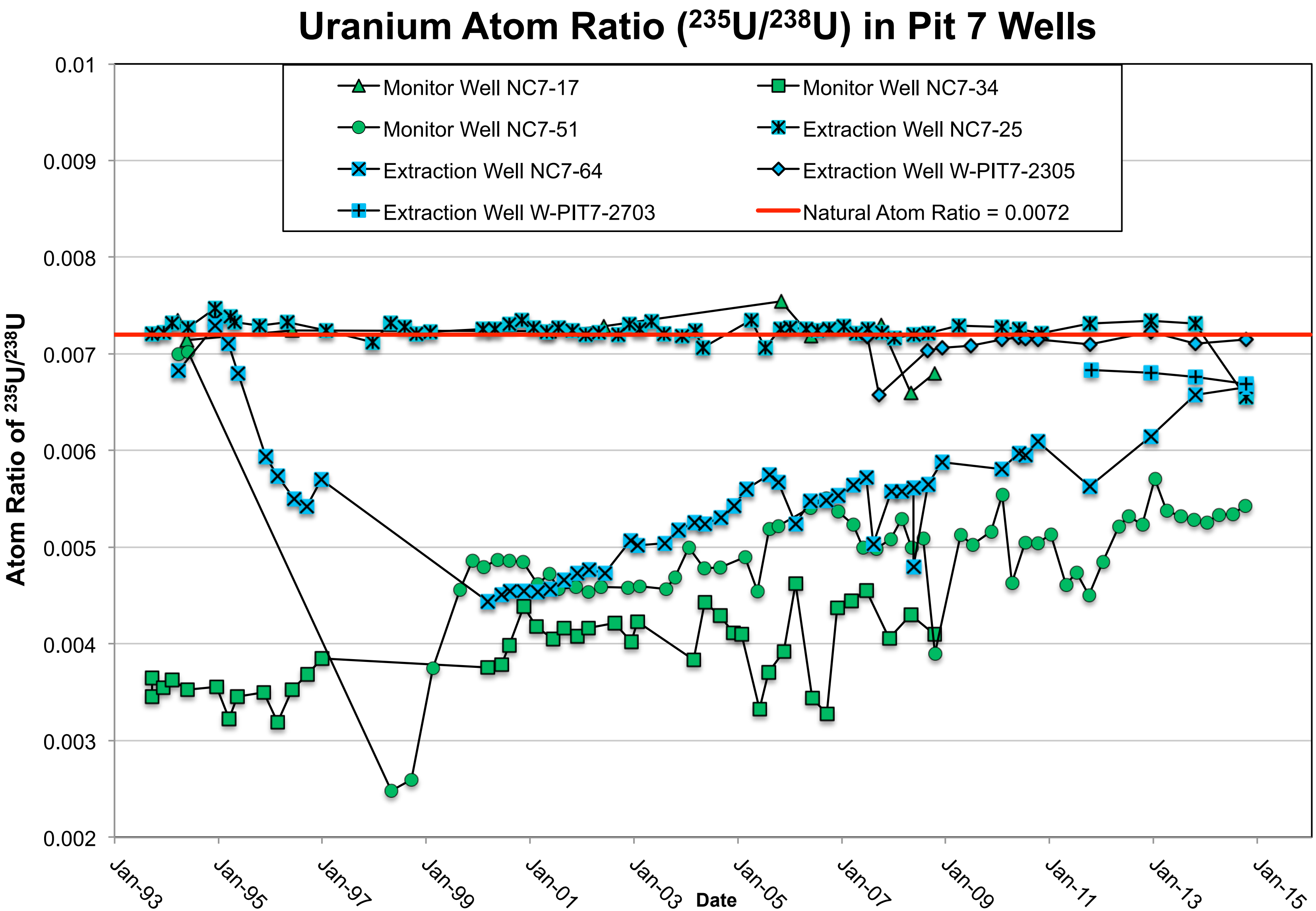


Figure 20b. Time-series plots of $^{235}U/^{238}U$ atom ratios in Pit 7 Complex ground water for selected extraction and monitor wells.

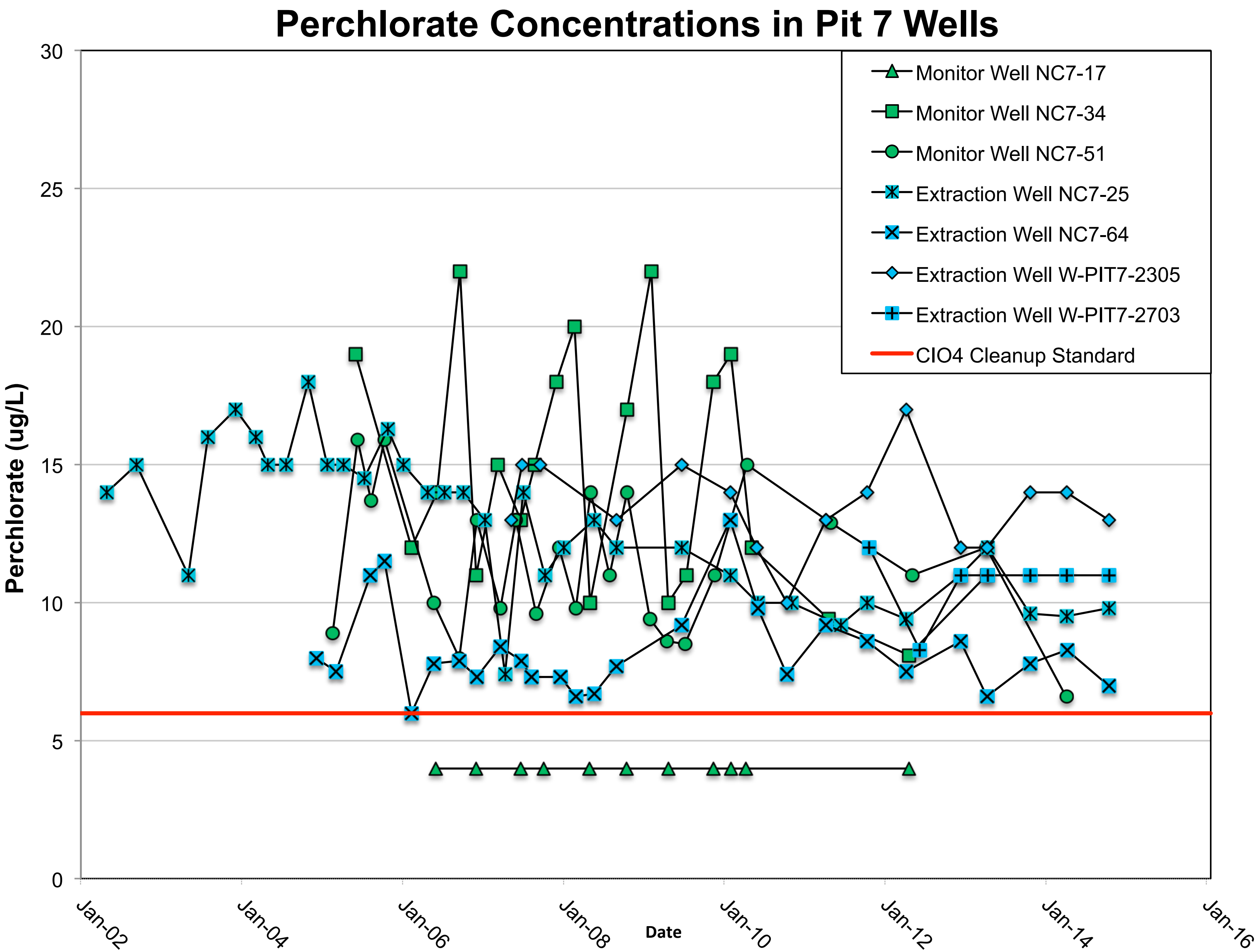


Figure 21. Time-series plots of perchlorate in Pit 7 Complex ground water for selected extraction and monitor wells.

Tables

List of Tables

Table 1. Annual budget and actual costs for the Building 850/Pit 7 Complex Operable Unit for fiscal years 2010 through 2014[a].

Fiscal Year	Annual Budget	Actual Annual Cost	Cost Variance
2010	$1,872,385[b]	$ 3,326,788[b]	-$1,454,403
2011	$962,414[c]	$1,224,502[c]	-$262,088
2012	$1,322,631[d]	$1,161,861[d]	$160,770
2013	$769,896	$761,109	$8,787
2014	$1,091,944[e]	$942,285[e]	$149,659

Notes:

[a] Budget and costs for the Building 850 and the Pit 7 Complex are captured in the same cost account and therefore cannot be presented separately. Activities covered include ongoing inspection and maintenance of the Building 850 Corrective Action Management Unit, the Pit 7 Complex drainage diversion system, and landfill covers/caps; operation and maintenance of the Pit 7-Source treatment facility, compliance monitoring (sample collection and analysis); data management; remedy performance evaluation; and any discrete activities scheduled in an fiscal year (i.e., drilling, wellfield expansions, etc.).

[b] Budget and cost numbers include funding and expenditures for completion of the Building 850 PCB-, dioxin-, and furan-contaminated soil excavation & stabilization removal action. The cost variance was due to: (1) delays in completion of the Building 850 soil removal action and (2) excavation and solidification of additional soil outside of the original planned work scope. The costs were covered by fiscal year 2009 carryover funding for this project and additional funds provided by DOE.

[c] Budget and cost numbers include funding and expenditures for ground water extraction well installation for the Pit 7 Complex and design of the mitigation pond. The cost variance resulted from the need to comply with the requirements of the U.S. Fish and Wildlife Service (USFWS) Biological Opinion for the Building 850 soil removal action. The cost variance was due to the additional unplanned costs for well drilling and mitigation pond design to comply with additional USFWS requirements. Costs were covered by fiscal year 2010 carryover.

[d] Budget and cost numbers include funding and expenditures for installation of a ground water extraction well and the design and construction of a pipeline to connect the additional extraction wells to the Pit 7-Source ground water treatment system. The cost variance was due to the well installation and pipeline design and construction costing less than planned.

[e] Budget and cost numbers include funding and expenditures for construction of a mitigation pond to comply with the requirements of the USFWS Biological Opinion for the Building 850 soil removal action. The cost variance was due to the mitigation pond construction costing less than planned.

Table 2. Description of institutional/land use controls for the Building 850 Firing Table[a].

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.	Tritium, depleted uranium, and nitrate concentrations in ground water exceeding drinking water standards.	There are no existing or planned water-supply wells in the Building 850 Firing Table area. 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents. Contamination is limited to onsite ground water and modeling indicates the plumes will not 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 subsurface soil does not pose an exposure risk to onsite workers.	Potential exposure to tritium and depleted uranium at depth in subsurface soil at the Building 850 Firing Table[b].	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.
Maintain land use restrictions in the vicinity of Building 850 Firing Table until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}.	5×10^{-4} and 1×10^{-4} risk for onsite workers from inhalation or ingestion of resuspended particulates and dermal contact with PCBs, and dioxin and furan compounds in surface soil at the Building 850 Firing Table, respectively.	Current activities in the vicinity of the Building 850 Firing Table are 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 on the firing table. Any significant changes in activities conducted in the Building 850 Firing Table must be cleared through LLNL Work Induction Board. The Work Induction Board coordinates with the LLNL Environmental Restoration Department. **(See next page for risk mitigation update)**

Table 2. Description of institutional/land use controls for the Building 850 Operable Unit[a]. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Maintain land use restrictions in the vicinity of Building 850 Firing Table until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}. (continued)		**Risk Mitigation Update:** Pre-remediation risks of risks of 5 x 10^{-4} and 1 x10^{-4} were calculated for onsite workers from inhalation, ingestion, and dermal contact of PCBs, and dioxin and furan compounds, respectively, in surface soil at the Building 850 Firing Table. These risks were successfully mitigated in 2010 by the removal action in which the PCB-, dioxin-, and furan-contaminated surface soil at Building 850 were excavated, consolidated, and solidified in a CAMU. Therefore, this land use control is no longer needed. However, controls to maintain the integrity of the Building 850 CAMU and prevent worker exposure to contaminated soil in the CAMU are discussed in Section 4.5.1.4.
Maintain land use restriction in the vicinity of Well 8 Spring until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	1 x 10^{-3} risk for onsite workers inhaling tritium volatilizing from Well 8 Spring into outdoor air.	There are currently no active facilities located in the vicinity of the Well 8 Spring and there is no surface water present in the spring. 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 Well 8 Spring. DOE will conduct annual risk re-evaluations when water is present in Well 8 Spring 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 Well 8 Spring area must be cleared through 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.
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated 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.

Table 2. Description of institutional/land use controls for the Building 850 Operable Unit[a]. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. (continued)		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, the 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.

Notes:

DOE = United States Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

LLNL = Lawrence Livermore National Laboratory.

PCB = Polychlorinated biphenyl.

RWQCB = California Regional Water Quality Control Board.

[a] **Table 2 reflects the verbatim language from Table 2.9-17 from the 2008 Site-Wide Record of Decision, with risk reduction and/or mitigation discussion added where appropriate.**

[b] **Risk for onsite worker exposure to tritium and depleted uranium 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 tritium and depleted uranium in subsurface soil during excavation/construction activities conservatively assume that the tritium and depleted uranium in subsurface soil may pose a risk to human health.**

Table 3. Description of institutional/land use controls for the Pit 7 Complex[a].

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated ground water until ground water cleanup levels are met.	Uranium, tritium, nitrate, and perchlorate concentrations in ground water exceeding drinking water standards or California Public Health Goal.	There are no existing or planned water-supply wells in the Pit 7 Complex area. Any proposed onsite well drilling activities will be submitted to the LLNL Work Induction Board, and 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents. Contamination is limited to onsite ground water and modeling indicates the plumes will not migrate offsite. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.
Maintain the integrity of Pit 7 Complex landfill covers and the drainage diversion system as long as the pit waste remains in place.	Potential exposure to contaminants in pit waste[a].	DOE will inspect and maintain the landfill covers and the drainage diversion system, and ground water monitoring systems. Landfill cap maintenance and inspection requirements are specified in post-closure plans for the landfills and will be included in the revision to the Site-Wide Compliance Monitoring Plan/Contingency Plan for LLNL Site 300.
Control construction and other ground-breaking activities on the Pit 7 Complex landfills 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, 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents. In addition, health and safety procedures will be developed as part of the Remedial Design Report for the Pit 7 Complex for both construction and long-term maintenance of the remedial action to ensure worker safety and the proper handling of all hazardous materials.

Table 3. Description of institutional/land use controls for the Pit 7 Complex[a]. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/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 7 Complex Landfills remain in place.	Potential exposure to contaminants in pit waste[b].	There are currently no active facilities located in the vicinity of the Pit 7 Complex. Signage is in place and will be maintained at the Pit 7 Landfill Complex 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.
Maintain access restrictions and activities at the Pit 3 Landfill to prevent onsite site worker inhalation exposure to tritium until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	4×10^{-6} risk to onsite workers from inhalation of tritium from subsurface soil in the vicinity of the Pit 3 Landfill.	There are currently no active facilities located in the vicinity of the Pit 7 Complex, and the Pit 3 Landfill was closed and covered with native soil fill in 1967. Current activities in the vicinity of the Pit 3 Landfill are restricted to quarterly sampling of monitor wells. 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 the Pit 3 Landfill. Any significant changes in activities conducted in the vicinity of the Pit 3 Landfill 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 or engineered control requirements to prevent exposure. Signage is in place and will be maintained at the Pit 7 Landfill Complex 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. All 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 is notified and provides project hazard control requirements to prevent exposure during construction. These access restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.

Table 3. Description of institutional/land use controls for the Pit 7 Complex[a]. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Access restrictions continued.		DOE will conduct annual risk re-evaluations to determine when the tritium inhalation risk at the Pit 3 Landfill has been mitigated. The risk re-evaluations mechanism, methodology, and frequency will be documented in the Remedial Design Report for the Pit 7 Complex. **Risk Mitigation Update:** A pre-remediation risk of 4 x 10^{-4} was calculated for onsite workers from inhalation of tritiated water vapor evaporating from subsurface soil by onsite workers in the vicinity of the Pit 3 Landfill. However, radioactive decay continues to reduce the mass of tritium in subsurface soil at the Pit 3 Landfill, thereby reducing the flux of tritium vapors to air. As discussed in Section 3.5.2.2, the tritium inhalation risk for onsite workers was recalculated in 2007, accounting for tritium decay that occurred between 1992 and 2007. An excess cancer risk of 8 x 10^{-7} was estimated for a worker spending 8 hours a day, 5 days a week for 25 years at the Pit 3 Landfill. Therefore, there is no longer an unacceptable risk to onsite worker health posed by tritium evaporating from the Pit 3 Landfill, and this land use control is no longer needed.
Prohibit transfer of lands at Site 300 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 (as described in Section 2.8.2). 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 the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.

Notes appear on the following page.

Table 3. Description of institutional/land use controls for the Pit 7 Complex[a]. (Continued)

Notes:

DOE = **United States 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.**

[a] Table 3 reflects the verbatim language from Table 2.9-18 from the 2008 Site-Wide Record of Decision, with risk reduction and/or mitigation discussion added where appropriate.

[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.

Appendix A

Appendix A

Appendix A1

Building 850

Five-Year Review Inspection Checklist Photographs

Building 850 Corrective Action Management Unit (CAMU)
Construction Photographs

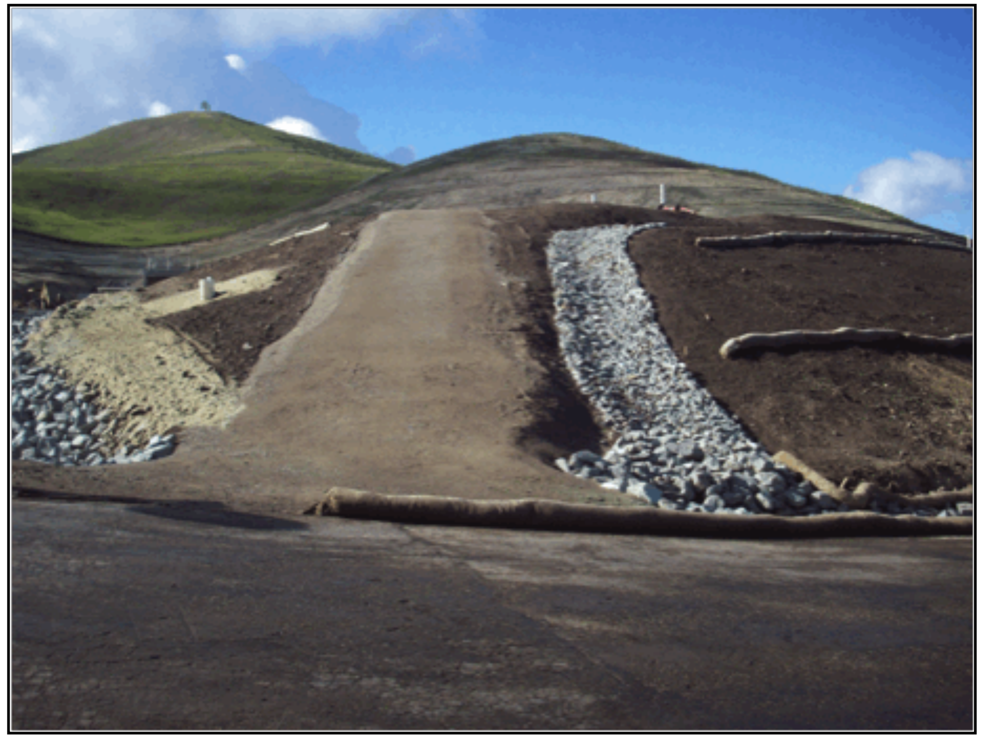
In the early 1960s, about 1,000 capacitors were destroyed during testing at the Building 850 Firing Table, contaminating soil on the surrounding hillsides with polychlorinated biphenyls (PCBs), dioxins, and furans. (Photograph of Building 850 Firing Table area prior to CERCLA soil removal action.)

In 2009, 29,000 cubic yards of PCB-, dioxin-, and furan-contaminated soil was excavated from the Building 850 Firing Table area as a CERCLA removal action.

The excavated contaminated soil was mixed with Portland cement and water to solidify the soil, thereby mitigating the exposure risk to onsite workers and ecological receptors.

The mixing and compaction of soil and cement was conducted manually around existing ground water monitor wells located within the footprint of the CAMU to protect the integrity of the wells.

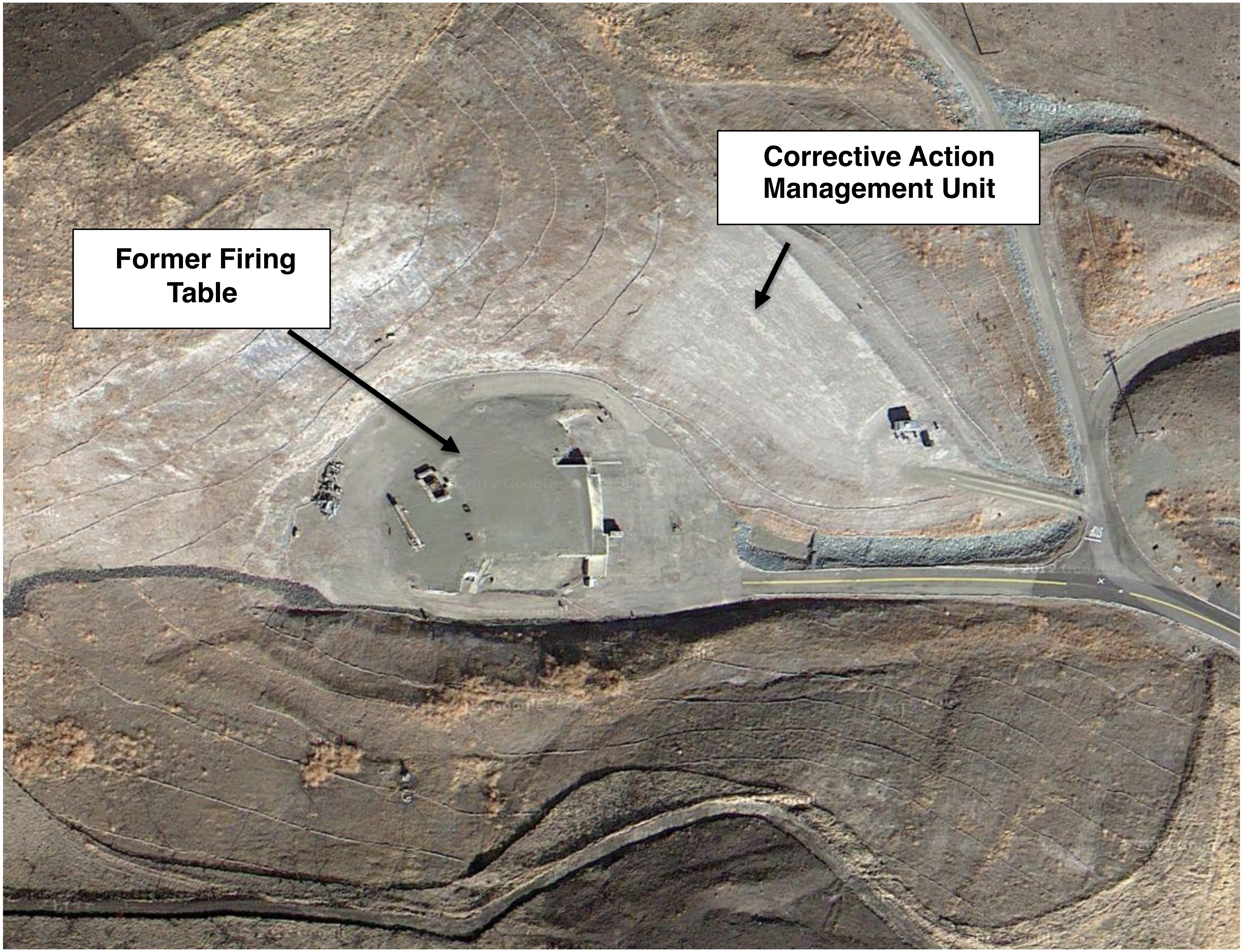
Surface water drainage on the east side of the CAMU.



Surface water drainage from the top to the base of the CAMU.

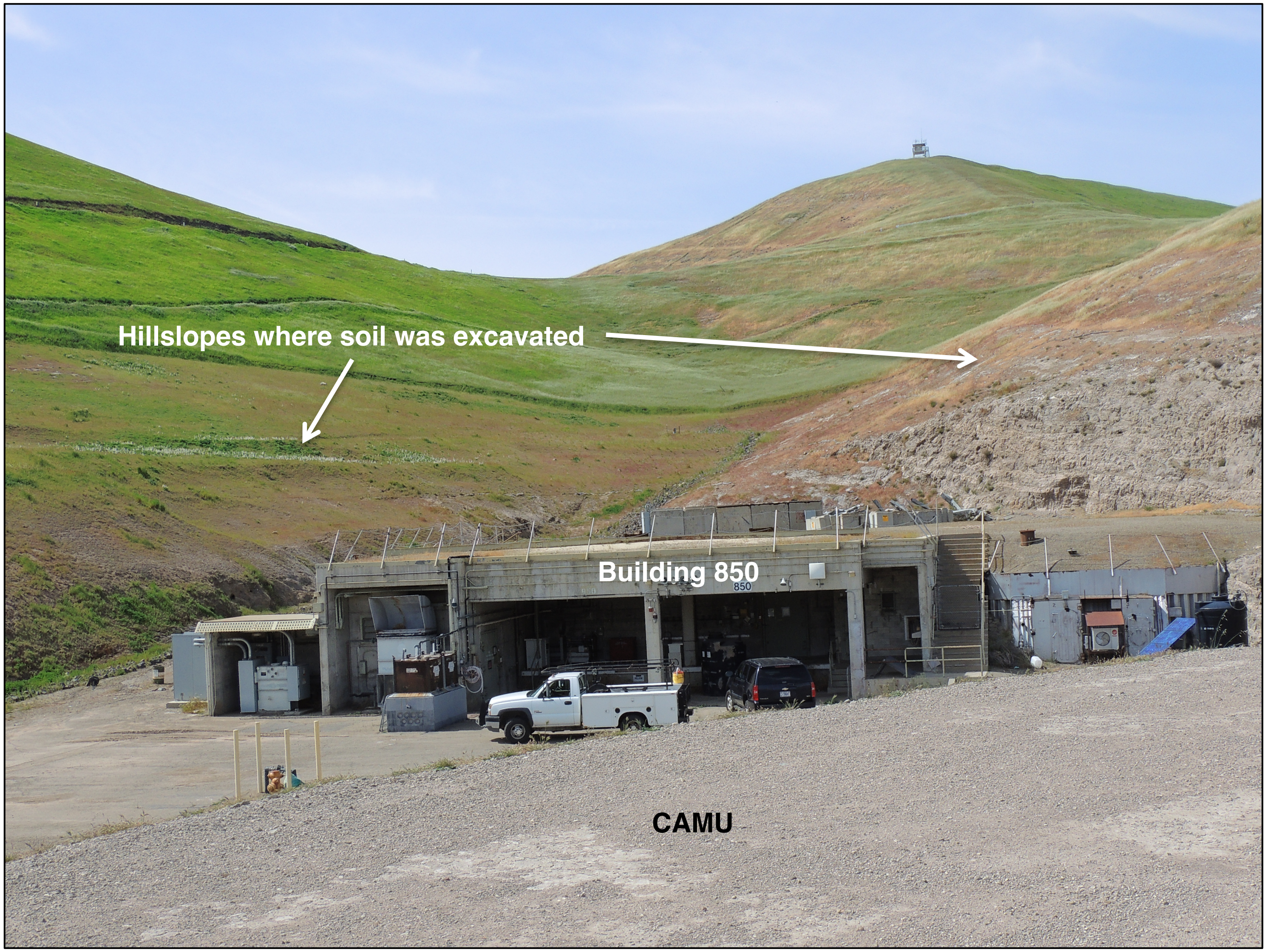
A drainage system was constructed on and around the perimeter of the CAMU to convey surface water runoff away from the CAMU.

Construction of the CAMU was completed in December of 2009 (View from hillslope north of the CAMU).



Aerial view of Building 850 CAMU following completion of soil excavation and CAMU construction.

Current photographs of the Building 850
Corrective Action Management Unit (CAMU)

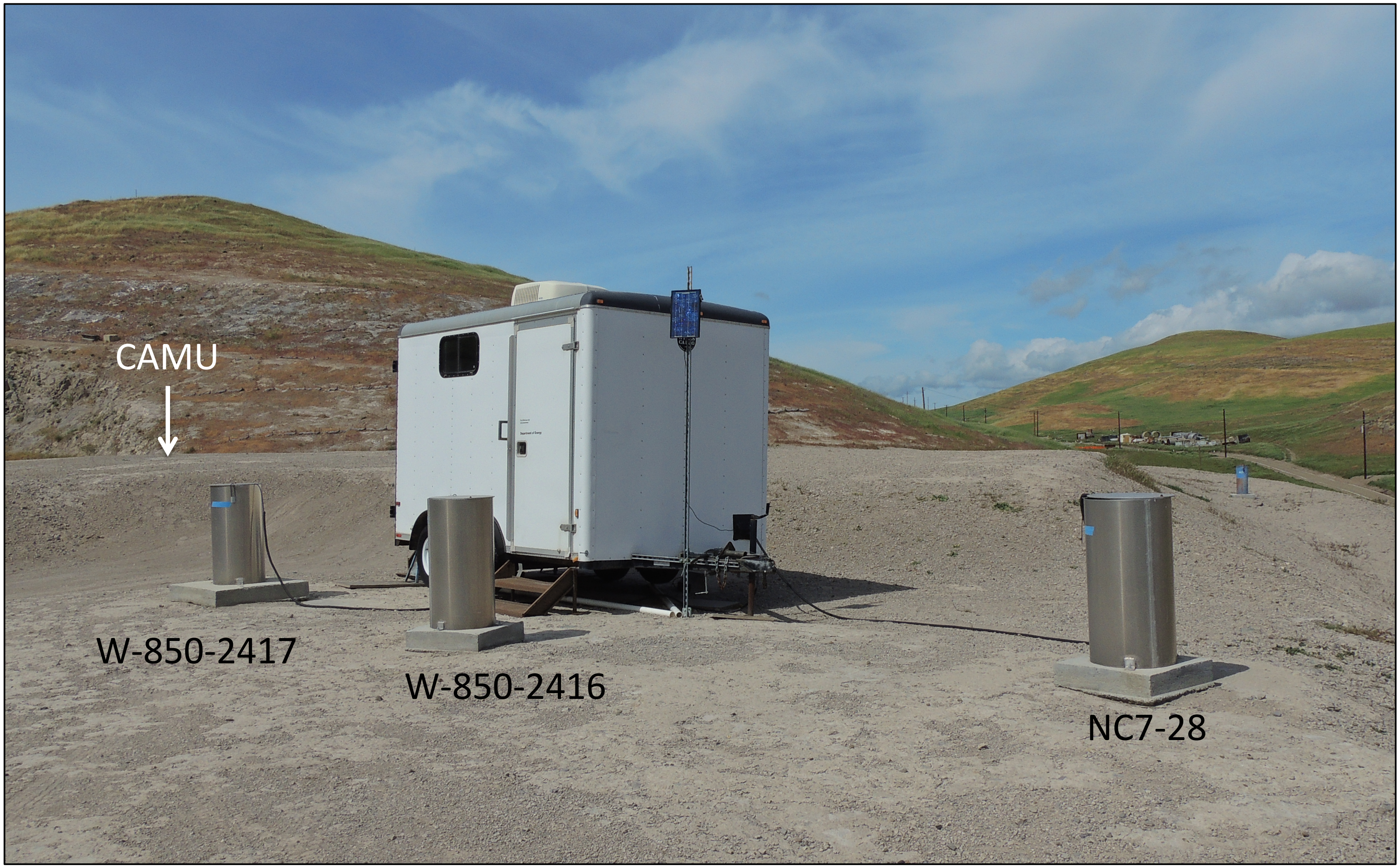


Use of Building 850 and its firing table were discontinued in 2008. The building is "cold and dark".

Photograph of top surface of Building 850 CAMU (looking south).

Photograph of Building 850 CAMU (looking east).

East side of Building 850 CAMU from the top of the CAMU (Looking north).



Ground water monitor wells within the CAMU.

Photograph of drainage channel on south side of CAMU (looking east).

Drainage system channel on the east side of the CAMU.

Drainage culvert under road.

Appendix A2

Building 850 Five-Year Review
Site Inspection Checklist

Appendix A2
Building 850 Portion of the Building 850/Pit 7 Complex Operable Unit Five-Year Review Site Inspection Checklist Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Building 850 portion of the Building 850/Pit 7 Complex Operable Unit (OU), LLNL Site 300

Date of inspection: March 24, 2015

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:

- Excavation, and onsite solidification and consolidation of contaminated soil into a Corrective Action Management Unit (CAMU) to mitigate risk to onsite workers and ecological receptors.
- Monitoring Natural Attenuation (MNA) of tritium in ground water.
- Monitoring of ground water and surface water contaminants of concern to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls for Building 850 specified in Table 2 of the Five-Year Review.
  - Inspect the Building 850 CAMU for damage that could compromise the integrity and repair any damage found.
  - Prevent onsite workers exposure to tritium evaporating from surface water in Well 8 Spring.
  - Sample outdoor ambient air annually for tritium near Well 8 Spring when surface water is present and re-evaluate risk until risk $<10^{-6}$ for 2 consecutive years.

Site Map: See Building 850/Pit 7 Complex Five-Year Review Figures 1, 2, and 3.

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), the LLNS Site 300 ER Program Leader, and the Site 300 ER Field Operations Manager, the oversight, inspections, evaluations, and discussions of the Building 850 remedy are ongoing. Remedy performance, CAMU 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, and 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 checklist is a compilation of this and other routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the Building 850 remedy. In addition, DOE/LLNS presents and discusses any CAMU inspection and maintenance, ground water monitoring, 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 Radyk, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).
- Larry Griffith, Site 300 ER CAMU inspection and maintenance coordinator (LLNS).
- 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 Field Operations and Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Building 850 remedy are ongoing. Any CAMU, monitor well, or other remedy 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, and 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 routine inspections, evaluations, and discussions regarding the Building 850 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:	Readily available
As-built drawings:	Readily available
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Building 850 CAMU are maintained in the LLNL Environmental Restoration Department (ERD) files. Inspection and maintenance procedures for the Building 850 CAMU are described in the Inspection and Maintenance Plan for the Building 850 Containment Embankment (CAMU) (SCS Engineers, 2010). ERD staff perform inspections of the CAMU and its surface water drainage channels annually and after each major storm. CAMU maintenance is performed by the LLNS ER Department and/or Maintenance Department as necessary. Inspections and maintenance activities for the CAMU are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports.

The ground water monitor well network for the Building 850 area is routinely inspected during semi-annual sampling activities. Maintenance activities for the monitoring network included pump replacements, repairing rodent damage to wiring, and general wellhead maintenance on an as-needed basis. Monitor well maintenance activities 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 850 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.

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 850 CAMU or monitoring network.

5. Gas Generation Records

Gas Generation Records:	Not applicable

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 850 portion of the Building 850/Pit 7 Complex 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

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: Readily available and up-to-date

Remarks: The entire perimeter of Site 300, including the Building 850 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). The Building 850/Pit 7 Complex OU is entirely surrounded by Site 300 property and does not extend to the site boundary. The OU is accessible only to DOE/LLNL workers. The only building located within the OU boundary is the bunker at the Building 850 Firing Table. Building 850 was closed and is no longer in use. There are no current plans to reactivate this building or firing table. There are no fulltime workers housed in this area. Occasional workers in this area include environmental restoration staff conducting monitoring, characterization, and remediation activities; and LLNL fire department personnel during controlled burns in the area.

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 850/Pit 7 Complex OU during the review period (2010-2014) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Building 850/Pit 7 Complex 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

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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)

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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: March 24, 2015

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 Land Use Controls section (4.5) of the Building 850/Pit 7 Complex Five-Year Review for further details on institutional controls.

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2. Adequacy

ICs are adequate: Yes

Remarks: Refer to the Land Use Controls section (4.5) of the Building 850/Pit 7 Complex 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 850/Pit 7 Complex OU during the five-year review period or since the 2008 Site-Wide Record of Decision and none are anticipated. Most of the land in the OU is undeveloped and is not used for LLNL programmatic activities. The only LLNL building located within the OU boundary is located in the Building 850 area, but it is not currently used or occupied. See the Land and Resource Use section (3.2) of this Five-Year Review for additional details.

3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Building 850/Pit 7 Complex OU is entirely surrounded by Site 300 property and does not extend to the site boundary. Land use adjacent to the site boundary closest to the Building 850/Pit 7 Complex OU consists of private rangeland. There is no known planned modification or proposed development of the offsite rangeland closest to (north and west of) the OU. There are plans to develop the land parcel east of Site 300 for residential housing, but thus far the development plans have been delayed by city restricted growth initiatives. As part of this development plan, a minimum buffer zone/open space of a mile to 1.5 miles is planned between residential development and the Site 300 boundary. DOE/LLNL was informed by the developer that ground water would not be used as the water-supply for this development. See the Land and Resource Use section (3.2) of this Five-Year Review for additional details.

VI. GENERAL SITE CONDITIONS

A. Roads

1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 850/Pit 7 Complex OU is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Building 850 CAMU and associated drainage system, and monitor wells are in good condition.

VII. LANDFILL COVERS — Not applicable

VIII. VERTICAL BARRIER WALLS — Not applicable

IX. GROUND WATER/SURFACE WATER REMEDIES — Applicable

A. Ground Water 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

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 tritium in Building 850 ground water. Samples are collected annually and reported in the Compliance Monitoring Reports.

* An old lysimeter (NC7-09) was identified as unlabeled during the field checklist inspection. This lysimeter is no longer functional or used and will be scheduled to be decommissioned.

X. OTHER REMEDIES

A Corrective Action Management Unit (CAMU) was designed and constructed to mitigate risk to onsite workers and ecological receptors from exposure to PCBs, dioxins, and furans in surface soil in the Building 850 Firing Table area. Approximately 29,000 cubic yards of PCB-, dioxin-, and furan-contaminated soil were excavated from the

Building 850 Firing Table area, mixed with Portland cement and water to solidify it, and consolidated in a CAMU.

Inspection and maintenance of the CAMU during the five-year review period is discussed in detail in Section 4.2.1 of this Five-Year Review. Photographs of the CAMU are included in Appendix A1.

A. CAMU 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	Not applicable
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 Monitor wells

Remarks: Three ground water monitor wells were in place during the construction of the CAMU. The CAMU was constructed to leave in-place and maintain the integrity of these wells. Photographs of these well during and after CAMU construction are presented in Appendix A1.

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 Perimeter Ditch Applicable

Remarks: Photographs of the CAMU drainage system during and after construction are presented in Appendix A1.

1. Siltation Siltation not evident

Remarks: The CAMU drainage system is inspected for the accumulation of sediment/silt during the rainy season, and sediment/silt is periodically removed, as needed.

2. Vegetative Growth No vegetation impeding flow

3. Erosion Erosion not evident

4. Discharge Structure Functioning

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 Building 850 is intended to contain contaminant sources and reduce contaminant concentrations in ground water to cleanup standards. A removal action mitigated PCB, dioxin, and furan exposure risk to onsite workers. Refer to the Section 4.1 of the Five-Year Review for further details on the remedial action objectives.

The inspection determined that the remedy at Building 850 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 850/Pit 7 Complex OU Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for Building 850 were identified during this field inspection. 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 inspection and maintenance procedures for the Building 850 CAMU or monitoring network from this field inspection or records review.

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 from this inspection that suggest that the protectiveness of the remedy at Building 850 may be compromised in the future. 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.

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:
No opportunities for remedy optimization were noted during this inspection. However, the following opportunities for future remedy maintenance were noted:

1. Use of a pre-emergent herbicide in the drainage channels on the perimeter of the CAMU would reduce maintenance labor and enhance the flow of surface water runoff during rain events.

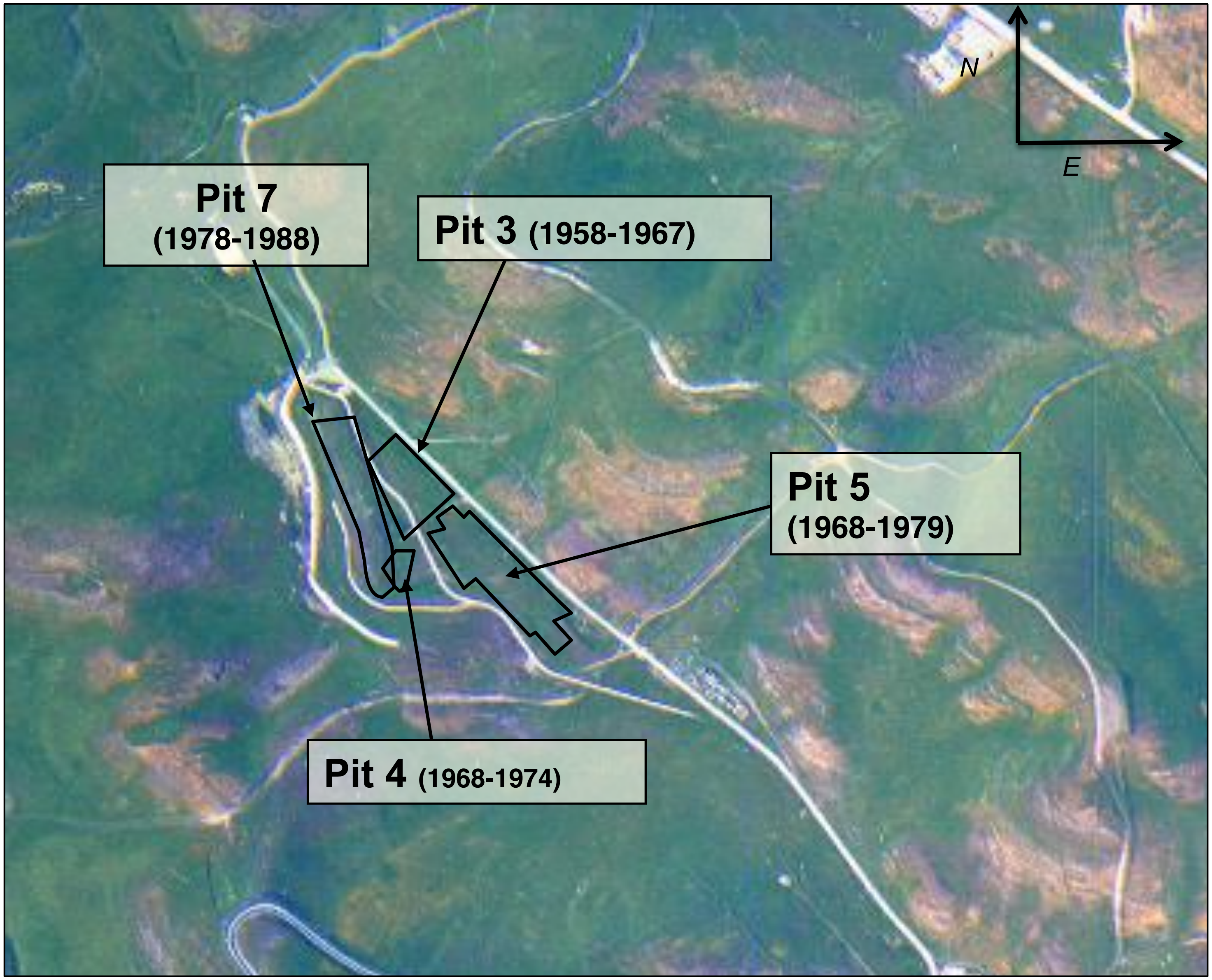
Appendix A3

Pit 7 Complex
Five-Year Review Inspection Checklist Photographs

Pit 7 Complex
Five-Year Review Inspection Checklist Photographs

- **Pit 7 Complex Landfills**
- **Drainage Diversion System**
- **Ground Water Extraction and Treatment System**

Pit 7 Complex Landfill Covers/Cap

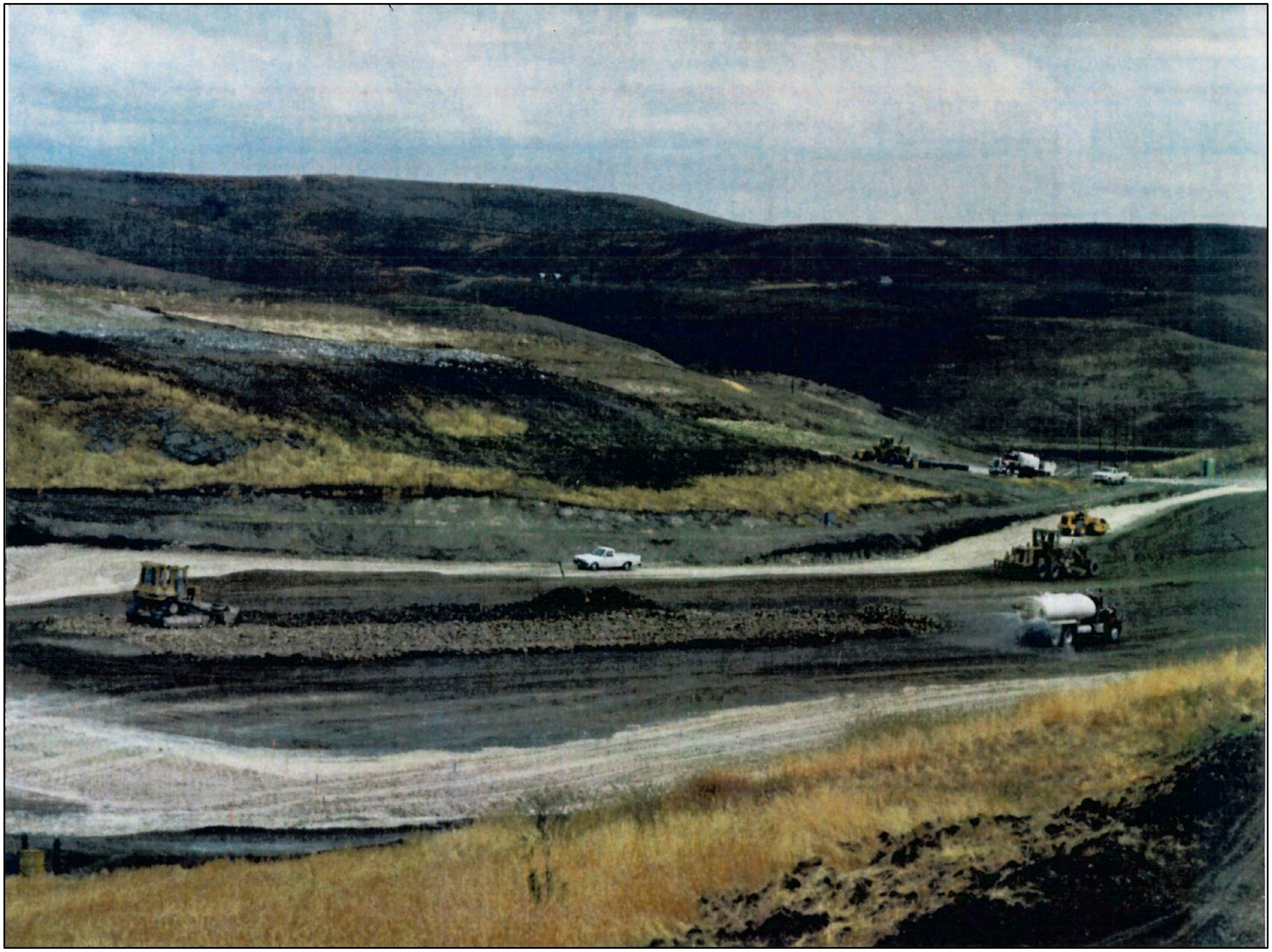


Aerial view of the Pit 7 Complex.

The Pit 7 Complex Landfills were used from 1958 to 1988 to dispose of firing table debris and gravel

Photograph of the Pit 7 Landfill while debris from firing table experiments was still being placed in the landfill.

Pit 7 Complex Landfills (Engineered cap construction)



Construction of the landfill cap at the Pit 7 Complex (1992).

Pit 7 Complex Landfills (Engineered cap construction)

Excavation for the surface water drainage for the landfill cap at the Pit 7 Complex (Sept. 1992).

Pit 7 Complex Landfills (Engineered cap construction)

Construction of the surface water drainage for the landfill cap at the Pit 7 Complex (Oct. 1992).

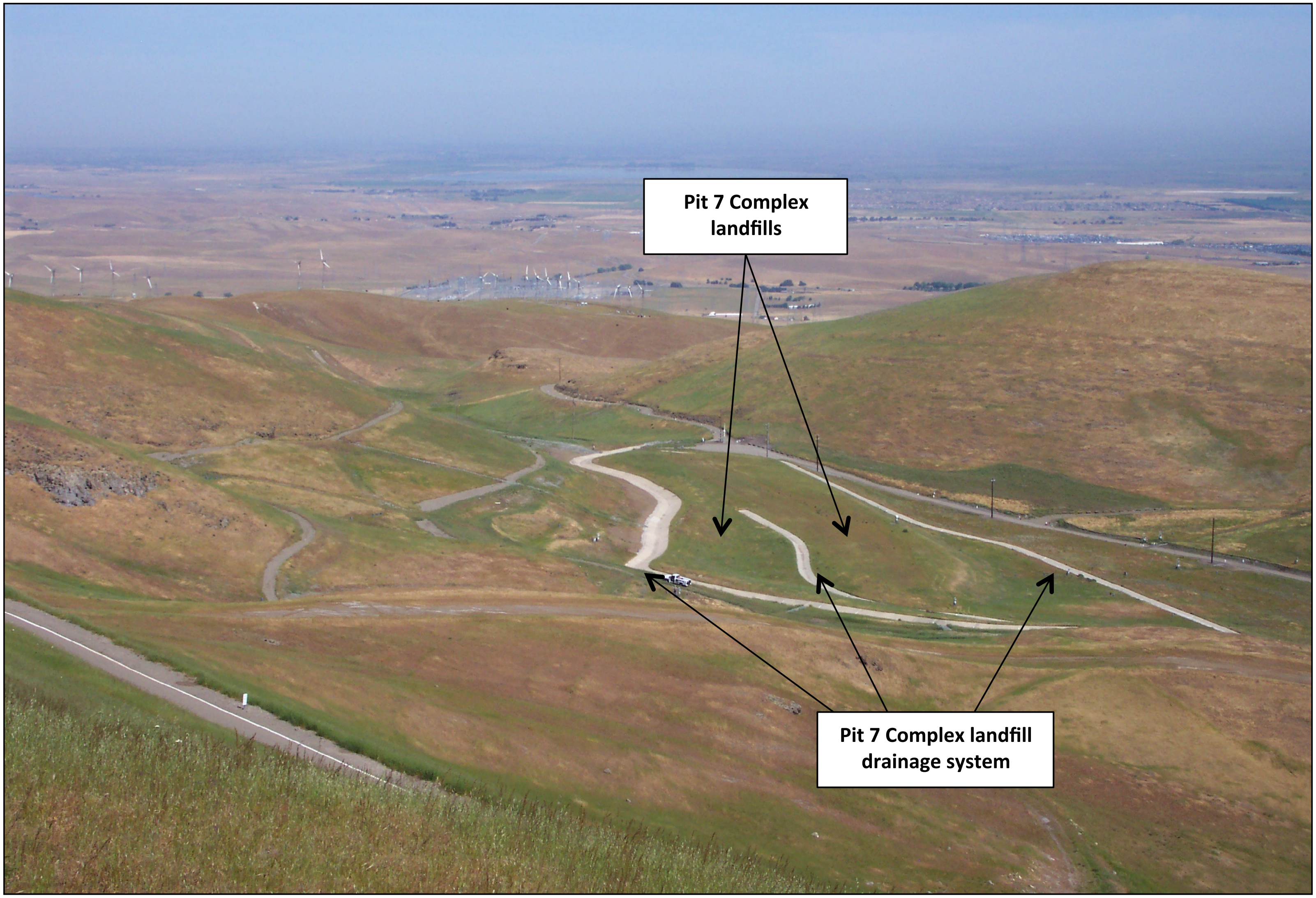
Pit 7 Complex Landfills (Engineered cap construction)

Northern landfill surface water drainage outfall (Northern rip-rap) for the landfill cap at the Pit 7 Complex (Dec. 1992).

Pit 7 Complex Landfills (Engineered cap construction)

Photograph at construction completion of the landfill cap at the Pit 7 Complex (Dec. 1992).

Pit 7 Complex Landfills (post-capping)

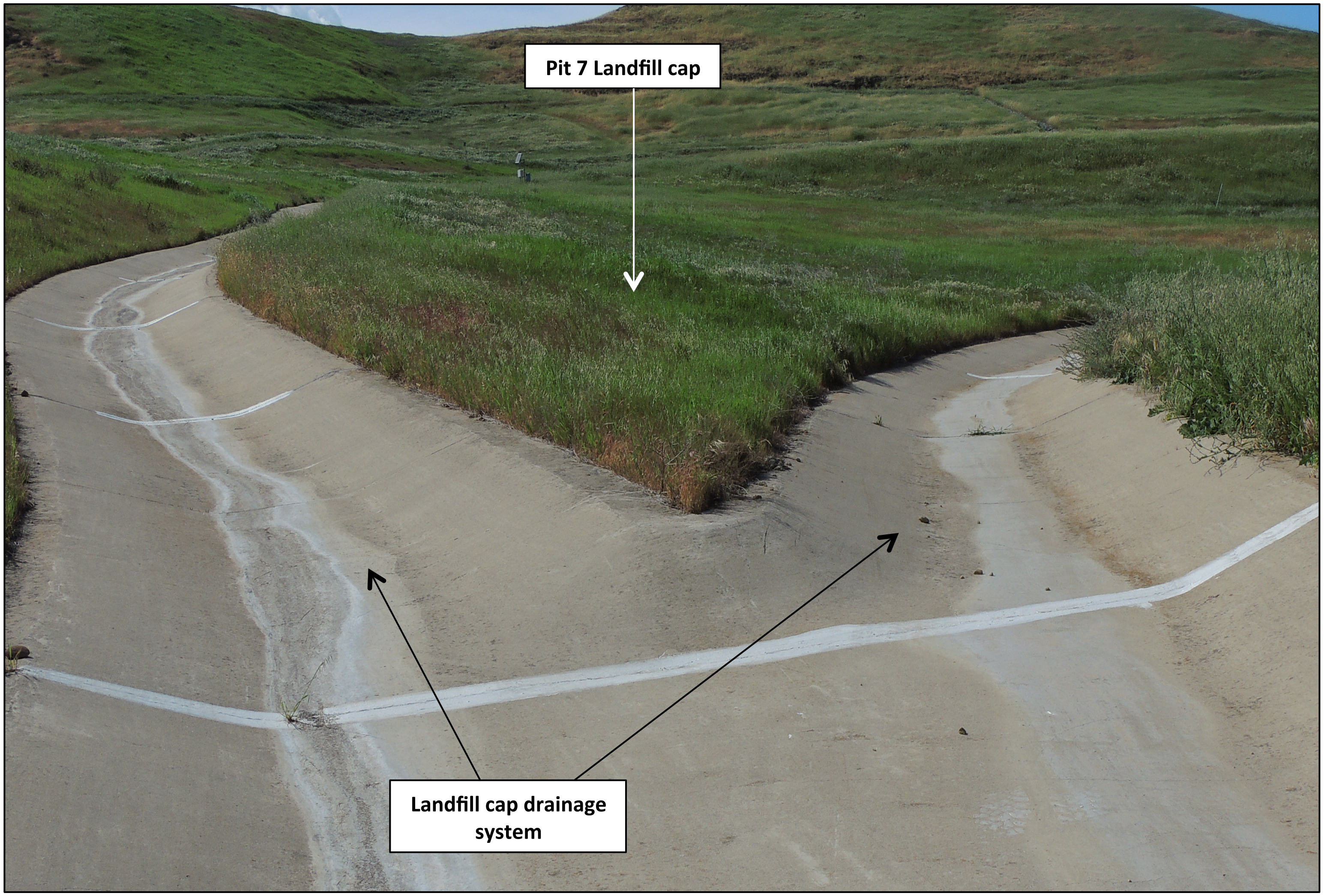


Overview of Pit 7 Complex landfills (looking northeast).

Pit 7 Complex Landfills

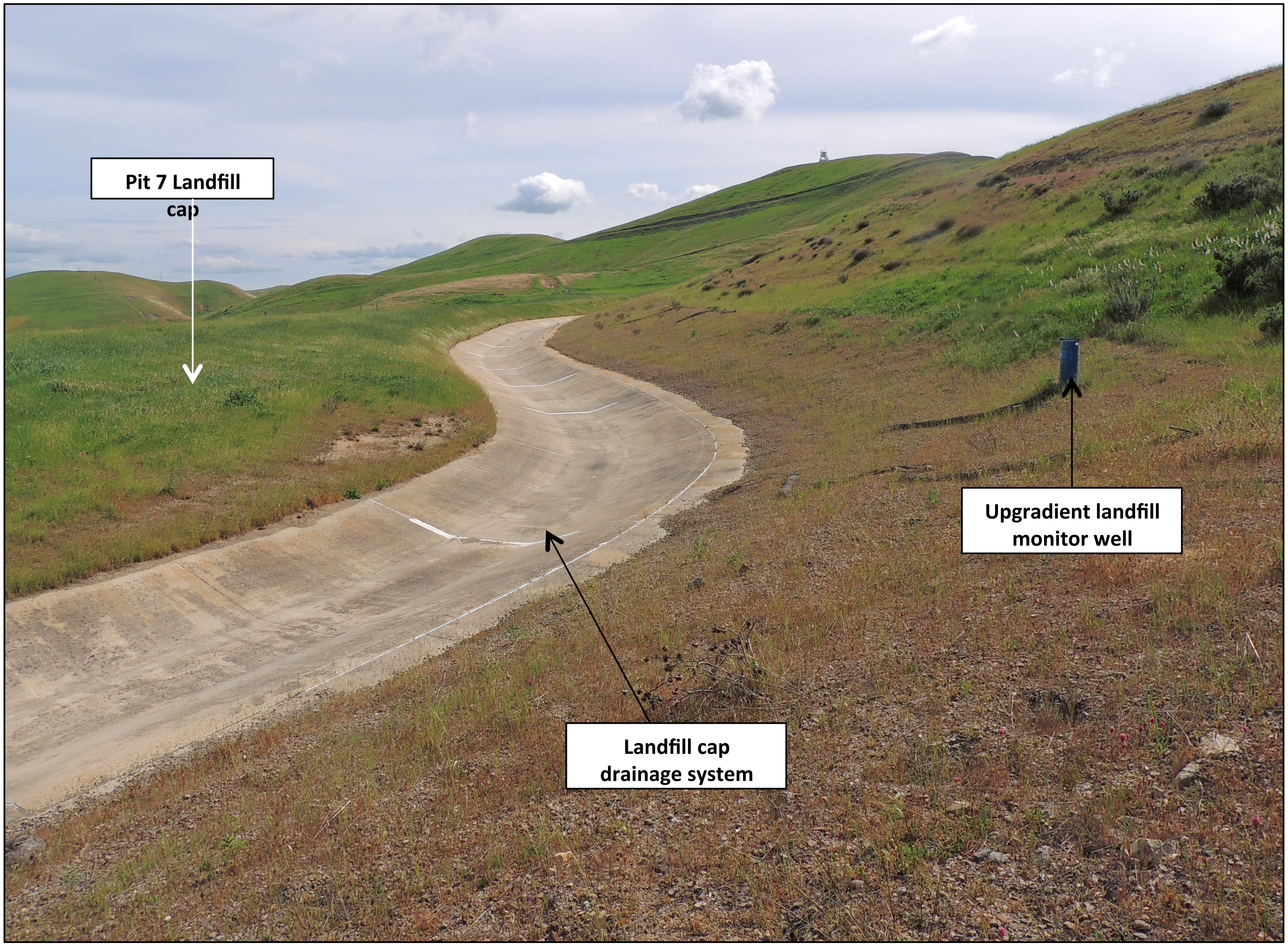
Signage at the Pit 7 Complex landfills (institutional controls).

Pit 7 Complex Landfills (post-capping)



Pit 7 Complex Landfill drainage system (looking north).

Pit 7 Complex Landfills (post-capping)

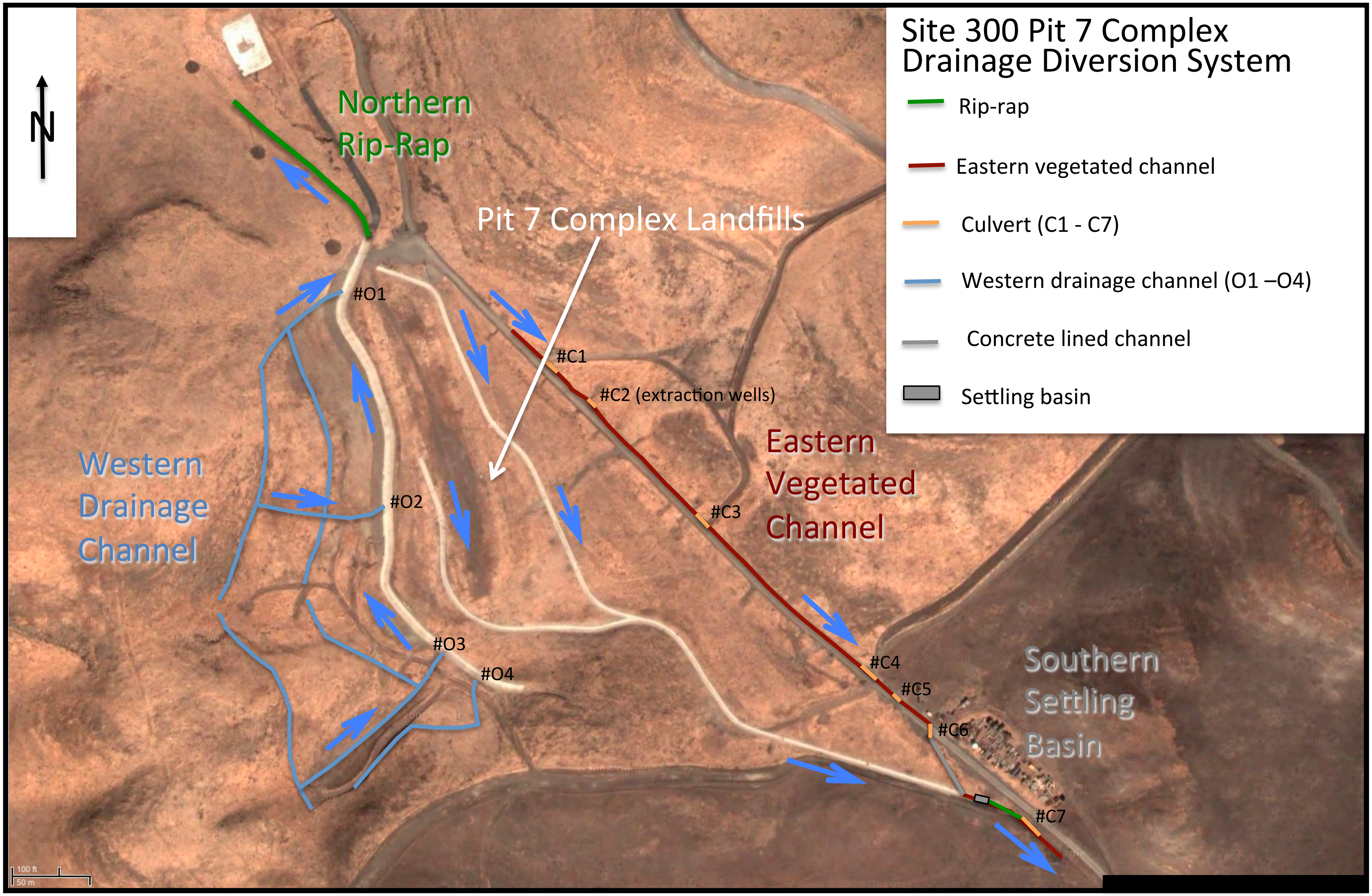


Pit 7 Complex Landfill cap, drainage system, and monitor well (looking south).

Pit 7 Complex Landfills

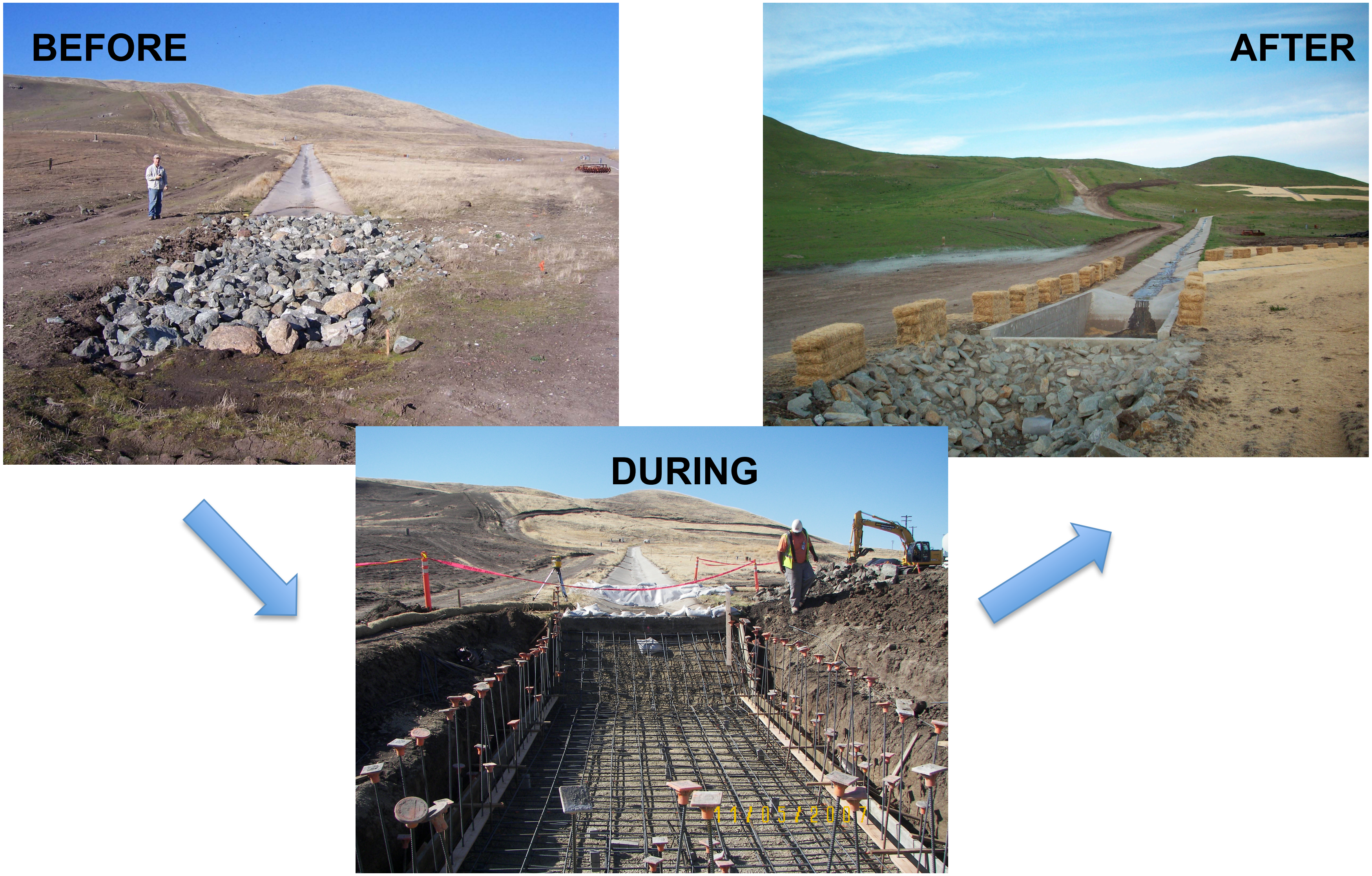
Pit 7 Landfill cap drainage outfall.

Pit 7 Complex Drainage Diversion System



The Drainage Diversion System consists of a series of drainages designed to divert surface and shallow subsurface water away from the Pit 7 Complex landfills to prevent ground water rises into the pit waste.

Drainage Diversion System: Southern Settling Basin



Photographs of the Southern Settling Basin component of the drainage diversion system at the Pit 7 Complex before, during, and immediately after construction.

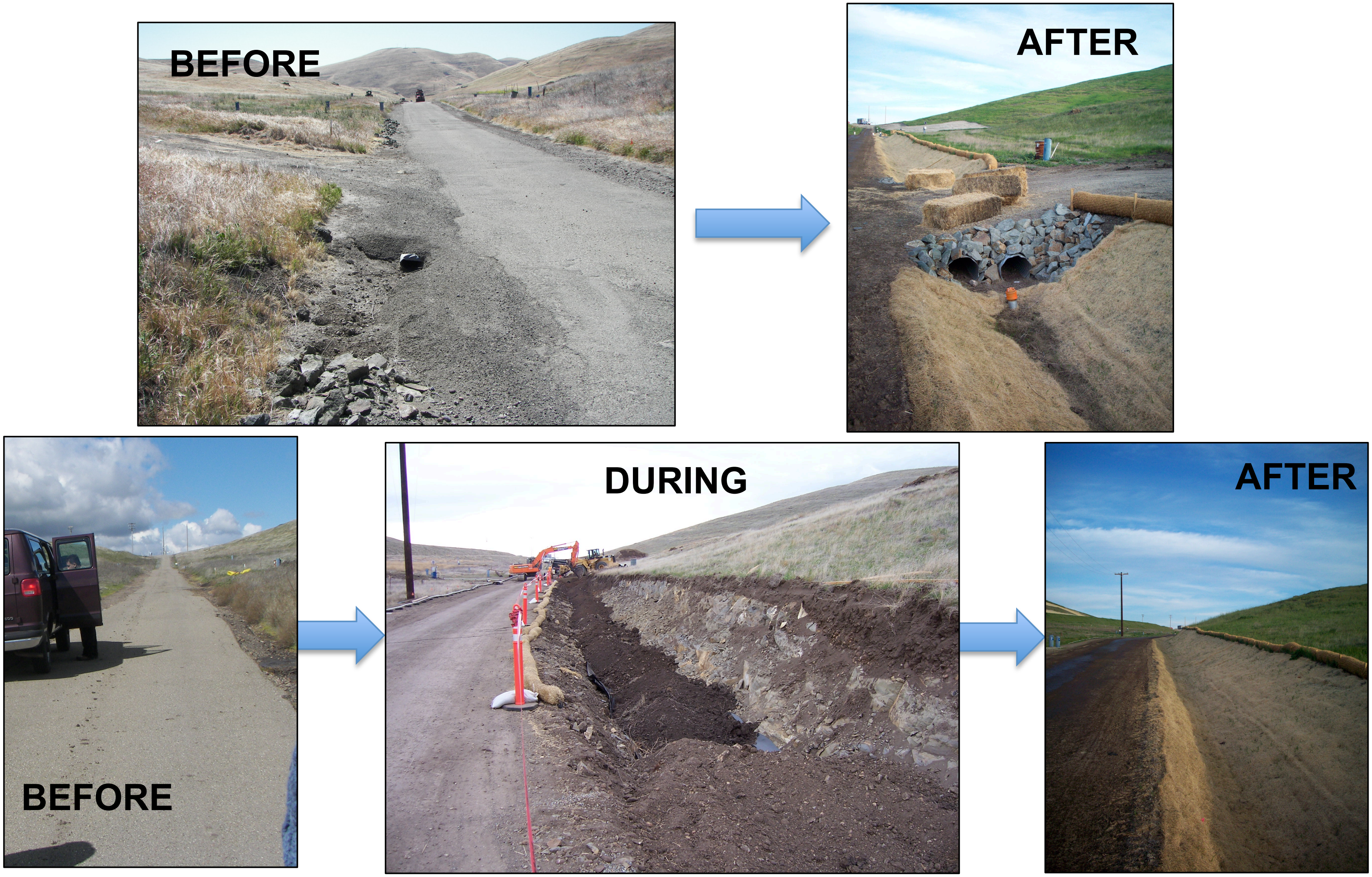
Drainage Diversion System: Southern Settling Basin

Current photographs of the Southern Settling Basin component of the drainage diversion system at the Pit 7 Complex.

Drainage Diversion System: Southern Settling Basin

Current photographs of the Southern Settling Basin component of the drainage diversion system at the Pit 7 Complex (orange fence is to prevent loose vegetation (i.e., tumbleweeds from accumulating in the basin).

Drainage Diversion System: Eastern Vegetated Channel



Photographs of the Eastern Vegetated Channel component of the drainage diversion system at the Pit 7 Complex before, during, and immediately after construction.

Drainage Diversion System: Eastern Vegetated Channel

Current photographs of the Eastern Vegetated Channel component of the drainage diversion system at the Pit 7 Complex.

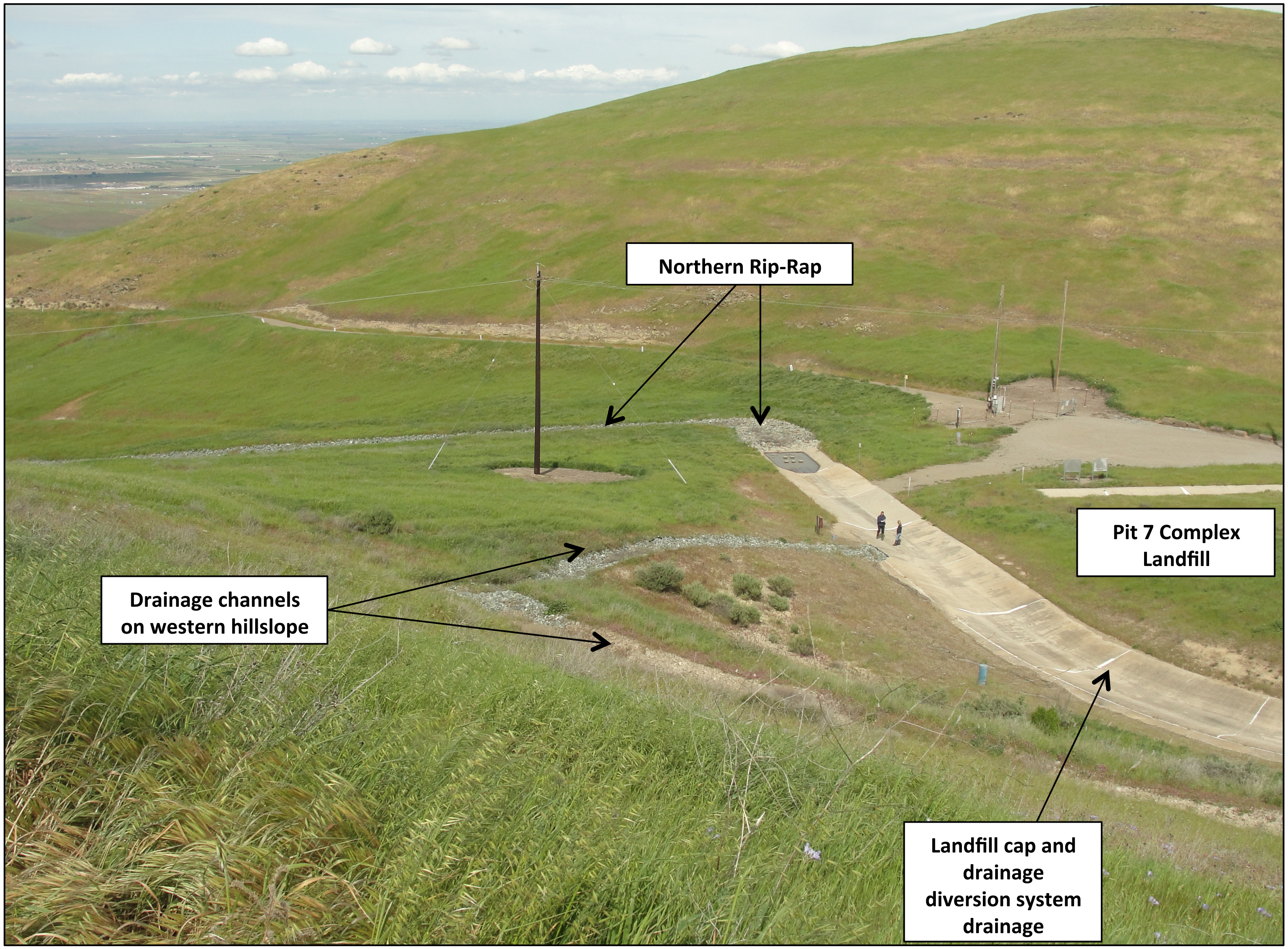
Drainage Diversion System: Northern Rip-rap

Photographs of the Northern Rip-rap component of the drainage diversion system at the Pit 7 Complex before, during, and immediately after construction.

Drainage Diversion System: Northern Rip-Rap

Current photographs of the Northern Rip-Rap component of the drainage diversion system at the Pit 7 Complex.

Drainage Diversion System: Northern Rip-rap



Overview of Northern Rip-Rap and drainages at the Pit 7 Complex landfills.

Drainage Diversion System: Western Drainage Channels

Photographs of the Western Drainage Channel component of the drainage diversion system at the Pit 7 Complex before, during, and immediately after construction.

Drainage Diversion System: Western Drainage Channels

Western hillslope drainage and monitor wells

Western hillslope drainage

Current photographs of the drainage channels on the western hillslope that capture surface runoff and shallow subsurface flow during rainfall events.

Drainage Diversion System: Western Drainage Channels

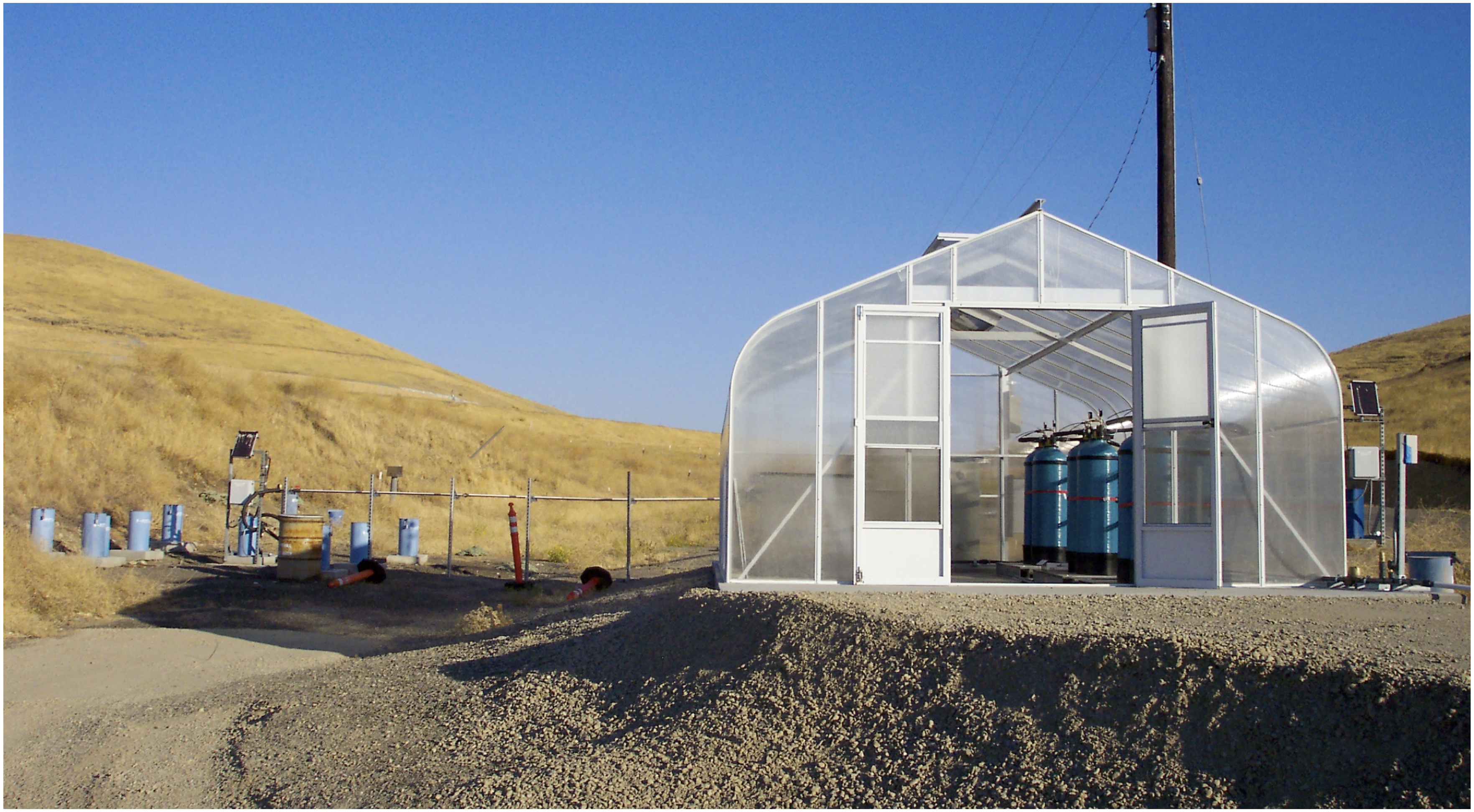
Western hillslope drainage to landfill drainage system

Drainage outfall

Drainages constructed perpendicular to the hillslope convey water from the western hillslope drainage channels to the landfill perimeter drainage system.

Pit 7 Complex Ground Water Extraction and Treatment System

Pit 7 – Source extraction wells and treatment facility enclosure

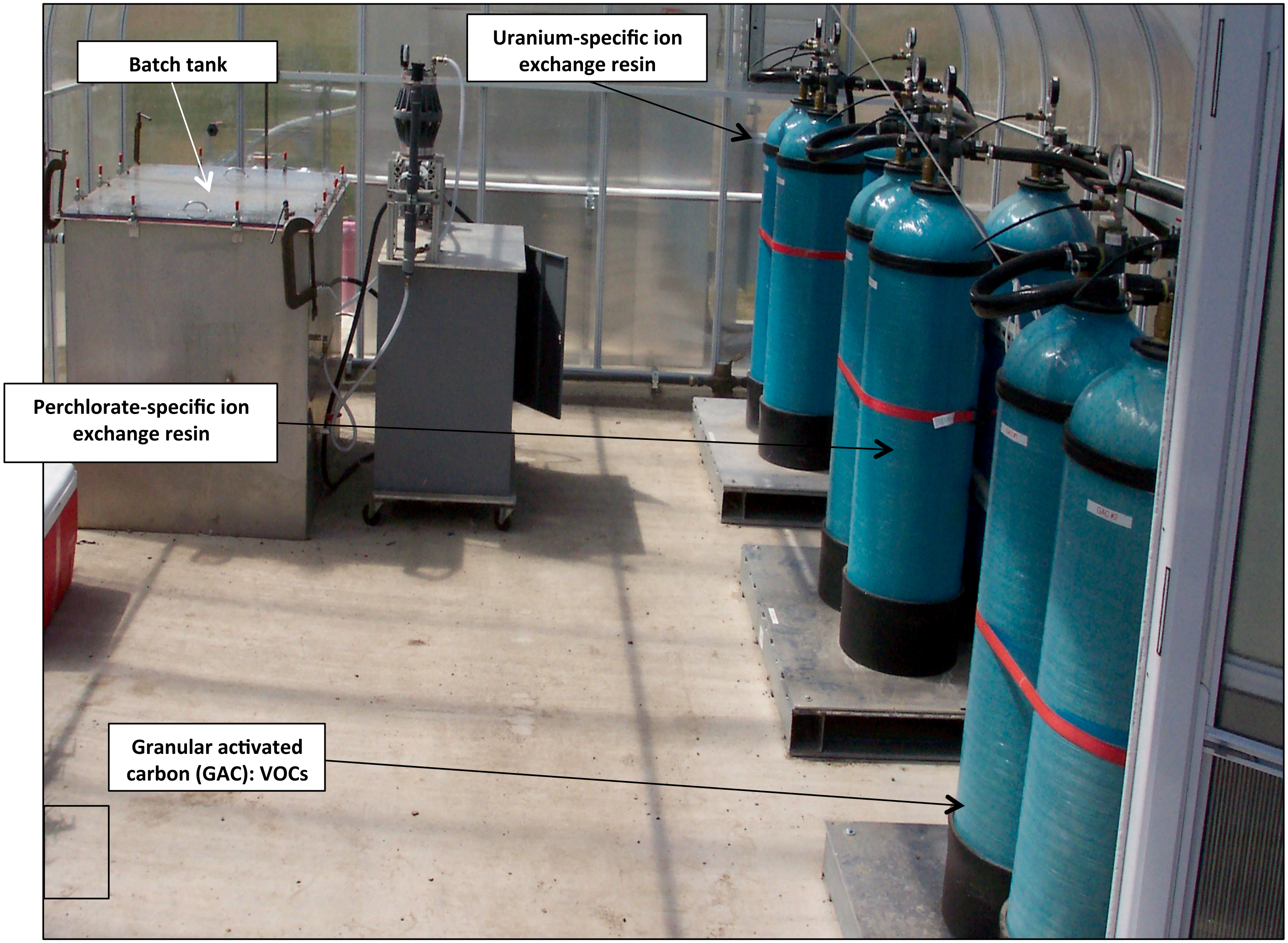


The Pit 7 – Source extraction and treatment system removes contaminants already released to ground water.

Pit 7 – Source extraction well and treatment facility enclosure

Ground water containing VOCs, uranium, perchlorate, nitrate, and tritium is extracted and piped to the Pit 7 – Source ground water treatment system.

Pit 7 – Source treatment media train and batch tank



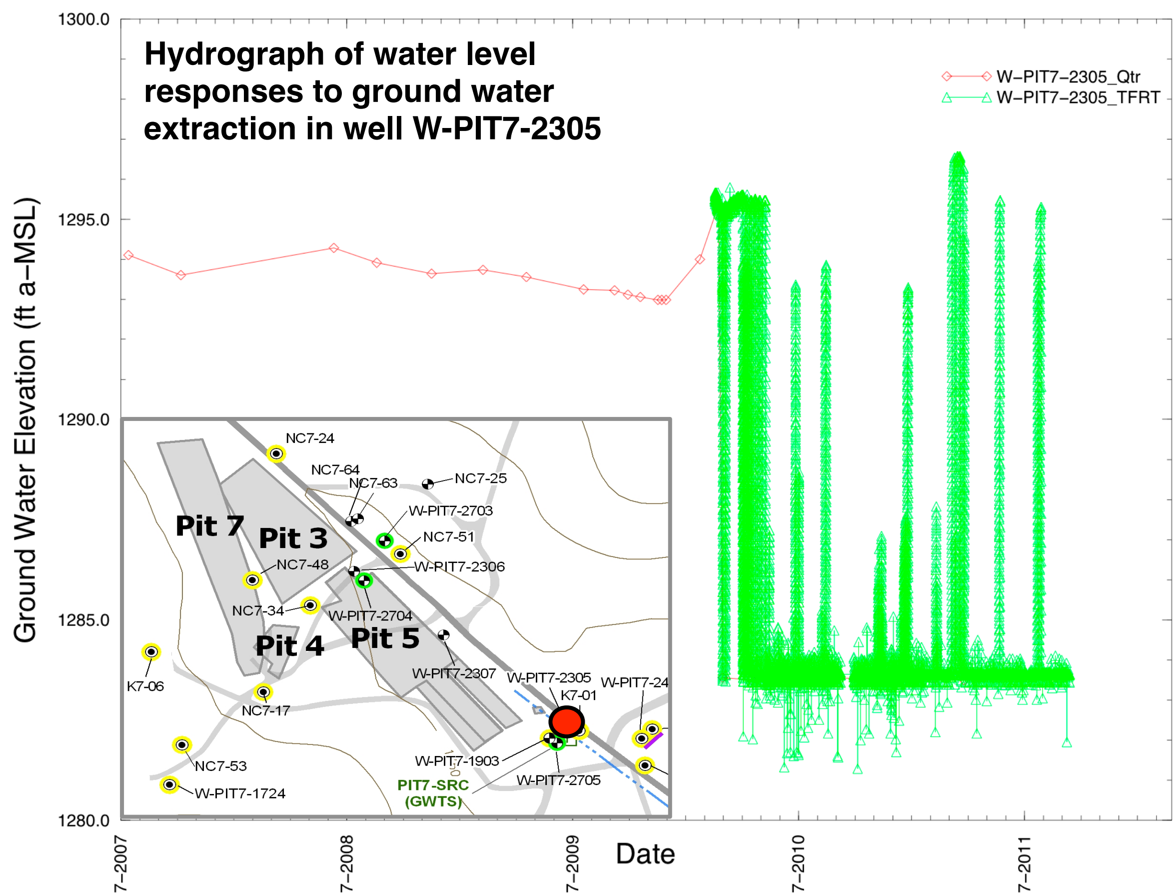
Uranium, VOCs, nitrate, and perchlorate are removed from ground water using GAC and ion-exchange resin. (Photograph of the Pit 7 – Source ground water treatment media train).

Pit 7 – Source concrete containment pad sump

A sump is located at the southeast corner of the containment pad for the Pit 7-Source ground water treatment system. The containment pad floor is sloped so that any liquid spills or leaks flow toward the sump. The sump is outfitted with an alarm that, when fluid is detected, triggers shut down of the treatment system.

Ground water monitoring data is used to evaluate remediation system performance

Wells are monitored to evaluate the effectiveness of both ground water cleanup and the drainage diversion system.

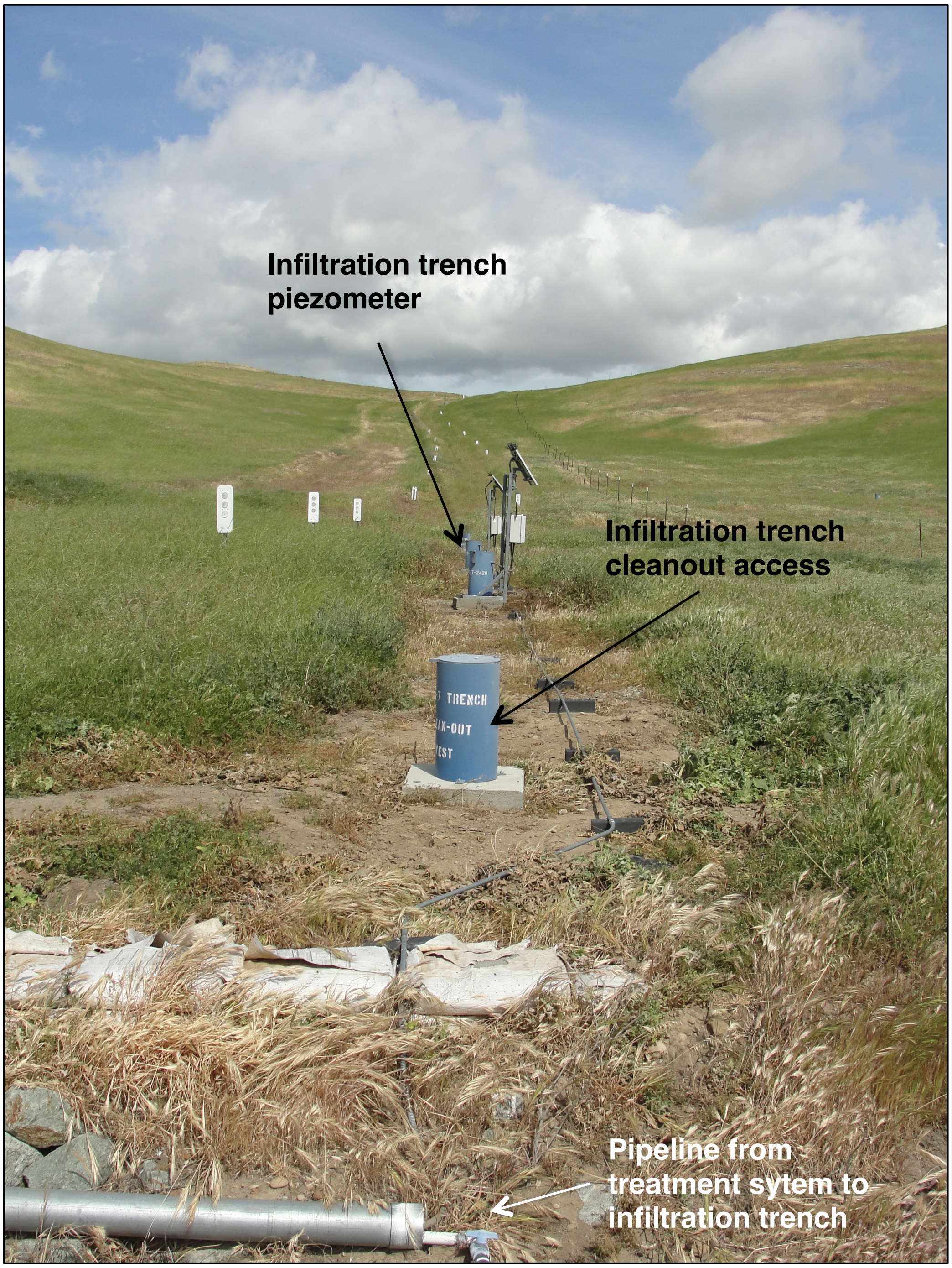


Data transmitted from the well can be plotted to evaluate water level responses to ground water extraction.

Pit 7 – Source effluent infiltration trench

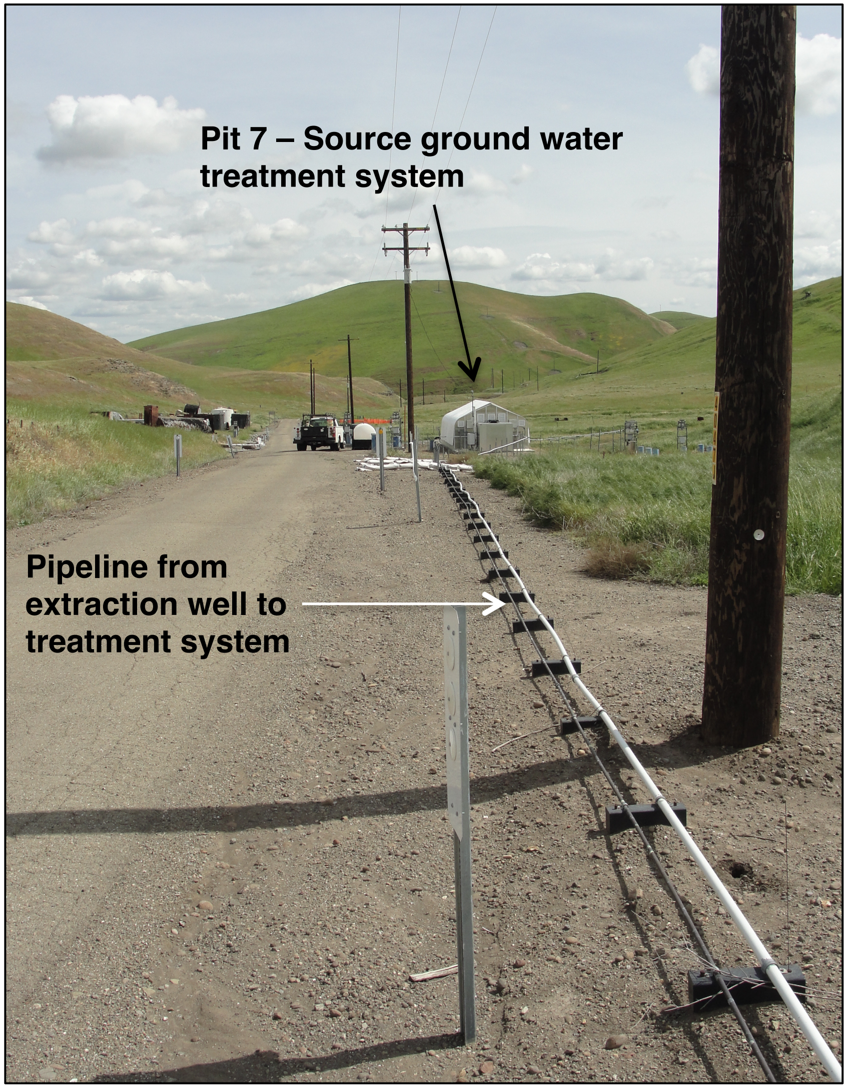
Tritiated effluent from the Pit 7-Source ground water treatment system discharged to the unsaturated part of the Qal/ WBR hydrostratigraphic unit via an infiltration trench to allow tritium to naturally-attenuate in the subsurface.

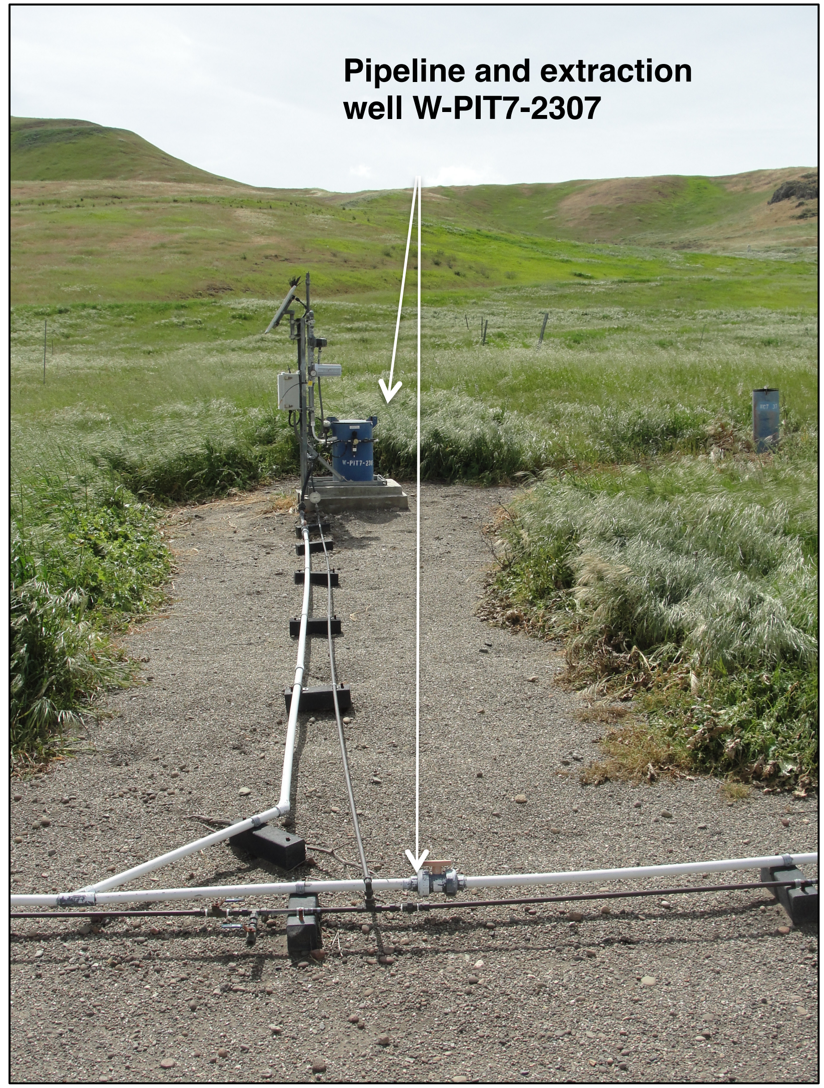
Pit 7 – Source effluent infiltration trench



Piezometers located within the infiltration trench are monitored to ensure the trench capacity is not exceeded.

Pit 7 – Source extraction system pipelines





Above-ground pipelines convey extracted ground water to the Pit 7 – Source ground water treatment system.

Appendix A4

Pit 7 Complex Landfill Five-Year Review Site Inspection Checklist

Appendix A4
Pit 7 Complex Landfill Portion of the Building 850/Pit 7 Complex Operable Unit Five-Year Review Site Inspection Checklist Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: Pit 7 Complex Landfill portion of the Building 850/Pit 7 Complex Operable Unit (OU), LLNL Site 300

Date of inspection: March 24, 2015

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 risk to ecological receptors.
- Installing an engineered drainage diversion system to hydraulically isolate the contaminant sources in the landfills and underlying bedrock from subsurface water, thereby preventing infiltration of rainwater runoff that can result in ground water rising into Pits 3, 4, 5, and 7 and releasing contaminants.
- Extracting and treating uranium, VOCs, nitrate, and perchlorate in Pit 7 Complex ground water to reduce contaminant concentrations in ground water to cleanup standards.
- Monitoring Natural Attenuation (MNA) of tritium in ground water.
- Monitoring of contaminants of concern in ground water to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management:
  - Maintain institutional/land use controls for the Pit 7 Complex specified in the in Table 3 of the Five-Year Review.

- Inspect the Pit 7 Complex Landfills covers/cap for damage that could compromise the integrity and repair any damage found.
- Inspect the engineered hydraulic drainage diversion system for damage that could compromise its integrity and repair any damage found.

Site Map: See Building 850/Pit 7 Complex Five-Year Review Figures 1, 2, and 3.

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 7 Complex remedy. In addition, DOE/LLNS presents and discusses landfill and drainage diversion system inspection and maintenance, ground water extraction and treatment system operation and maintenance, ground water monitoring, or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory Remedial Project Manager (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 Radyk, Site 300 ER Hydrogeologist (Weiss Associates – LLNS Subcontractor).

- Joe Faria, Site 300 ER Landfill and Drainage Diversion System inspection and maintenance coordinator and ground water extraction and treatment system operator (LLNS).
- 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 Field Operations and Sampling Technicians at the site, the oversight, inspections, evaluations, and discussions of the Pit 7 Complex remedy are ongoing. Any landfill, drainage diversion system, extraction and treatment system, monitor well, or other remedy 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, and 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 7 Complex 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 :	Readily available and up-to-date
As-built drawings:	Readily available and up-to-date
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the Pit 7 Complex Landfill RCRA cap, the drainage diversion system, and ground water extraction and treatment system are maintained in the LLNL Environmental Restoration Department files.

The Pit 7 Complex landfills are maintained as described in the Closure and Post-Closure Plan for Landfills Pits 1 and 7 (Rogers and Pacific Corporation Engineering Consultants (1990) and the Site 300 Compliance Monitoring Plan/Contingency Plan

(Dibley et al., 2009). Site 300 Management coordinates the Pit 7 Complex landfill inspections and maintenance. A registered civil engineer or certified engineering geologist performs the inspections of the Pit 7 Complex landfill covers/cap, and landfill maintenance is performed by the LLNS Maintenance Department as necessary. Annual subsidence monitoring for the landfills is performed by a registered civil engineer. ERD staff performs inspections of the drainage diversion system and maintenance is performed by the LLNS Environmental Restoration Department or Maintenance Department as necessary. Inspections of the drainage diversion channels, settling basin, and rip-rap are performed at the beginning and end of the rainy season and monthly during the rainy season as specified in the Compliance Monitoring Plan and Contingency Plan (Dibley et al, 2009). Inspections and maintenance activities are documented on the inspection checklists and summarized in the semi-annual and annual Site-Wide Compliance Monitoring Reports. Inspections, operation, and maintenance of the Pit 7-Source ground water extraction and treatment system are performed under the lead of the treatment facility operator, with as-needed maintenance assistance from mechanical and electrical/electronics technicians and engineers. Treatment facility inspection, operation, and routine maintenance procedures are documented in the Operations and Maintenance Manual for the Pit 7-Source Treatment System. The ground water monitor well network for the Pit 7 Complex is routinely inspected during semi-annual sampling activities. Maintenance activities for the monitoring network included pump replacements, repairing rodent damage to wiring, and general wellhead maintenance on an as-needed basis. Operation and maintenance activities associated with the Pit 7 Complex 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 7 Complex 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.

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 7 Complex remedies.

5. Gas Generation Records

Gas Generation Records: — Not applicable

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-inch 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 7 Complex landfill cap, 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 7 Complex landfills are inspected at least annually.

7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the Pit 7 Complex 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: Readily available and up-to-date

Remarks: The Pit 7-Source treatment system effluent is monitored monthly by the treatment facility operator for compliance with the effluent discharge limits specified in the 2008 Record of Decision. Effluent sample analytic results and compliance status 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 DTSC, and are available on-line at www-erd.llnl.gov/library/index.html.

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 7 Complex, 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). The Building 850/Pit 7 Complex OU is entirely surrounded by Site 300 property and does not extend to the site boundary. The OU is accessible only to DOE/LLNL workers. There are no fulltime workers housed in this area. Occasional workers in this area include environmental restoration staff conducting monitoring, characterization, and remediation activities; and LLNL Maintenance Department personnel during road maintenance.

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 850/Pit 7 Complex OU during the review period (2010-2014) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on Building 850/Pit 7 Complex 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

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: March 24, 2015

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 Land Use Controls section (4.5) of the Building 850/Pit 7 Complex Five-Year Review for further details on institutional controls.

2. Adequacy

ICs are adequate: Yes

Remarks: Refer to the Land Use Controls section (4.5) of the Building 850/Pit 7 Complex 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 850/Pit 7 Complex OU during the five-year review period or since the 2008 Site-Wide Record of Decision and none are anticipated. Most of the land in the OU is undeveloped and is not used for LLNL programmatic activities. The only LLNL building located within the OU boundary is located in the Building 850 area, but it is not currently used or occupied. See the Land and Resource Use section (3.2) of this Five-Year Review for additional details.

3. Land Use Changes Offsite

Land Use Changes Offsite: None

Remarks: The Building 850/Pit 7 Complex OU is entirely surrounded by Site 300 property and does not extend to the site boundary. Land use adjacent to the site boundary closest to the Building 850/Pit 7 Complex OU consists of private rangeland. There is no known planned modification or proposed development of the offsite rangeland closest to (north and west of) the OU. There are plans to develop the land parcel east of Site 300 for residential housing, but thus far the development plans have been delayed by city restricted growth initiatives. As part of this development plan, a minimum buffer zone/open space of a mile to 1.5 miles is planned between residential development and the Site 300 boundary. DOE/LLNL was informed by the developer that ground water would not be used as the water-supply for this development. See the Land and Resource Use section (3.2) of this Five-Year Review for additional details.

VI. GENERAL SITE CONDITIONS

A. Roads

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1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The Building 850/Pit 7 Complex OU is accessed by roads maintained by the LLNS Site 300 Management.

B. Other Site Conditions

Remarks: The Pit 7 Complex landfill covers/cap and associated drainage system, drainage diversion system, ground water extraction and treatment system, and monitor wells are in good condition. Photographs of the Pit 7 Landfill Complex are included in Appendix A3.

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

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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. Ground Water Extraction Wells, Pumps, and Pipelines	Applicable

1. Pumps, Wellhead Plumbing, and Electrical

Good condition:	Yes
All required wells properly operating:	Yes

Remarks: The ground water extraction wells are inspected weekly and are in good condition and operating properly.

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances

Good condition:	Yes

Remarks: All extraction system pipelines and valves are inspected weekly and are in good condition.

3. Spare Parts and Equipment

Readily available:	Yes
Good condition:	Yes

Remarks: Spare parts for routine equipment maintenance are readily available and in good condition.

B. Surface Water Collection Structures, Pumps, and Pipelines Not applicable

C. Treatment System Applicable

1. Treatment Train (check components that apply)

Metals removal:	Not applicable
Air Stripping:	Not applicable
Oil/Water separation:	Not applicable
Bioremediation:	Not applicable
Carbon adsorbers:	Yes
Ion exchange resins:	Yes
Filters: Cuno particulate filters:	Yes
Additive (e.g., chelation agent, flocculent):	Not applicable
Good condition:	Yes
Sampling ports properly marked and functional:	Yes
Sampling/maintenance log displayed and up-to-date:	Yes
Equipment properly identified:	Yes
Quantity of ground water treated annually:	41,000 gallons*
Quantity of surface water treated annually:	Not applicable
Quantity of soil vapor treated annually:	Not applicable

*** Quantities based on 2014 annual totals.**

Remarks: Refer to Section 4.4.2 (Pit 7 Complex Remedy Operation and Maintenance) of the Building 850/Pit 7 Complex OU Five-Year Review for further details about the Pit 7 - Source ground water extraction and treatment systems operations and maintenance. Photographs of the ground water extraction and treatment system are included in Appendix A3.

2. Electrical Enclosures and Panels (properly rated and functional)

Good condition: Yes

Remarks: The electrical control panel and enclosure are in good condition, properly rated, and functional.

3. Tanks, Vaults, Storage Vessels

Good condition:	Yes
Proper secondary containment	Yes

Remarks: A 250-gallon batch tank is located adjacent to the treatment media containers and is used to store extracted ground water prior to treatment. The treatment media and batch tank are located on concrete containment pad that prevents releases of untreated water. A sump is located at the southeast corner of the containment pad to collect water in the event of a unanticipated leak or release. The tank and concrete containment pad enclosure are in good condition, properly rated, and functional. Photographs of the batch tank and containment enclosure are included in Appendix A3.

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4. Discharge Structure and Appurtenances

Good condition: Yes

Remarks: The effluent from Pit 7 - Source ground water extraction and treatment systems is discharged to an infiltration trench located southeast of the treatment facility. A photograph of treatment facility effluent infiltration trench is included in Appendix A3.

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5. Treatment Buildings Not applicable

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6. Monitoring Wells

Properly secured/locked: Yes
Functioning: Yes
Routinely sampled: Yes
Good condition: Yes
All required wells located: Yes
Needs maintenance: No*

Remarks: The Pit 7 - Source wellfield consists of 8 ground water extraction wells. During 2014, ground water monitoring was conducted in accordance with the CMP monitoring requirements with the following exceptions; 106 required analyses in 20 different wells were not performed because the wells were dry or there was insufficient water in the wells to collect the samples, and one required analysis from well W-PIT7-13 was not performed due to an electrical issue with the sampling truck..

* Well W-PIT7-13 could not be sampled due to an electrical issue with the sampling truck. The sampling truck electrical issues were resolved in March of 2015, and the sampling of well W-PIT7-13 recommenced in April 2015.

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

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:	No*

Remarks: MNA is the remedy for tritium in Pit 7 Complex ground water. Samples are collected semi-annually to monitor the effectiveness of natural attenuation in reducing tritium activities to meet cleanup standards. Sample results and MNA remediation progress is reported in the Compliance Monitoring Reports.

* The pump in well W-PIT7-13 could not be sampled due to an electrical issue with the sampling truck. The sampling truck electrical issues were resolved in March of 2015, and the sampling of well W-PIT7-13 recommenced in April 2015.

X. OTHER REMEDIES

The Drainage Diversion System at the Pit 7 Complex was designed and installed to prevent further releases of COCs from the pits and underlying bedrock to ground water.

The four components of the drainage diversion system included:
1. A subsurface drainage network on the western hillslope.
2. Upgraded rip-rap at the end of the existing north-flowing concrete channel for the Pit 7 Complex landfill cap.
3. A vegetated surface water diversion swale along the base of the eastern hillslope.
4. An upgraded surface water-settling basin at the south end of the existing south-flowing concrete channel for the Pit 7 Complex Landfill cap

Operation and maintenance of the Drainage Diversion System during the five-year review period is discussed in detail in Section 4.2.2 of this Five-Year Review. A copy of the drainage diversion system inspection sheet is attached to this Inspection Checklist. The drainage diversion system was inspected and found to be in good condition. During the inspection, a recommendation was made by the field inspector and project engineer that improvements could be made to improve surface water runoff drainage on the east side of the landfills, to reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system. Photographs of drainage diversion system components are included in Appendix A3.

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 7 Complex is intended to prevent further releases from the contaminant sources in the landfills, 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 7 Complex 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 850/Pit 7 Complex OU Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the Pit 7 Complex were identified during this field inspection. 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 7 Complex landfill covers/cap, drainage diversion system, ground water extraction and treatment system, or monitoring network.

However, during the inspection, a recommendation was made by the field inspector and project engineer that improvements could be made to better handle surface water runoff drainage on the east side of the landfills, to reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system.

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, which suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations from this inspection that suggest that the protectiveness of the remedy at the Pit 7 Complex may be compromised in the future.

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.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

No opportunities for remedy optimization were noted during this inspection. Refer to the Recommendations and Follow-up Actions sections of the Five-Year Review for further details regarding recommendations for optimization of the Pit 7-Source ground water extraction and treatment system developed as part of the review process.

However, the following opportunities for future remedy maintenance were noted during the inspection:

1. A recommendation was made by the field inspector and project engineer that improvements could be made to better handle surface water runoff drainage on the east side of the landfills, to reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system.

Pit 7 Complex Drainage Diversion System Inspections and Maintenance Field Sheet

Pit 7 Complex Drainage Diversion System Inspections and Maintenance Field Sheet

Inspected by:

Joe Faria ______________________________ **Date: 12/3/14**__________

(Print Name) **(Signature)**

Inspection Purpose & Schedule:

Pre-season	Monthly	Monthly	Monthly	Monthly	Monthly	Post-season	Post Storm
Oct 15	Nov 15	Dec 15	Jan 15	Feb 15	Mar 15	Apr 15	Date:12/3/14

Notes:

Note 1. Inspect at the beginning (October 15) and end of the rainy season (April 15) and monthly during the rainy season. Additional inspections may be conducted following heavy storm events.

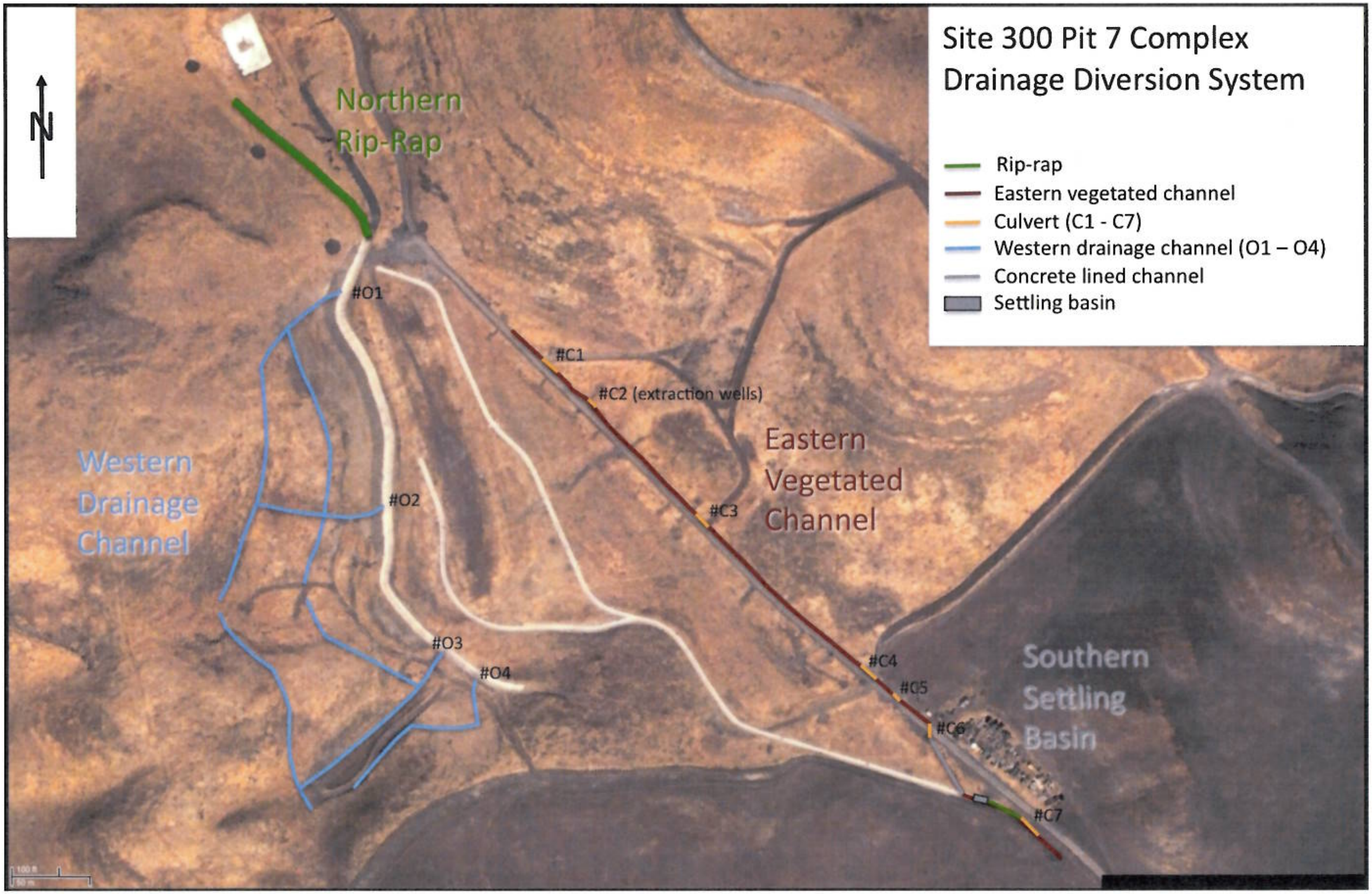
Note 2. Inspect annually at the end of the rainy season (April 15).

Note 3. Pit 7 Complex RCRA Landfill Cover and related concrete lined drainage channels are inspected separately.

Note 4. Requirements presented in the Pit 7 Complex Remedial Design (2008). Debris disposal should be conducted according to WDR Order R5-2008-0148 Attachment-4 under "culvert flushing": *"Culvert flushing (varies from 100 to 5000 gallons): Culverts are visually inspected annually and cleaned when needed. Cleaning involves removing accumulated sediments either with a backhoe or hand digging. Residual sediments may be flushed from the culvert with potable water. Removed sediments are used to reinforce channel banks or removed from the drainage channel for disposal or reuse elsewhere at Site 300."*

Note 5. Satisfactory status indicated by "Yes". Unsatisfactory status indicated by "No". Unsatisfactory status requires explanation. The Inspector shall immediately notify the Environmental Restoration Program Leader of any unsatisfactory status.

LOCATION MAP:



Inspection	Inspection Frequency	Status Satisfactory (Y/N)	Observations and Corrective Action
SOUTHERN SETTLING BASIN AREA			
Settling Basin and Drain - Examine settling basin banks for seepage and structural soundness. - Inspect the settling basin for cracks on concrete walls and joints. - Check inlet channels and overflow spillways for any damage or obstructions. - Check the outlet standpipe for clogging. - Check inlet and outlet areas for erosion and stabilize if required. - Evaluate the depth of sediment in the settling basin. Sediment should be removed when sediment accumulation reaches one half of the designated sediment storage volume (when 6-in. deep in the basin).	**See Note 1**	**Y**	*- Remove vegetation (typically tumbleweed) from inside and near the settling basin.* *- Remove sediment from the settling basin using snow shovel and/or heavy equipment.* *- Flush settling basin bottom and inlet filter with water.* ***No tumbleweeds in basin. Has ~2' of water in the basin with it flowing water through the standpipe with no obstructions.***
Southern Rip-Rap, Culvert-C7, and Vegetated Channel - Inspect vegetated swales for erosion, damage to vegetation, and sediment and debris accumulation. - Evaluate the depth of sediment accumulating near culverts and in channels within the vegetated swales. Sediment should be removed when sediment accumulation reaches a 3-in height at any spot or covers vegetation. - Inspect all channels for erosion, damage to channel and banks, and sediment and debris accumulation.	**See Note 1**	**Y**	*- Remove vegetation (typically tumbleweed) from inside and near the rip-rap, culverts, and channel.* *- Flush culvert-C7, rip-rap and channel with water, if required.*

EASTERN VEGETATED CHANNEL			
Eastern Vegetated Channel, Culverts C1 through C6 - Inspect vegetated swales for erosion, damage to vegetation, and sediment and debris accumulation. - Evaluate the depth of sediment accumulating near culverts and in channels within the vegetated swales. Sediment should be removed when sediment accumulation reaches a 3-in height at any spot or covers vegetation. - Inspect all channels for erosion, damage to channel and banks, and sediment and debris accumulation.	**See Note 1**	**Y**	*- Remove vegetation (typically tumbleweed) from inside and near the rip-rap, culverts, and channel.* *- Flush culverts and channel with water, if required.* *Small spots of sediment in some places but no obstructions. Shoveled away what was there.*
- Inspect perforated pipe in the vegetated channel	**See Note 2**	**Y**	*- Flush perforated pipe in the vegetated channel with water, if required.*

NORTHERN RIP-RAP			
Northern Rip-Rap - Inspect rip-rap for erosion, damage, sediment and debris accumulation. - Inspect all channels for erosion, damage, sediment and debris accumulation.	**See Note 1**	**Y**	*- Remove vegetation (typically tumbleweed) from rip-rap.* *Dragon teeth still under water, no obstructions.*

WESTERN DRAINAGE CHANNEL			
Western Drainage Channel, Outlets O1 through O4 - Check gravel bed and the permeable fabric for damage - Check sediment and debris accumulation. - Evaluate the depth of sediment accumulating in channels. Sediment should be removed when sediment accumulation reaches a 3-in height at any spot. - Inspect all channels for erosion, damage to channel and banks, and sediment and debris accumulation. - Inspect outlets to concrete lined channels	**See Note 1**	**Y**	*- Remove vegetation (typically tumbleweed) from inside and near the channels, and outlets.* *- Flush culverts and channel with water, if required.*
- Inspect perforated pipe in the drainage channels.	**See Note 2**	**Y**	*- Flush perforated pipe in the drainage channel with water, if required.*

Appendix B

Responses to Regulatory Comments

Appendix B

Appendix B1

Responses to Regulatory Comments on the Draft Five-Year Review

Appendix B1

Comment Responses for the Draft First Five-Year Review Report for Operable Unit 5 at Lawrence Livermore National Laboratory (LLNL) Site 300

California Department of Toxic Substances (DTSC) Control comments:

1. Five-Year Review Summary Form – Several action items/recommendations are discussed in this form. However, none on them include a schedule indicating when these items will be performed. It is important that schedules are provided in order to avoid delays.

Response: **A schedule is provided as a milestone date for each recommendation presented in the Five-Year Review Summary Form. However, the specific schedule for implementation will be dependent on various factors, including funding. The schedule for implementing the recommendations for the Pit 7 Complex will be discussed with the regulatory agencies once the factors that affect the schedule have been evaluated.**

2. Section 1.7.4, Building 851 Firing Table (OU 8), Last Paragraph – Add that DOE/LLNL is currently drafting a work plan for investigation of uranium at the Building 851 Firing Table. The work plan will be submitted to the regulatory agencies for review and approval in the summer of 2015?

Response: **Because a schedule for submittal of a work plan for the investigation of uranium at the Building 851 Firing Table has not yet been developed while several issues are resolved (i.e., U.S. Fish and Wildlife Service requirements), it has not been added to the Five-Year Review for Operable Unit (OU) 5. The schedule for submittal of the Building 851 Work Plan will continue to be discussed with the regulatory agencies and documented in Remedial Project Manager's (RPM) meeting minutes.**

3. Section 1.8, Building 812 (OU 9) - Discuss status of the Draft WP for Additional Characterization of Surface Soil in the Building 812 Firing Table Area.

Response: **Text was added to Section 1.8 indicating the date on which the Final Work Plan for additional characterization of polychlorinated biphenyls (PCBs) and high explosive (HE) compounds was submitted to the regulatory agencies.**

4. Section 8.2, Pit 7 Complex Recommendations and Follow-up Actions, Items 1 and 2 – Add that timetables to perform the actions recommended will be discussed with regulatory agencies.

Response: **Milestone dates for the recommendations for the Pit 7 Complex are presented in the Five-Year Review Summary Form. However, text was added to Section 8.2 indicating that the schedule for implementing the recommendations for the Pit 7 Complex will be discussed with the regulatory agencies.**

DTSC Geological Service Unit's comments:

COMMENTS AND RECOMMENDATIONS

1. The 5YR Report concludes that there are no deficiencies or issues related to: (1) the remedy selected to address tritium, uranium, and nitrate in groundwater and (2) the removal action that addressed soil contaminated with polychlorinated biphenyls (PCBs), dioxin, and furan at Building 850 in Operable Unit 5 (OU5). Characterization and treatability studies are underway for perchlorate: after review of study results, a remedy for perchlorate will be proposed.

   Comment

   With respect to the items described above, the findings and recommendations in the 5YR Report are supported by the data presented.

Response: **Comment noted.**

2. Research Department explosive (RDX) and High Melting explosive (HMX) were detected in Building 850 groundwater during this 5YR Review period. The 5YR Report states: (1) the data indicate that the extents of RDX and HMX in groundwater are currently limited and (2) the RDX and HMX groundwater concentrations and extents are decreasing.

   However, the data presented in the 5YR Report are not sufficient to support the conclusions that RDX and HMX groundwater concentrations and extents are limited and decreasing.

   DOE proposed the following actions:

   a. Monitor RDX and HMX concentrations in groundwater to verify trends in concentrations and extents.

   b. Collect subsurface soil samples for High Explosive (HE) compounds from the boreholes to be drilled as part of Building 850 perchlorate characterization. The soil data would be used to determine if a significant, ongoing source of HE compounds is present in the vadose zone that could impact groundwater above cleanup standards.

Recommendations

GSU agrees that the proposed actions are appropriate.

To support the conclusions regarding decreasing RDX and HMX concentrations and extents, add a section summarizing historical groundwater results and cleanup criteria. Include groundwater iso-concentration contour maps illustrating the historical extents of HDX and RDX in the Building 850 area.

Response: **Maps included as Attachments 1a and 1b show the extent of High Melting Explosive (HMX) and Research Department Explosive (RDX), respectively, in Building 850 ground water with concentrations above the 1 microgram (µg/L) analytical reporting limit based on data for samples collected in 2010 and 2014. HMX and RDX have only been detected in shallow groundwater in the Quaternary alluvium/weathered bedrock (Qal/WBR) hydrostratigraphic unit (HSU) immediately downgradient of the Building 850 firing table at concentrations less than 10 µg/L.**

In the 2014 ground water samples, RDX was detected in only one well (NC7-61 at 3.8 µg/L) located downgradient of the Building 850 firing table. In 2014, HMX was detected in three wells (W-850-2417, NC7-28, and NC7-61) at concentrations ranging from 2.4 to 5 µg/L. To be conservative, the HMX and RDX maps include the most recent results where 2014 data were not available.

As discussed in Section 5.4.1.1.5, HE compounds were not identified as contaminants of concern (COCs) in the 2008 Record of Decision (ROD). However, in the past, contract laboratory reporting limits for RDX and HMX were higher than are now available, varying from 5 to 20 µg/L. In 2008, RDX and HMX were detected in the baseline sample collected from new monitor well W-850-2417 drilled and installed downgradient of Building 850. Based on these detections, monitoring for HE compounds was expanded to include additional wells. These data are discussed in detail in Section 5.4.1.1.5 including an analysis of RDX and HMX concentrations and extents, and a summary of historical ground water concentrations of these constituents.

There are no RDX and HMX cleanup standards/criteria for the Building 850 area, as these compounds were not identified as contaminants of concern. However, the ground water cleanup standard for RDX and HMX in the HE process area is 1 µg/L.

3. Pit 7 Complex

The 5YR Report identified no issues related to the remedy for the Pit 7 Complex. However, to optimize the operation and maintenance of the groundwater pump and treat system and the drainage diversion system, the following actions were recommended:

a. Convert the current extraction well NC7-25 to a monitoring well and install a larger diameter extraction well nearby to optimize groundwater extraction of uranium-contaminated groundwater.

b. Implement improvements to the surface and slope of the road and the roadside drainage way on the east side of the Pit 7 Complex landfills to: minimize erosion and accumulation of sediment; reduce flooding during heavy rain; and, improve operation and reduce maintenance requirements for the eastern vegetated channel.

Recommendation

GSU supports the recommendations for optimization of operations and maintenance of the Pit 7 Complex remedy.

Response: **DOE/LLNL appreciate DTSC GSU's support for the recommendations for optimization of operations and maintenance of the Pit 7 Complex remedy.**

4. Acceptability of the 5YR Report

The GSU recommends approval of the 5YR Report, provided Comment 2 is adequately addressed.

Response: **Comment noted.**

U.S. Environmental Protection Agency (EPA) comments:

GENERAL COMMENTS

1. The in situ bioremediation treatability study for reduction of perchlorate in groundwater immediately downgradient of Building 850 commenced in September 2011 and is ongoing. Evaluation and selection of remedial alternatives to address perchlorate in groundwater will be presented in a future Focused Feasibility Study.

   ***Response:* Comment noted.**

2. According to the FFYR, the drainage diversion system is operating as intended. However, the drainage diversion system is designed to divert recharge during peak events and has not yet been tested under the above-average annual rainfall conditions for which it was designed.

Response: **As indicated in Section 5.4.2.5.4 of this Five-Year Review and the Remedial Design for the Pit 7 Complex, the drainage diversion system was designed to divert excess surface water runoff and shallow subsurface recharge from the hillslopes to the west and east of the Pit 7 Complex landfills during high intensity storms and periods of extreme rainfall (i.e., the 1997-1998 El Niño) to minimize ground water rises into the pit waste and underlying contaminated bedrock. Thus, the drainage diversion system performance can best be evaluated during a future El Niño season or other period of extended intense rainfall (e.g., several continuous days with >1 inch of daily rainfall). DOE/LLNL acknowledge that there has not been an El Niño event since the drainage diversion system was installed. However, DOE/LLNL has been monitoring and evaluating ground water data (i.e., ground water elevations) in the Pit 7 Complex area since the drainage diversion system was installed. As discussed, these data indicate that the drainage diversion system is operating as intended to: (1) reduce ground water elevation responses to rainfall, (2) prevent ground water rises into the pit waste, and (3) decrease concentrations of contaminants of concern (COCs) in ground water.**

3. Based on Appendices A2 and A4, regulatory agency regional project managers were not interviewed as part of the five-year review (FYR) site inspection and were not invited to participate in the FYR site inspection.

Response: **Section 3.5.2 of EPA's Comprehensive Five-Year Review Guidance indicates that: "Interviews should be conducted, if necessary, to provide additional information on the site's status. Those interviews may include…Federal and State regulatory authorities….." Section 3.5.3 of the guidance indicates that: "At Federal facility sites, a State and/or EPA representative may wish to be present and/or participate in conducting site inspections."**

The status and progress of site remediation is reported and discussed regularly with the regulatory agencies at Remedial Project Manager's (RPM) meetings and reported in detail semi-annually in the Compliance Monitoring Reports. In addition, the State Regional Water Quality Control Board (RWQCB) RPM conducts site inspections semi-annually. The EPA and State agency RPMs regularly provide input on the remediation progress and discuss any issues they have as part of these processes. The procedures followed for this Five-Year Review process are the same as were followed for other Five-Year Reviews at both LLNL Site 300 and Livermore Site. Since the EPA, DTSC, or the RWQCB RPMs have never expressed a desire to participate in a site inspection for any of the previous Five-Year Reviews, DOE/LLNL were not aware that they wished to do so for this site inspection. However, if any of the agencies wish to participate in site inspections for future Five-Year Reviews, it can certainly be arranged.

4. Insufficient information is presented in the Draft First Five-Year Review for Operable Unit 5 at Lawrence Livermore National Laboratory Site 300, May 2015 (the FFYR) to substantiate that the infiltrating treatment facility effluent is not accelerating downgradient migration of tritium in groundwater. According to Section 5.4.2.2, the PIT7-SRC groundwater treatment system (GWTS) is designed to remove uranium, perchlorate, nitrate, and volatile organic compounds (VOCs) from the tritium-bearing groundwater and inject the treated tritium-bearing effluent into an infiltration trench in the vadose zone overlying the Quaternary alluvium/weather bedrock (Qal/WBR) downgradient of the PIT7-SRC GWTS. Section 5.4.2.2 also indicates that "To date, this has been done without any significant local tritium increases in groundwater in the vicinity of the infiltration trench." Similarly, Section 5.4.2.5.2 indicates that tritium activities in wells downgradient of the infiltration trench are stable or decreasing, indicating that the discharge of tritium-bearing water is not adversely impacting downgradient groundwater. However, the FFYR does not specifically discuss the tritium activity in the wells immediately downgradient of the infiltration trench (e.g., NC7-2, NC7-16, NC721, K7-07) or if the tritium concentrations are stable or decreasing. In addition, it is not clear if the lack of significant local tritium activity increases in groundwater in the vicinity of the infiltration trench are associated with the declining extent of saturation resulting from the low rainfall. Please revise the FFYR to provide sufficient information to substantiate that the infiltrating treatment facility effluent is not accelerating downgradient migration of tritium in groundwater. In addition, please clarify whether the lack of significant local tritium activity increases in groundwater in the vicinity of the infiltration trench is associated with the declining extent of saturation resulting from the low rainfall.

Response: **To clarify that local ground water tritium activities have not been adversely impacted by the discharge of tritium-bearing effluent into the infiltration trench, the following text has been added to Section 5.4.2.5.2:**

"Specifically, tritium activities in water samples collected from wells NC7-16 and NC7-21, located immediately downgradient of the infiltration trench in the Qal/WBR HSU, have decreased from 2010 maxima of 42,700 and 64,700 picocuries per liter (pCi/L) respectively to the most recent five-year review period maxima of 20,700 and 32,800 pCi/L, respectively. The most recent sample from NC7-16 was collected on July 10, 2013; the well subsequently went dry. The most recent sample from well NC7-21 was collected on October 14, 2014."

DOE/LLNL note that the declining extent of saturation and volume of water within the Qal/WBR that are a result of reduced local recharge arising from drought conditions would not in themselves cause a lack of significant local tritium activity increases (or cause decreases). The observed reduction in tritium activities in the area of the infiltration trench is presumed to be the result of radioactive decay and dispersive mixing of tritium from the treatment facility effluent with that already in the ground water.

Regarding the other 2 wells mentioned in EPA's comment above (NC7-2 and K7-07): There is no NC7-2 well, so DOE/LLNL presume that that EPA was referring to NC7-22 that is located downgradient of the infiltration trench. Well NC7-22 has been "dry" since 2000. K7-07 has also been "dry" (insufficient water to sample) since 2010. The last tritium sample, collected in April 2010, was 2,000 pCi/L. Because there is no recent tritium data available for wells NC7-22 and K7-07, a discussion of these wells relative to impacts of tritium-bearing effluent on downgradient ground water was not added to the text.

5. Insufficient information is provided regarding the local source of elevated nitrate concentrations in groundwater in Section 5.4.1.1.3. The text states, "The highest nitrate concentrations (> 100 mg/L [greater than 100 milligram per liter] as N03 [nitrate]) were detected in NC7-29, screened in the $Tnbs_1/Tnbs_o$ [Neroly silty Sandstone/Tertiary Neroly Lower Blue Sandstone] HSU [hydrostratigraphic unit]. Because this well also contains perchlorate and it is located south and cross-gradient of Building 850, this elevated nitrate is from a local source and not Building 850." However, the basis for the statement regarding the local source of elevated nitrate concentrations in groundwater is unsubstantiated. Please revise the FFYR to provide sufficient information regarding the local source of elevated nitrate concentrations in groundwater.

Response: **The local source of nitrate (and perchlorate) in ground water at well NC7-29 is believed to be the corporation yard (and associated equipment stored there in the past) located immediately east of this well, as there is no other potential source in the area. This information has been added to the existing text on page 57 (Section 5.4.1.1.1.3).**

6. With the exception of the Qal/WBR HSU subsection of Section 5.4.1.1.1, Section 5.4 does not discuss whether the low rainfall during the last three years has resulted in changes in the contaminant distribution, concentrations, and remedial progress. For example, the Qal/WBR HSU subsection of Section 5.4.1.1.1 indicates that the spatial extent of tritium decreased in size due to a declining extent of saturation resulting from low rainfall; however, the $Tnbs_1/Tnbs_0$ HSU subsection of Section 5.4.1.1.1 does not discuss whether the extent of tritium may be decreasing in size due to the declining extent of saturation resulting from the drought. Similarly, Sections 5.4.1.1.3, 5.4.1.1.4, 5.4.1.1.5 do not discuss whether the low rainfall during the last three years impacted the nitrate, perchlorate, or high explosives (HE) contaminant distribution, concentrations, and/or remedial progress. Please revise the FFYR to discuss whether the low rainfall during the last three years has resulted in changes in the contaminant distribution, concentrations, and remedial progress.

Response: **As detailed in the comment, the second bullet in Section 5.4.1.1.1 (under Qal/WBR HSU [for the Building 850 area]) in the Draft Five-Year Review stated that: "The extent of tritium with activities greater than 1,000 pCi/L remains relatively stable, but has decreased in size due to a declining extent of saturation resulting from low rainfall." Upon closer review, LLNL hydrogeologists noted that both the extent of tritium in excess of 1,000 pCi/L and the extent of saturation in the Qal/WBR HSU remained relatively stable but have not decreased during the five-year review period. Thus, the last part of the bullet has been deleted and the referenced text now reads: "The extent of tritium with activities greater than 1,000 pCi/L remains relatively stable." During the five-year review period, there has also been little to no change in the extent of saturation in the $Tnbs_1/Tnbs_0$ HSU in the Building 850 area (due to low rainfall or for any other reason). Therefore, the extent of COCs in ground water in this HSU has also not been affected by the recent declines in annual rainfall. Because low rainfall during the last three years has not impacted the distribution, concentrations or remedial progress of tritium, nitrate, perchlorate, or high explosives (HE) in the Qal/WBR or $Tnbs_1/Tnbs_0$ HSU in the Building 850 area, the text in Sections 5.4.1.1.1, 5.4.1.1.3, 5.4.1.1.4, 5.4.1.1.5 has not been revised to discuss impacts. However, to respond to the comment, text has been added to Section 5.4.1.1 stating that: "Despite the decline in annual rainfall during the last few years, the extent of saturation in the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs remains relatively stable, and there is no apparent impact to COC extent or concentrations noted during the five-year review period as a result of these recent declines in annual rainfall."**

7. The $Tnbs_1/Tnbs_0$ HSU subsection of Section 5.4.1.1.1 states, "tritium activities above background in wells in the furthest downgradient portion of the plume exhibit a slowly increasing trend," yet the FFYR does not discuss how this trend will be monitored or evaluated during the next five-year review period. The issue of an expanding groundwater plume also implicates ICs, as Fig. 6 indicates ICs

limited to areas above plumes. Please revise the FFYR to specifically indicate how this increasing trend and potentially expanding groundwater contaminant plume will be monitored, evaluated and institutionally documented during the next five-year review (FYR) period.

Response: **Tritium activities in Building 850/Pit 7 Complex ground water will continue to be monitored per the requirements in the Site-Wide Compliance Monitoring Plan, and evaluated and reported in the Annual and Semi-Annual Compliance Monitoring Reports. This text was added to the $Tnbs_1/Tnbs_0$ HSU subsection of Section 5.4.1.1.1. Per the sampling and analysis plan documented in the annual 2014 Compliance Monitoring Report (CMR) Table 2.5-1, water samples are collected from guard wells immediately beyond the current extent of the ground water tritium plume with concentrations above the 100 pCi/L background level and analyzed for tritium quarterly. Samples collected from plume tracking wells completed in portions of the plume above tritium background are analyzed semi-annually. The resulting annual ground water tritium activity maps produced from these analytical results are compared to determine any changes in the extent of tritium above background. Tritium activity trends in these wells completed in the leading edge of the tritium plume are regularly evaluated. These results are presented in the CMRs and summarized in the Five-Year Review.**

As discussed in Section 5.4.1.1.1, the extent of tritium above the Maximum Contaminant Level (MCL) drinking water cleanup standard in the Building 850 area has declined markedly over time and, as of the data cutoff date for this Five-Year Review (December 2014), was limited to one well (NC7-70) immediately downgradient of Building 850. (Note: Tritium data from the first semester of 2015 indicate that tritium activities are below the 20,000 pCi/L drinking water MCL cleanup standard in all ground water monitor wells at and downgradient of Building 850). The discussion of the increasing tritium activity trend was related to tritium activities above (100 pCi/L) background (analytical reporting limit) in wells in the farthest downgradient portion of the plume. However, as also stated in Section 5.4.1.1.1 and shown on Figure 8, the extent of tritium with activities above the 100 pCi/L background has remained stable during the five-year review period. Therefore, changes to institutional controls (ICs) are not needed.

8. Section 5.4.1, Pages 38-49: the discussion of LUCs is very difficult to follow. Request the organization of this section with a goal of simplifying it.

Response: **In a teleconference call (telecon) with EPA on August 6, EPA confirmed that the section referenced in this comment was Section 4.5.1 (Land Use Control Objectives) rather than Section 5.4.1. In the telecon, DOE/LLNL said that the discussion and organization of the land use controls (LUCs) in Section 4.5.1 is based on the format and organization of LUC discussions in previous Site 300**

Five-Year Reviews. DOE/LLNL noted that this format and organization was originally suggested by EPA to link it to the LUC tables from the ROD, with changes made based on EPA comments on Five-Year Review reports submitted since the ROD. Therefore, DOE/LLNL were reluctant to make major organizational changes to this section without specific input from EPA as to exactly how they would like this information to be presented. Eric Esler, EPA's legal counsel, suggested more closely linking the Land Use Control Objectives in Section 4.5.1 with the corresponding Land Use Controls discussed in Section 4.5.2 to make the text easier to follow. Eric indicated that he would review the section the following week (week of August 10-14) and provide any additional organizational input to DOE/LLNL.

In response to this comment and discussion, the text in Section 4.5 has been reorganized to present the: (1) land use control objectives, (2) risk necessitating these controls, (3) specific land use controls and implementation mechanisms used to prevent exposure to contamination by objective, and (4) status of the land use controls, separately for the Building 850 area (new Section 4.5.1) and Pit 7 Complex area (new Section 4.5.2) of OU 5. Within these two revised sections (4.5.1 and 4.5.2), the information above is presented by land use control objectives (headers). On August 25, DOE transmitted the reorganized text in Section 4.5 to EPA for review and comment.

9. Section 5.4.1.3 indicates that the "temporary increase in uranium activities in one well (NC7-28) is thought to be the result of temporary immobilization of uranium, followed by re-mobilization, due to ethyl lactate injections as part of the perchlorate treatability study;" however, Figure l7a does not indicate when the ethyl lactate injections occurred to substantiate that the increased uranium activities are associated with the perchlorate treatability study injections. In addition, the FFYR does not propose additional monitoring following future perchlorate treatability study injections to provide data to help substantiate the conclusion that the increased uranium activities are associated with the perchlorate treatability study injections. Further, it should be noted that Section 5.4.1.2 indicates that during the FYR period, total uranium activities in groundwater at and downgradient from Building 850 were below the 20 PicoCuries per liter (pCi/L) cleanup standard with one exception; however, Figure 17a shows at least seven detections above the 20 pCi/L cleanup standard. Please revise Figure 17a to indicate when the ethyl lactate injections occurred to help substantiate that the increased uranium activities are associated with the perchlorate treatability study injections. In addition, please revise the FFYR to include additional monitoring following future perchlorate treatability study injections to provide data to help substantiate that the increased uranium activities are associated with the perchlorate treatability study injections. Also, please revise Section 5.4.1.2 to clarify that uranium was detected more than once above the 20 pCi/L cleanup standard.

Response: **The Five-Year Review is intended to evaluate and report the status of the remedies for contamination at Building 850 selected in the Site-Wide ROD. Because perchlorate is not addressed in the ROD and characterization and an *in situ* bioremediation test are still underway, details on the effects of the test on local ground water contaminant concentrations are discussed in the Five-Year Review but are not intended to be complete. DOE/LLNL have conducted enhanced monitoring of pH, dissolved oxygen, oxidation potential (Eh), general minerals, and other chemical parameters during and after injection that enabled the determination that re-mobilization of reduced uranium was most likely the result of oxidation-reduction change and other chemical factors. Such enhanced monitoring will continue during and following future lactate injection activities. An analysis of this enhanced monitoring data and its implications for causes and timing of uranium re-mobilization will be presented in the Focused Feasibility Study (FFS) for perchlorate in ground water at Building 850. A revised Figure 17a, showing the timing of ethyl lactate injection will be included in the FFS. As requested in the comment, Section 5.4.1.2 of the Five-Year Review has been revised to state that uranium was detected above the 20 pCi/L cleanup standard several times. To address the comment, text has also been added to Section 5.4.1.2 as follows: "The enhanced monitoring of chemical parameters (pH, dissolved oxygen, oxidation potential, and general minerals) outlined in the Treatability Study Work Plan for Enhanced *In Situ* Bioremediation of Perchlorate in Ground water at Building 850 (Holtzapple, 2011a) will continue following future lactate injections. This monitoring will provide more information documenting whether increases in uranium concentrations after initial declines are associated with chemical changes brought about by lactate oxidation and associated initial reduction of dissolved uranium, followed by re-oxidation."**

10. Section 8.1 recommends monitoring HE compounds in Building 850 groundwater to verify the continued decrease in research department explosive (RDX) and high melting explosive (HMX) concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases; however, the monitoring wells that will be sampled and the frequency of sampling is not provided and/or referenced. Please revise the FFYR to clarify the monitoring wells that will be sampled for HE compounds in Building 850 groundwater to verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases. In addition, please clarify the frequency of sampling that will be conducted at these monitoring wells.

Response: **To verify the continued decrease in RDX and HMX concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases, samples for HE compound analysis by EPA Method 8330 will be collected semi-annually from monitor wells NC7-10, NC7-11, NC7-14, NC7-15, NC7-19, NC7-27, NC7-28, NC7-44, NC7-54, NC7-55, NC7-60, NC7-61, NC7-70, NC7-71, NC7-73, W-850-05, W-850-2313, W-850-2314, and W-850-2417. This**

information has been added to Section 8.1 of the FYR and will be reported in the annual Compliance Monitoring Reports.

11. Section 8.2 recommends "improvements to the surface and slope of the road and the roadside drainage way on the east side of the Pit 7 Complex landfills to minimize erosion and accumulation of sediment, reduce flooding during heavy rain events, and both improve operation and reduce maintenance requirements for the eastern vegetated channel component of the drainage diversion system;" however, the need for these improvements is not discussed elsewhere in the FFYR. Please revise the FFYR to ensure that the need for these recommendations, and the recommendations themselves, are thoroughly discussed and documented.

Response: **Text has been added to Sections 4.4.2.2 and 8.2 of the Five-Year Review detailing the observed erosion and resulting sedimentation at the road and roadside drainage way (vegetated swale) on the east side of the Pit 7 Complex and the potential for flooding that resulted in the recommendations, and the recommendations themselves.**

12. The FFYR does not include a recommendations and follow-up actions table. Based on Section IX of Appendix E of the Comprehensive Five-Year Review Guidance, EPA/540/R-01/007, dated June 2001 (FYR Guidance), the FFYR should specify the required and suggested improvements to current site operations, activities, remedy, or conditions noting the parties responsible for actions, milestone dates, and which agencies have oversight authority. Please revise the FFYR to include the information specified in Section IX of Appendix E of the FYR Guidance.

Response: **The Five-Year Review Summary Form in the front of the document contains a table for each recommendation that specifies the action to be taken (recommendation), the issue (what condition the recommendation is intended to address), the Implementing Party (party responsible for the action), the Oversight Party (agencies with oversight authority), and Milestone Dates for each action/recommendation. Therefore, the information specified in Section IX of Appendix E of the FYR Guidance is already provided in the Five-Year Review Summary Form tables.**

13. While perchlorate in groundwater is acknowledged (e.g., Section 5.4.1.1, page 51), the FFYR does not discuss the potential for perchlorate to be present in soil. Given that one to two inches of water was used to flood the Building 850 firing table after each shot, the potential exists for perchlorate to be present in soil beneath the three inches of gravel that were removed and replaced periodically. Similarly, the potential exists for perchlorate to be present in the soil on the hillslopes above the excavated area. This potential was not addressed during confirmation sampling since perchlorate was not an analyte. Please revise the FFYR to acknowledge the potential for perchlorate to be present in soil.

Response: **Text was added to Section 5.4.1.1 regarding the additional perchlorate characterization work for soil and ground water at the Building 850 firing table. Text stating the potential for perchlorate to be present in soil beneath the Building 850 firing table (and potentially on the hillslopes) has also been added to Section 5.4.1.1 of the FYR: "Because the source of perchlorate to ground water is most likely soil and rock beneath the Building 850 firing table, the characterization work plan focuses on that area. Soil containing PCBs above cleanup standards was removed from the hillslopes above the firing table, reducing the possibility that soils containing perchlorate are present on the hillslopes." However, as discussed in Section 5.4.1.1, while perchlorate was identified as a ground water COC in the 2008 Site-Wide ROD, no remedy was selected as it was only recently identified as a ground water contaminant at the time of the ROD. A Remedial Investigation/Feasibility Study (RI/FS) report will be prepared and remedy for perchlorate will be selected in an Amendment to the 2008 Site-Wide ROD at a later date. Therefore, while the perchlorate concentrations and distribution are discussed in this Five-Year Review for completeness, perchlorate is outside the scope of this document.**

14. The FFYR utilizes January 2015 EPA Regional Screening Levels (RSLs); however, the RSLs were updated in June 2015. Please ensure that the June 2015 updates are incorporated into the FFYR and referenced in Section 6.2.

Response: **The RSLs for PCBs (as Aroclor-1254) and dioxins/furans (as TCDD) are referenced in Section 6.2. Because the Draft FYR was submitted in May 2015, the June RSLs were not available. The January 2015 industrial RSL of 1.0 mg/kg for PCBs has been revised to 0.97 mg/kg but is above the 0.74 mg/kg PRG standard and is therefore protective. The 2.2 X 10^{-5} mg/kg RSL for TCDD remains unchanged. The PCB RSL has been updated in the text.**

SPECIFIC COMMENTS

1. **Summary Form, Page ii, footnote:** Text is missing a closing parenthesis. Please also note the potential (given that EPA has so requested) for the FYR period to be adjusted to accommodate the consolidation of Site 300 FYRs.

Response: **A closing parenthesis has been added to the footnote on Page ii of the Summary Form.**

EPA's request for consolidation of Site 300 Five-Year Reviews and DOE's response are noted in the minutes for the May 15, 2014 Remedial Project Manager's meeting. As discussed in the September 1, 2015 Remedial Project Manager's meeting, the Federal Facility Agreement states the Five Year Reviews will be consolidated following the initiation of the final remedial action for the Site. Because the date for initiation of the final remedial action is not known at this time, a footnote was not added to the Summary Form.

2. **Summary Form, Page vi:**
Introduction: The text references "institutional controls, the Health and Safety Plan, and the Contingency Plan." The draft FYR does not describe the contents of the HSP or Contingency Plan but, depending what these plans provide, they potentially could be considered as ICs, at least in part. Please consider whether the HSP and Contingency Plan are ICs when evaluated against EPA's ICs Guidance.

Line item 4: As currently drafted, the text states that by preventing ground water level rise the drainage system releases contaminants to ground water. Please revise the last clause of the text by deleting the comma after "waste" and revising the text which follows it to read: "which would release contaminants from the wastes to ground water."

Line item 7: The reference to "Pit 3" is confusing for the reader with no/limited knowledge about OU-5, as the OU is also referred to as the Building 850/Pit 7 Complex OU," and there is no discussion/explanation of Pit 3's relation to Pit 7 Complex. Please add the following text to the end of the existing text "which is part of the Pit 7 Complex."

Response: **Introduction:**

The Contingency Plan identifies possible situations and uncontrollable natural events that could arise during remediation that could warrant additional actions, and several possible actions that could be taken to address these situations. The possible actions described to address contingencies do not constitute a part of or modifications to the selected remedies. Per EPA's direction, specific actions to be taken were not specified in the Contingency Plan, but rather would be decided at the time a specific contingency situation occurred in consultation with the regulatory agencies. Based on this information and direction from EPA and in reviewing EPA's IC guidance, the contingency plan actions do not appear to be applicable to ICs.

The Health and Safety Plan identifies organizational responsibilities, evaluates hazards that may be posed during the conduct of environmental restoration work at Site 300 and identifies controls for those hazards (i.e., personal protective and monitoring equipment), training requirements and emergency procedures. The elements of the Health and Safety Plan do not fit any of the types of ICs defined in the EPA guidance:

- ***"Proprietary controls*** **refer to controls on land use that are considered private in nature because they tend to affect a single parcel of property and are established by private agreement between the property owner and a second party who, in turn, can enforce the controls.**
- ***Governmental controls*** **impose restrictions on land or resource use using the authority of a government entity.**

- ***Enforcement and permit tools with IC components*** **are legal tools, such as administrative orders, permits, Federal Facility Agreements (FFAs), and Consent Decrees (CDs), that limit certain site activities or require the performance of specific activities (e.g., monitor and report on IC effectiveness).**
- ***Informational devices*** **provide information or notification often as recorded notice in property records or as advisories to local communities, tourists, recreational users, or other interested persons that residual contamination remains on site."**

Line item 4: The text has been modified as requested.
Line item 7: The text has been modified as requested.

3. **Section 1.0, Page 1, ¶ 1:** The text references the "Building 850/Pit 7 Complex Operable Unit (OU) 5" (this same reference appears elsewhere in the text as well including, e.g. on page 10, as the sole identifying reference). Given that the FYR is for OU-5, suggest using OU-5 as primary reference and placing the text "Building 850/Pit 7 Complex" in a parenthetical following the reference to OU-5 as necessary and appropriate for clarity.

Response: **The Site 300 OUs are referenced in current and historical documents by the name of the area (i.e., GSA, Pit 6 Landfill, Building 834, HE Process Area, Building 850/Pit 7 Complex, etc.) to avoid confusion on the part of the reader as to which area of the site is being discussed, which can be the case if the OUs were referred to only by the OU number (i.e., OU 1, 2, 3, 4, 5, etc.). Therefore, the use of the nomenclature (Building 850/Pit 7 Complex OU) has been retained to maintain consistency with historical and current Site 300 documents. However, a sentence was added to the first paragraph of Section 1 to clarify that OU 5 is referred to (in the rest of the document) as the Building 850/Pit 7 Complex OU. In addition, OU references in the document have all been changed to "Building 850/Pit 7 Complex OU" for consistency and clarification.**

4. **Section 1.0, Page 2, ¶ 1:** Please add text in parenthetical or footnote regarding EPA's request for consolidation of Site 300 FYRs and LLNL's plans for such.

Response: **EPA's request for consolidation of Site 300 Five-Year Reviews and DOE's response are noted in the minutes for the May 15, 2014 Remedial Project Manager's meeting. As discussed in the September 1, 2015 Remedial Project Manager's meeting, the Federal Facility Agreement states the Five Year Reviews will be consolidated following the initiation of the final remedial action for the Site. Because DOE does not have a current plan for consolidation of Site 300 Five-Year Reviews in the near future, a footnote/parenthetical was not added to the text.**

5. Section 1.1, Page 2, penultimate sentence: The sentence seems to mischaracterize the "Third Five-Year Review" with regard to "offsite land use controls." While the 3rd FYR, at EPA's instigation, noted EPA's policy preference for layered ICs, the primary point of EPA's comments on the draft 3rd FYR regarding LUCs (including ICs) was that the IC called for in the GSA ROD had not been implemented. Please revise text to more accurately describe the situation, such as: "The Third Five-Year Review for the GSA determined that offsite land use controls for long-term protectiveness due to the presence of contamination in offsite groundwater, part of the selected remedy, had not been implemented as stated in earlier FYRs, and that ICs are necessary to ensure long-term protectiveness."

Response: **The penultimate sentence in Section 1.1 states that: "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."**

DOE understands the priority EPA attaches to institutional controls for the GSA OU. However, since the GSA OU is unrelated to the Building 850/Pit 7 Complex OU 5, DOE is concerned that EPA's proposed revisions to the OU 5 review might cause confusion when reviewed by the public. In the most recent Five-Year Review for the GSA OU, DOE stated, and the regulatory agencies concurred, that ICs and LUCs were no longer required for the Eastern GSA. In the central GSA, existing offsite downgradient water-supply wells continue to be monitored monthly for contaminants of concern, and there is a Settlement Agreement with the owners of the offsite downgradient water-supply wells that includes replacement water supplies if VOCs above the MCL cleanup standard are detected in their wells. Given these circumstances, DOE believes the statement in the penultimate sentence in Section 1.1, as stated in the Draft Five-Year Review for the Building 850/Pit 7 Complex OU, correctly characterizes the status of the LUCs in the GSA OU.

DOE/NNSA understands and anticipates that EPA will want to address LUCs at the GSA OU in the next five-year review of that OU. In the meantime, DOE intends to continue to work toward meeting EPA's guidance on the implementation of proper land use controls for the GSA OU. Therefore, DOE believes that the statement in the penultimate sentence in Section 1.1, as stated in the Draft Five-Year Review for the Building 850/Pit 7 Complex OU, is correct.

6. **Section 1.2, Page 4, ¶ 3:** Description of the FYRs at some of the other Site 300 OUs reference some issues raised therein, but not this paragraph. Please include a statement noting no issues identified in FYRs or noting important issues.

Response: **The following text was added to address this comment:**

- **Added as the second to last sentence to Section 1.2 (Building 834 [OU 2]): "No deficiencies that affect the protectiveness of the remedy for the Building 834 OU were identified in the last (third) Five-Year Review in 2012."**
- **Added as the second to last sentence to Section 1.5 (Building 854 [OU 6]): "No deficiencies that affect the protectiveness of the remedy for the Building 854 OU were identified in the last (second) Five-Year Review in 2013."**
- **Added as the second to last sentence to Section 1.6 (Building 832 Canyon [OU 7]): "No deficiencies that affect the protectiveness of the remedy for the Building 832 Canyon OU were identified in the last (first) Five-Year Review in 2011."**
- **Added to the last paragraph in Section 1.7 (Site-Wide [OU 8]): "No deficiencies that affect the protectiveness of the remedy for the Site-Wide OU were identified in the last (first) Five-Year Review in 2013. In the 2013 Five-Year Review, the regulatory agencies agreed to remove cis-1,2-dichloroethene (DCE) as a ground water COC at Building 833 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."**

7. **Section 1.4, Page 6, ¶1:** The text references the 2nd FYRs determination of the need for off-site LUCs, but doesn't reference what, if anything has been done to achieve this recommendation, or whether the ROD will require modification. Please revise the text to discuss the status of efforts to put LUCs in place and whether a ROD modification will be required.

Response: **As noted in specific comment 5 above, DOE believes the discussion of offsite LUCs in the context of OUs other than the Building 850/Pit 7 Complex OU 5 will not aid in public understanding of the situation at OU 5, and could lead to confusion.**

As an aside and an update, DOE recognizes EPA's concerns about LUCs at the GSA and HE Process Area. As you know, DOE has been working with EPA and the owners of the water-supply well (GALLO-1) to put an agreement in place to establish offsite LUCs to prevent the installation of offsite water-supply or agricultural wells within the offsite portion of the VOC plume originating from the GSA and HE Process Area OU. Once an agreement is in place, DOE looks forward to EPA's input and guidance in executing the proper documentation under the CERCLA process.

8. **Section 1.6, Page 7, ¶ 1, last sentence:** Please revise the sentence to clarify what and where of the referenced mitigated risks.

Response: **The text in Section 1.6 has been modified to indicate the type of risk to onsite workers that has been mitigated and location where the risk has been mitigated.**

9. **Section 1.7, Page 8, § 1.7.2, 1.7.3, 1.7.4, 1.7.5:** Each of these sections includes the statement "No Remedial Design document was required for this area" notwithstanding that the remedy selected for the respective sites within OU-8 includes LUCs, for which RD is appropriate/required. Please explain why no RD was prepared in relation to LUCs for the referenced sites with OU-8.

Response: **In accordance with EPA's earlier guidance and concurrence, DOE did not prepare a Remedial Design (RD) for the OU 8 sites. DOE's understanding is that EPA's determination was based on the fact that the remedies for the OU 8 sites did not include any active remedial measures and the monitoring network was already in place. EPA determined the best way to proceed was to include the LUCs for OU 8 in the 2008 Site-Wide ROD, and did not in fact require a remedial design document for the monitoring remedy or the land use controls. However, EPA did provide the elements of the LUCs that they required be included in the ROD. These elements and the sections, figures, and/or tables in the 2008 ROD in which they were addressed are as follows:**

- **Current and potential land uses (Section 2.6).**
- **Summary of human health risk(s) posed by the site(s) (Sections 2.7.2.8 - 2.7.2.12).**
- **Areas requiring ICs/LUCs and the risk necessitating the IC/LUCs (Table 2.9-21).**
- **The performance objectives and duration of the IC/LUCs (Table 2.9-21).**
- **The ICs/LUCs and implementing mechanism including land use and transfer restrictions (Section 2.9.1.2 and/or Table 2.9-21).**
- **Responsibility for implementing, maintaining, reporting on, and enforcing ICs/LUCs. (Section 2.9.1.2).**
- **Maps that show the boundaries and areas of IC/LUC implementation in OU 8 (Figures 2.9-7 through 2.9-10).**

Effectively, the EPA determined that the 2008 ROD contained sufficient information on the LUCs and the development of a separate RD document for the OU8 sites was not necessary. If EPA believes it is appropriate to revisit its prior decisions, DOE is willing to discuss how an RD for OU 8 might be retroactively developed.

10. **Section 2, Site Chronology, Page 11:** The second bullet under the 1998 subsection indicates that polychlorinated biphenyl (PCB)-contaminated shrapnel and

debris was removed from the area around the Building 850 Firing Table; however, the disposal location is not specified. Please revise Section 2 to clarify where the PCB-contaminated shrapnel and debris was disposed.

Response: **Based on DOE/LLNL knowledge, this shrapnel and debris was disposed at the Envirocare facility in Utah. This information has been added to Section 2.**

11. **Section 3.1.1, Site Description, Page 13:** Section 3.1.1 indicates that the climate at Site 300 is semi-arid and "approximately 10 to 15 inches of precipitation falls each year, mostly in the winter;" however, Section C-2 of Appendix C indicates that precipitation during the last three years was significantly below average with 7.00 inches (2012), 8.33 inches (2013), and 5.25 inches (2014) of precipitation. Given the impact of the low rainfall on the extent of saturation, please revise Section 3.1.1 to discuss the decreased precipitation in the last three years. Additionally, please make references to annual rainfall consistent throughout the text.

Response: **Text was added to Section 3.1.1 discussing decreased precipitation at Site 300 during 2012 through 2014. References to annual rainfall in the text have been made consistent.**

12. **Section 3.1.1.2, Pit 7 Complex Site Description, Page 15:** The Pit 7 Landfill subsection indicates that the locations of Doall and Elk Ravines, the landfill, drainage diversion system, extraction and monitor wells, and the treatment system are presented on Figure 3. Please revise Figure 3 to identify the Doall and Elk ravines as noted in Section 3.1.1.2.

Response: **Figure 3 has been revised to denote the locations of Doall and Elk Ravines.**

13. **Section 3.5, Page 23, 2nd full ¶, last sentence:** Please provide a citation to the reference agreement between DOE and the regulators.

Response: **The referenced text in Section 3.5 has been modified to state: "Drinking water MCLs were selected as the cleanup standards for COCs in ground water in the Building 850/Pit 7 Complex OU in the 2008 Site-Wide ROD. Therefore, ground water cleanup is driven by the MCL ground water cleanup standards selected in the Site-Wide ROD, rather than by a specific risk number/level. Ground water in the Building 850/Pit 7 Complex OU is not currently used as drinking water and institutional controls will prohibit such use during cleanup."**

14. **Section 3.6.1, Page 27, 1st full ¶:** The text should provide a reference for the statement that the Site-Wide ROD documents an agreement regarding perchlorate

treatability study and FS leading to remedy selection for perchlorate given that a ROD is a remedy selection document and typically not used to document determinations outside of the remedy selection.

Response: **Section 2.9.5 (Remedial Alternative for Building 850 [OU 5]) of the 2008 Site-Wide ROD states that: "Based on the recent identification of perchlorate in ground water, DOE will implement an *in situ* bioremediation treatability study for perchlorate in ground water and discuss possible remedial measures with the regulatory agencies. Public input will be solicited prior to the selection of any remedial action for perchlorate in ground water. The selected remedy will be documented in an Amendment to the Site–Wide ROD." A reference to the Section (2.9.5) of the ROD, and the document reference (DOE, 2008) were added to the referenced text in Section 3.6.1.**

15. **Section 4.3.1, Page 30:** Include a brief description of the CAMU, e.g., what ARARs applied to its construction (does it have an engineered cap, etc.).

    3rd ¶, 1st sentence: Include a statement of the CAMU's location and a parenthetical reference to Figure 3, which the text on page 22 notes shows the location of the CAMU.

Response: **The description of the Corrective Action Management Unit (CAMU) was expanded in Section 4.3.1, as requested.**

The applicable or relevant and appropriate requirements (ARARs) that applied to the soil excavation, solidification, and consolidation (into a CAMU) remedy are presented in Table 2 of the "Action Memorandum for the Removal Action at the Building 850 Firing Table, LLNL Site 300" (Dibley et al., 2008). Because this table contains six pages of ARAR information, the individual ARARs that were applicable to the Building 850 soil removal action were not added to the text of Section 4.3.1. Instead a reference to Table 2 of the Action Memorandum for the Building 850 Firing Table Removal Action (Dibley et al., 2008b) was added to the text in Section 4.3.1.

The last paragraph of Section 4.3.1 already contained a reference to the location of the CAMU in Figure 3. However, a parenthetical reference to Figure 3 was also added to the 3rd paragraph of this section.

16. **Section 4.4.1, Page 32, 1st ¶:** Please explain the absence here of a description of how the remedy for the Building 850 Firing Table operated compared with the inclusion of such a description in the 2nd paragraph of § 4.4.2. (Overall the discussion of remedy implementation at the Building 850 Firing Table is far less extensive than is the discussion in relation to the Pit 7 Complex).

After 1st sentence: If true, add the term "inspection" (e.g., in the 1st sentence of § 4.4.2).

Response: **A description of how the remedy for the Building 850 Firing Table operated (similar to that in the 2nd paragraph of Section 4.4.2) was added to Section 4.4.1.**

Sections 4.4.1 and 4.4.2 contain operation and maintenance (O&M) information for Building 850 and the Pit 7 Complex, respectively. Because the remedy for the Pit 7 Complex is more extensive (i.e., ground water extraction and treatment O&M; inspection, maintenance, and monitoring of the four Pit 7 Complex Landfills; and drainage diversion system inspection, maintenance, and monitoring) as opposed to CAMU inspection and maintenance and ground water monitoring at Building 850, the O&M discussion for the Pit 7 Complex area in Section 4.4.2 is more extensive.

The term "inspection" was added to the first sentence of the first paragraph of Section 4.4.1.

17. **Section 4.4.1, Building 850 Remedy Operation and Maintenance, Page 33:** The text indicates that maintenance activities for the monitoring network included pump replacements, repairing rodent damage to wiring, and general wellhead maintenance on an as-needed basis; however, details regarding the pump replacements, repaired wiring, and wellhead maintenance are not provided and/or referenced. For completeness, please revise the FFYR to provide and/or reference details regarding the maintenance activities for the monitoring network.

Response: **Text describing well pump replacements was added to Section 4.4.1. A reference to the semi-annual and annual Compliance Monitoring Reports (1st Semester 2010 through 2014 Annual) where additional details of maintenance activities are described was also added to this section.**

18. **Section 4.4.2.1, Pit 7 – Source Ground Water Extraction and Treatment System O&M, Page 35:** Section 4.4.2.1 indicates that the spent ion-exchange resin and granular activated carbon (GAC) treatment media were replaced on an as-needed basis; however, information regarding the replacement of the spent ion-exchange resin and GAC treatment media are not provided and/or referenced. For example, the frequency of replacement for the spent ion-exchange resin and GAC treatment media is not discussed. As such, it is unclear if the treatment system is operating effectively or if modifications are necessary. Please revise the FFYR to provide details regarding the replacement of the spent ion-exchange resin and GAC treatment media.

Response: **As discussed in Section 4.3.2, the Pit 7 – Source ground water treatment system consists of three ion-exchange resin vessels for the removal of uranium**

followed by three ion-exchange resin vessels containing a perchlorate-selective resin that is also effective in removing nitrate. Ground water that has been treated to remove uranium, perchlorate, and nitrate is then piped through three aqueous-phase GAC vessels to remove VOCs. Although the perchlorate-specific ion-exchange resin is also effective in removing nitrate, the perchlorate resin becomes loaded with nitrate over time due to the much higher concentrations of nitrate (milligram per liter [mg/L] of nitrate vs. µg/L of perchlorate), and then releases nitrate as more perchlorate is sorbed to the resin. For this reason, a vessel containing nitrate-selective ion-exchange resin was placed at the end of the treatment train (after the GAC vessels) to ensure nitrate effluent discharge limits are met.

The following procedures are followed to determine when the treatment media at the Pit 7-Source treatment facility is becoming saturated, and change-out is needed to ensure that water being discharged from the facility meets the treatment facility effluent discharge limits.

Water samples are collected in between the first and second uranium-specific resin columns and analyzed for uranium quarterly to determine when uranium breakthrough in the first resin vessel occurs. When uranium is detected at an activity at or above the 0.1 pCi/L analytical reporting limit in the water sample collected from between the first and second uranium ion-exchange vessels, monitoring of uranium in water samples collected between the second and third uranium ion-exchange vessels is initiated and conducted quarterly. When uranium is detected at an activity at or above the 5.1 pCi/L uranium monthly median effluent limit in the water sample collected from between the second and third uranium ion-exchange vessels, change-out of the uranium-specific ion exchange resin is initiated. Uranium breakthrough in the uranium-specific ion-exchange resin has not been detected during the five-year review period. However, replacement of two of the uranium-specific ion-exchange resin vessels at the Pit 7-Source facility was conducted twice during the five-year review period solely due to clogging of the ion-exchange resin with sediment.

Water samples are collected in between the first and second perchlorate-specific resin vessels and analyzed for perchlorate quarterly to determine when perchlorate breakthrough in the first resin vessel occurs. When perchlorate is detected at concentration at or above the 4 µg/L perchlorate monthly median effluent limit in the water sample collected from between the first and second perchlorate ion-exchange vessels, monitoring of perchlorate in water samples collected between the second and third perchlorate ion exchange vessels is initiated and conducted quarterly. When perchlorate is detected at concentrations above the 4 µg/L perchlorate monthly median effluent limit in the water sample collected from between the second and third perchlorate-specific ion-exchange resin vessels, change-out of the perchlorate-specific ion-exchange resin is initiated. Breakthrough of the perchlorate-specific ion-

exchange resin has not been detected during the five-year review period. Therefore, replacement of the perchlorate-specific ion-exchange resin at the Pit 7-Source facility was not conducted during the five-year review period.

Water samples are collected in between the first and second GAC vessels and analyzed for VOCs quarterly to determine when VOC breakthrough in the first GAC vessel occurs. When VOCs are detected at concentration at or above the 0.5 µg/L VOC monthly median effluent limit in the water sample collected from between the first and second GAC vessels, monitoring of VOCs in water samples collected between the second and third GAC vessels is initiated and conducted quarterly. When VOCs are detected at concentrations above the 0.5 µg/L VOC monthly median effluent limit in the water sample collected from between the second and third GAC vessels, change-out of the GAC is initiated. Breakthrough of VOCs from the GAC vessels has not been detected during the five-year review period. Therefore, replacement of the GAC at the Pit 7-Source facility was not conducted during the five-year review period. Please note that VOCs have not been detected in the facility influent samples since April 2012.

Because contaminant breakthrough can occur before the treatment media in a specific vessel is fully saturated, the following treatment media change-out procedures are followed to maximize the use of the treatment media. When uranium, perchlorate, and/or VOCs are detected in a water sample collected in between the second and third vessels, the first and second vessels are removed and the third vessel moved into the first position. Two vessels containing clean, unused treatment media is moved into the second and third positions.

With the exception of two samples collected in April 2011, nitrate concentrations in the influent to the Pit7-Source ground water treatment system are below the 45 mg/L effluent limits. However, nitrate has been periodically detected in the effluent above the nitrate effluent discharge limits due to the accumulation and periodic release of nitrate from the perchlorate-specific ion-exchange resin. A nitrate-specific ion-exchange resin is in place at the end of the treatment train as a polishing step to prevent the release of nitrate above the effluent limits. The nitrate-specific resin is replaced when nitrate concentrations in the effluent approach the 45 mg/L effluent discharge limit. The nitrate-specific resin was changed-out 3 times during the five-year review period.

Text was added to Section 4.4.2 to clarify the frequency of the replacement of the spent ion-exchange resin and GAC treatment media conducted during the five-year review period.

19. **Section 5.1, Notification of Review/Community Involvement, Page 49:** The date the initial notice was published in The Tracy Press and San Joaquin Herald is not provided. Please revise Section 5.1 to ensure the date the report was initiated

and completed is placed in The Tracy Press and San Joaquin Herald.

Response: **Because the initial notice is intended to notify the public of the availability of the Draft Five-Year Review, it was published in the Tracy Press and San Joaquin Herald after the Draft Five-Year Review was reviewed and released, printed, provided to the regulatory agencies, and placed in the repositories. Therefore, the date of publication was not provided in the draft document. The date of publication of the initial notice has been included in the Draft Final Five-Year Review. This is the standard procedure in the Draft Five-Year Review to put a place-holder for the date of publication of the notice of availability of the document, as the notice publication date will always be after the draft document is issued.**

20. **Section 5.1, Notification of Review/Community Involvement, Page 49:** The web page listed for the LLNL Environmental Restoration Department electronic library (i.e., http://www-erd/librarv/) does not work. Please ensure that all web pages listed in the FFYR link to working web pages.

Response: **The correct addresses for the web pages listed in the Five-Year Review are:**

LLNL Environmental Restoration Department electronic library:
https://www-erd.llnl.gov/library/index.html
LLNL Environmental Community Relations:
https://www-envirinfo.llnl.gov/

21. **Section 5.4.2.3, Capture Zone Analysis, Page 78:** Figures and/or tables to substantiate the capture zone statements made in Section 5.4.2.3 are not provided. Section 5.4.2.3 indicates that the best indicators of hydraulic capture are the constituent of concern (COC) concentration trends in downgradient wells; however, figures and/or tables to support this statement are not provided and/or referenced. Please revise the FFYR to include figures and/or tables with information to substantiate the capture zone statements made in Section 5.4.2.3.

Response: **To address the comment, the following text has been added to Section 5.4.2.3: "The combined long-term flow rate from the entire extraction wellfield is less than 2,000 gallons per month (less than 0.05 gpm). In fact, these extraction wells are routinely shut down several days prior to scheduled sampling events to ensure that sufficient water is available to satisfy the ground water sampling requirements. In spite of these conditions, hydraulic influence from cyclic pumping has been observed in the vicinity of wells W-PIT7-2305 and W-PIT7-2705, the two wells providing the majority of the flow from the extraction wellfield. For example, a rapid ground water elevation response of up to 0.7 feet has been observed in monitor well W-PIT7-1918, located 52 feet and 22 feet from extraction wells W-PIT7-2305 and W-PIT7-2705, respectively.**

The magnitude and rapid timing of this response to pumping indicates that there is some measureable hydraulic connection between these wells.

Given the current low rainfall conditions, the best indicators of hydraulic capture are the COC trends in extraction wells, and more importantly, the COC trends observed in downgradient performance monitoring wells. COC maps and time-series plots of uranium activities and perchlorate concentrations (Figs. 20a and 21, respectively) indicate that the extraction wells are removing dissolved COC mass from areas of the highest activities/concentrations (Figures-7 through 14 and 19) in the shallow ground water adjacent to the Pit 3 and Pit 5 source areas. As shown in Figure 20b, uranium isotopic composition in PIT7-SRC area performance monitor wells exhibits a trend toward a more natural composition, suggesting that anthropogenic depleted uranium is adequately captured by the extraction wellfield.

It should also be pointed out that extraction well NC7-25 was activated in 2012 to increase uranium mass removal. After nearly two years of operation, recent analytical results indicate a significant increase in uranium activity and a slight shift in isotopic composition toward a more depleted signature (Figures 20a and 20b, respectively). Prior to the initiation of ground water extraction from NC7-25, the ground water extracted from this well contained only natural uranium. The shift in uranium isotopic composition indicates hydraulic capture of depleted uranium in the shallow ground water in close proximity to this well. To date, all ground water monitoring wells downgradient of NC7-25 continue to exhibit uranium activities that remain significantly below the MCL cleanup standard and isotopic composition indicative of only natural uranium.

The most diagnostic performance monitor wells at Pit 7-Source are NC7-51 and W-PIT7-1918. NC7-51 is located downgradient of the Pit 3 source area and within the area of highest COC concentrations. The long-term uranium trends in this well are indicative of hydraulic capture and extraction wellfield performance from extraction wells NC7-64 and W-PIT7-2703. Although the uranium activity in NC7-51 has remained relatively stable during the period of operation of the Pit 7-Source wellfield, it has declined significantly from the maximum uranium activity observed following the 1998 El Niño. However, during the extraction wellfield operation period, the isotopic composition in this well has exhibited a trend toward more natural composition indicating hydraulic capture and removal of anthropogenic depleted uranium. Additionally, the perchlorate concentrations in NC7-51 exhibit a declining trend indicating hydraulic capture and removal of perchlorate by the upgradient extraction wells. Although perchlorate trends in performance monitoring well W-PIT7-1918 have not significantly decreased during the period of wellfield operation, this well exhibits similar uranium trends to NC7-51 (Figure 19). The COC trends in W-PIT7-1918, located downgradient

from the Pit 5 source area, are due to extraction and hydraulic capture from nearby extraction wells W-PIT7-2705 and W-PIT7-2305.

Given the hydraulic properties of the Qal/WBR HSU materials in the PIT7-SRC area and the existing rainfall conditions, the Pit 7-Source extraction wellfield is capturing and removing COC mass from the areas of highest concentrations in the ground water as well as can reasonably be expected."

22. **Figure 4, Building 850 and Pit 7 Complex area ground water potentiometric surface map for the Qal/WBR hydrostratigraphic unit and Figure 5, Building 850 and Pit 7 Complex area ground water potentiometric surface map for the $Tnbs_1/Tnbs_o$ hydrostratigraphic unit:** The date(s) when the water level measurements were made are not provided on Figures 4 or 5. Please revise Figures 4 and 5 to include the date(s) when the water level measurements were made.

Response: **The water level measurements used to construct Figures 4 and 5 were collected during the fourth quarter 2014. To address the comment, the words "4th Quarter 2014" have been added to the ends of the captions of Figures 4 and 5.**

23. **Appendix Al, Building 850 Five-Year Review Inspection Checklist Photographs, Current photographs of the Building 850 Corrective Action Management Unit (CAMU):** Several of the photographs show debris (e.g., sticks, tumbleweeds) within the drainage system; however, the FFYR text does not discuss the specific inspection and maintenance activities conducted during the FYR period to ensure clogging of the drainage diversion system did not occur. It should be noted that the Pit 7 Complex Drainage Diversion System Inspections and Maintenance Field Sheet does discuss the inspection and maintenance activities conducted during the FYR period to ensure clogging of the drainage diversion system did not occur. Please revise the FFYR to discuss the inspection and maintenance activities that were conducted to ensure clogging of the drainage diversion system was prevented.

Response: **Section 4.4.1 of the FYR report does discuss the specific inspection and maintenance activities that were conducted to ensure clogging of the CAMU surface water drainage system (there is no drainage diversion system there) was prevented. These are listed as some of the major maintenance activities conducted there (on the top of Page 33):**

- **Removing sediment from the drainage system catch basin to restore water flow (2013).**
- **Removing vegetative debris and sediment from the CAMU surface water drainage system (as needed).**

The CAMU and drainage system are inspected after each significant rain event to ensure that the drainage ways are not clogged.

24. **Appendix A2, Building 850 Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist and Appendix A4, Pit 7 Complex Landfill Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist:** Based on Appendices A2 and A4, regulatory agency regional project managers (RPMs) were not interviewed as part of the FYR site inspection. Further, it is unclear if the regulatory agencies were invited to participate in the FYR site inspection. Based on Appendix C of the FYR Guidance, interviews should be conducted with the various individuals or groups, including the operation and maintenance (O&M) site manager, O&M staff, local regulatory authorities and response agencies, community action groups or associations, site neighbors, and other stakeholders. Please revise the FFYR to clarify why Appendices A2 and A4 do not include interviews with the regulatory agency RPMs. In addition, please clarify whether the regulatory agencies were invited to participate in the FYR site inspection.

Response: **Please refer to the response to EPA General Comment #3.**

25. **Appendix A2, Building 850 Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist:** Section VI.IX.E.1 indicates that an old lysimeter (NC7-09) was identified as unlabeled during the field checklist inspection and is no longer functional or used and will be schedule to be decommissioned; however, the FFYR text does not discuss this lysimeter and/or its decommissioning. Please revise the FFYR text to discuss this lysimeter and its decommissioning.

Response: **The following text has been added to Section 4.4.1 of the FYR: "During the five-year review inspection, it was also noted that non-functional lysimeter NC7-09 continues to exist in the area between the southern engineered drainage channel and the CAMU. A schedule for the decommissioning and proper abandonment of the lysimeter is being developed."**

26. **Appendix A2, Building 850 Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist:** Section XI.D suggests the use of a pre-emergent herbicide in the drainage channels on the perimeter of the CAMU to reduce maintenance labor and enhance the flow of surface water runoff during rain events; however, this opportunity for optimization is not discussed in the FFYR text. Please revise the FFYR text to discuss this opportunity for optimization.

Response: **Text in the Five-Year Inspection Checklist regarding the suggestion of using pre-emergent herbicide in the drainage channels on the perimeter of the CAMU to reduce maintenance labor and enhance the flow of surface water runoff during rain events has been added to Section 4.4.1.**

27. **Appendix A3, Pit 7 Complex Five-Year Review Inspection Checklist Photographs:** The purpose of the orange fencing around the Southern Settling Basin in the Drainage Diversion System photographs is not discussed. For example, it is unclear if the fencing is intended to prevent tumbleweeds from entering the Southern Settling Basin. Please revise the FFYR to clarify the purpose of the orange fencing around the Southern Settling Basin.

Response: **The purpose of the orange fencing around the Southern Settling Basin in the Drainage Diversion System is to help prevent the accumulation of loose vegetation (i.e., tumbleweeds) from accumulating in the settling basin, which could reduce the effectiveness of the settling basin. Text was added to the caption in the photograph of the Southern Settling Basin in Appendix A4 to explain the purpose of the fence.**

28. **Appendix A4, Pit 7 Complex Landfill Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist:** Section III.6 indicates that benchmarks around the Pit 7 Complex landfills are inspected at least annually; however, details regarding these annual inspections are not provided and/or referenced in the FFYR text. Please revise the FFYR text to provide and/or reference details regarding the annual inspection of the benchmarks around the Pit 7 Complex landfills.

Response: **Text was added to Section 4.4.2.3 (Landfill Inspection and Maintenance) discussing the inspection of the landfill benchmarks.**

29. **Appendix A4, Pit 7 Complex Landfill Portion of Operable Unit 5, Five-Year Review Site Inspection Checklist:** Section IX.C.6 indicates that monitoring wells do not need maintenance; however, the Remarks section indicates that analysis from well W-Pit7-13 was not performed due to an inoperable pump. While Section IX.E.1 indicates that well W-Pit7-13 is inoperable and is scheduled to be replaced, Section IX.C.6 does not. Please revise Section IX.C.6 to clarify that well W-Pit7-13 is inoperable, provide the replacement schedule, and state that that monitoring wells do need maintenance.

Response: **It has been determined that the well (W-PIT7-13) was unable to be sampled due to electrical issues with the sampling truck rather than due to an inoperable pump. The sampling truck electrical issues were resolved in March of 2015, and the sampling of well W-PIT7-13 recommenced in April 2015. The text in Section IX.C.6 and IX.E.1 of Appendix A4 has been modified accordingly.**

MINOR COMMENTS

1. **Section 3.1.1, Page 13, ¶ 1:** Delete the comma after the word "development."

Response: **The referenced text in Section 3.1.1 has been modified to state: "At Site 300, DOE conducts research, development, and testing associated with high explosive materials."**

2. **Section 3.2, Page 20, 1st full ¶, 5th sentence:** Put a space between the terms "special" and "status."

Response: **The text in Section 3.2 has been modified as suggested.**

3. **Section 3.3.1, Page 20, ¶ 1, 2nd sentence:** Change the first word to "The" from "These" as there is no antecedent reference.

Response: **The text in Section 3.3.1 has been modified as suggested.**

4. **Section 4.3.1, Page 30, last paragraph:** Insert the article "the" before the term "Building. "

Response: **The text in Section 4.3.1 has been modified as suggested.**

5. **Section 4.3.2, Page 31, 3rd ¶, last sentence:** Change the word "reasonable" to "reasonably."

Response: **The text in Section 4.3.2 has been modified as suggested.**

6. **Section 4.5, Page 38, 1st ¶, 3rd sentence:** Change to the plural form, the word "type" to "types."

   Page 38, 3rd ¶[, 1st sentence: Change the phrase "that presents" to "which present."

Response: **The text in Section 4.5 has been modified as suggested.**

7. **Section 4.5.1, Page 38:** The phrase "ground water" is used in this section (and others), although at other places in the text (including Tables 2 and 3), the phrase is used as a single term "groundwater." Use the word consistently throughout the text unless a reason for not doing so (e.g., a quotation of text where it is used differently).

Response: **The text, tables, and appendices were checked and revised as necessary for consistency in use of the phrase "ground water." (The DOE document convention is to use "ground water" as two words.)**

Regional Water Quality Control Board (RWQCB) comments:

GENERAL COMMENTS

1. Regional Water Board staff concur with the recommendations presented in the Report. However, Regional Water Board staff cannot concur with the Report's conclusions regarding COC activities/concentrations in groundwater until the discrepancies and inconsistencies noted in the comments below are resolved. There are several discrepancies between the concentration/activity data presented in the text of the Report and the concentration/activity data presented on the figures, particularly for the year 2010. The Report needs to be revised so that data presented in the text corresponds to data presented on the figures. Please also see Specific Comments No. 2, 3, 6, 7, 8, 10, and 11 below.

Response: **Comment noted. Specifics of this comment are addressed in detail in the responses to Specific Comments 2, 3, 6, 7, 8, 10, and 11.**

2. The Report is not consistent with the description of the location of well NC7-29 in relation to Building 850. Some portions of the Report (e.g. second paragraphs of Sections 5.4.1.1.2 and 5.4.1.1.3, seventh paragraph of Section 5.4.1.1.4, and fourth paragraph of Section 5.4.1.3) describe NC7-29 as being located south of Building 850 while other portions of the report (e.g. fourth paragraph of Section 5.4.1.1.3) describe the well as being located south- southeast of Building 850. Based on the figures included in the Report, NC7-29 is depicted in a south-southeast direction from Building 850. The Report should be revised so that the text and the figures are consistent.

Response: **The text referenced in the comment has been revised so that well NC7-29 is consistently described in the FYR as being located south-southeast of Building 850.**

3. The Report states that well NC7-29 is located cross-gradient of Building 850. Regional Water Board staff's interpretation of the groundwater potentiometric map shown on Figure 5 is that well NC7-29 is located downgradient of Building 850. Please provide the rationale for concluding that NC7-29 is located cross-gradient and not downgradient of Building 850.

Response: **DOE/LLNL's conclusion that NC7-29 is located cross-gradient and not downgradient of Building 850 is based on the potentiometric surface contours shown on Figure 5 that indicate ground water flow from Building 850 is in a west to east flow direction (perpendicular to the potentiometric surface contours). Well NC7-29 is located about 1,500 ft southeast of Building 850 in a location that can only be defined as cross-gradient based on the potentiometric surface contours.**

4. The Report states that the source of contamination at the Pit 7 Complex is the firing table debris and gravel buried in the landfills that contained residual VOCs, tritium,

depleted uranium, perchlorate, and nitrate, from experiments conducted on the firing tables. Because the test assemblies used at the firing tables are not reported to have contained VOCs, the source of the VOCs detected in groundwater at the Pit 7 Complex is not clear. The Report should include a description of operations conducted at the firing tables that used VOCs to clarify the origin of the VOCs in the Pit 7 Complex groundwater.

Response: **The following text has been added to Section 3.1.1.2: "There is no historical documentation stating VOCs were used at the Building 850 or Building 851 firing tables, and if they were, how they were used. Despite detailed records searches and interviews with firing table personnel, the origin of VOCs in Pit 7 Complex waste is still unknown. However, given the low concentrations of VOCs detected in Pit 7 Complex ground water (i.e., individual VOC concentrations all below ground water cleanup standards in 2014), the presence of VOCs could be attributable to residual/incidental contamination of materials placed in the landfill."**

SPECIFIC COMMENTS

1. *Section 3.4, Initial Response and Section 4.3.1, Building 850 Remedy Implementation*: The last paragraph of Section 3.4 states that a total of 27,592 cubic yards of PCB-, dioxin-, and furan-contaminated surface soil were excavated from the Building 850 Firing Table area while the third paragraph of Section 4.3.1 states that 29,000 cubic yards of PCB-, dioxin-, and furan-contaminated surface soil were excavated from the Building 850 Firing Table area. The Report should be revised so that the reported volumes of excavated soil are consistent throughout the report.

Response: **The text of the report has been changed so that the volume of soil excavated at the Building 850 firing table area is consistently stated to be a total of 27,592 cubic yards of PCB-, dioxin-, and furan-contaminated surface and subsurface soil.**

2. *Section 5.4.1.1.1, Tritium Activities, Distribution, and Remediation*: This section states that the highest tritium activity in the Lower Neroly Formation ($Tnbs_1/Tnbs_0$) hydrostratigraphic unit (HSU) wells in the year 2010 was 10,200 picocuries per liter (pCi/L) in a sample from well NC2-08. However the tritium activity shown on Figure 7 for NC2-08 during 2010 is 4,240 pCi/L. Figure 7 shows the highest tritium activity of 10,200 pCi/L in well NC2-18 for the year 2010. It appears that well NC2-18 was inadvertently typed as NC2-08. Please correct this discrepancy.

Response: **The text of Section 5.4.1.1.1 (tritium in $Tnbs_1/Tnbs_0$ HSU) has been corrected to state that the maximum 2010 tritium activity of 10,200 pCi/L was detected in well NC2-18 (and not well NC2-08).**

3. *Section 5.4.1.1.2, Uranium Activities, Distribution, and Remediation*: The second and fifth paragraphs of this section state that during the five-year review period, total uranium was detected at an activity (of 24 pCi/L) exceeding the 20 pCi/L cleanup standard in a 2013 sample from Quaternary Alluvium/Weathered Bedrock (Qal/WBR) HSU well NC7-28 and that prior to this sampling event, uranium had been detected above the cleanup standard only once in February 2008. However, based on Figure 9, uranium activities exceeded the cleanup standard of 20 pCi/L during 2010 in five Qal/WBR HSU wells (W-850-2417 at 79 pCi/L; NC7-28 at 69 pCi/L; NC7-70 at 43 pCi/L; NC7-61 at 47 pCi/L; and NC7-10 at 21 pCi/L). Therefore, the data presented on Figure 9 contradicts Section 5.4.1.1.2. Please revise Figure 9 or the Report (Section 5.4.1.1.2 and subsequent sections that discuss uranium activity at Building 850 during the five-year period [i.e. Section 5.4.1.2 and Section 5.4.1.3]) to correct the discrepancies.

Response: **Figure 9 was inadvertently published in the Draft Five-Year Review with 2010 perchlorate concentrations shown instead of 2010 uranium activities. Figure 9 has been corrected to indicate uranium activities and thus the data discussed in the text is now consistent with the data shown on the figure.**

4. *Section 5.4.1.1.3 Nitrate Concentrations, Distribution, and Remediation*: The second paragraph states that "The highest nitrate concentrations (>100 mg/L as NO3) were detected in NC7-29, screened in the Tnbs1/Tnbs0 HSU. Because this well also contains perchlorate and it is located south and cross-gradient of Building 850, this elevated nitrate is from a local source and not Building 850". It is not clear how the presence of perchlorate in NC7-29 precludes this well from being potentially contaminated by groundwater flow from Building 850. Additionally, based on the groundwater potentiometric map shown on Figure 5, it appears that NC7-29 is downgradient of Building 850 (see General Comment No. 4) and not cross-gradient. Please clarify how the presence of perchlorate in NC7-29 and the groundwater potentiometric map shown on Figure 5 provide evidence that the nitrate detected in NC7-29 is not from Building 850. Also, please specify the "local source" which is inferred to be the source of nitrate in well NC7-29.

Response: **As described in DOE/LLNL response to RWQCB General Comment 3, the potentiometric surface contours for the $Tnbs_1/Tnbs_0$ HSU shown in Figure 5, indicate that well NC7-29 is cross-gradient of Building 850. Thus, as described in DOE/LLNL response to EPA General Comment 5, the nitrate and perchlorate observed in ground water samples from well NC7-29 arise from a local source at the corporation yard located immediately east of the well.**

5. *Section 5.4.1.1.3, Nitrate Concentrations, Distribution, and Remediation*: The third paragraph states that samples collected from NC7-61 in May 2014 contained nitrate at a concentration of 49 mg/L. However, the 2014 data shown on Figure 11 indicates a concentration of 50 mg/L. Please revise the text of the Report or Figure 11 for consistency.

Response: **Text has been corrected in Section 5.4.1.1.3 to state that the 2014 maximum nitrate concentration observed in Qal/WBR HSU well NC7-61 was 50 mg/L (not 49 mg/L).**

6. *Section 5.4.2.1.1, Tritium Activities, Distribution, and Remediation*:

   a. The second paragraph states that during the five-year review period, tritium activities continued to decrease from a 2010 maximum of 255,000 pCi/L in a sample from NC7-63 to 115,000 pCi/L by October 2014. Based on Figure 7 however, well NC7-63 had insufficient water to collect a sample in 2010 and was dry in 2014. The 2014 maximum activity of 115,000 pCi/L is shown for well NC7-51 instead. Please revise the Report so that the text and Figure 7 are consistent.

   b. The fourth paragraph states that the 2010 maximum tritium activity in the Tnbs1/Tnbs0 HSU was in well NC7-25 at 271,000 pCi/L. However the 2010 data depicted on Figure 8 shows NC7-25 with a tritium activity of 230,000 pCi/L. Please correct this discrepancy.

Response:

a. Text has been added to the referenced paragraph in Section 5.4.2.1.1 stating that the 2014 maximum Qal/WBR HSU tritium activity of 115,000 pCi/L in the Pit 7 Complex was detected in a sample from well NC7-51. Thus, the figure and text are now consistent.

b. The 2010 maximum tritium activity in the Tnbs1/Tnbs0 HSU (271,000 pCi/L at well NC7-25) has been added to Figure 8 in place of the 230,000 pCi/L (November 2010) previously shown on Figure 8 for this well.

7. *Section 5.4.2.1.2, Uranium Activities, Distribution, and Remediation*:

   a. The third paragraph states that in 2010, uranium activities exceeded the 20 pCi/L cleanup standard in samples from 12 wells in the Qal/WBR HSU. However, based on the 2010 data shown on Figure 9, only one well (W-PIT7-2306 with an activity of 25 pCi/L) is indicated to have contained uranium with an activity above 20 pCi/L. The Report should be revised to correct this discrepancy.

   b. Furthermore, the third paragraph states that the maximum uranium activity in 2010 was in former extraction well NC7-63 at 120 pCi/L. However, as stated in 7a. above, based on data presented on Figure 9, the maximum uranium activity during 2010 was 25 pCi/L in well W-PIT7-2306. Please revise the Report to correct this discrepancy.

Response:

a. As stated in the response to RWQCB Specific Comment 3, Figure 9 was inadvertently published in the Draft Five-Year Review with 2010

perchlorate concentrations shown instead of 2010 uranium activities. Figure 9 has been corrected to indicate uranium activities and thus the text is now consistent with the figure.

b. The corrected Figure 9 now shows the 120 pCi/L maxima for uranium activity at well NC7-63.

8. *Figure 9 and Figure 19*: Both Figure 9 and Figure 19 show uranium activity data in the Qal/WBR HSU during 2010 and 2014 for the Pit 7 Complex. However the 2010 uranium activity data presented on Figure 9 is different from the 2010 uranium activity data presented on Figure 19. The figures should be revised for consistency or the Report should provide an explanation for the difference in the uranium activities presented on the two figures.

Response: **As stated in the response to RWQCB Specific Comments 3 and 7, Figure 9 has been corrected. Uranium data depicted on the corrected Figure 9 are now consistent with those depicted on Figure 19.**

9. *Section 5.4.2.1.4, Perchlorate Concentrations, Distribution, and Remediation*:

a. The third paragraph states that perchlorate in the Qal/WBR HSU decreased to a maximum of 14 microgram per liter (ug/L) in a sample from W-PIT7-2305 during 2014, and that wells containing perchlorate at concentrations exceeding the 6 ug/L cleanup standard were wells NC7-51, NC7-64, W-PIT7-2703, -1918, 2305, and 2705. However, based on Figure 13, perchlorate was also detected at 14 ug/L in K7-01. Please revise the Report to include information for K7-01.

b. The fourth paragraph states that the 2010 maximum perchlorate in the Qal/WBR HSU was 27 ug/L from well W-PIT-2306. However, the concentration shown for this well on Figure 13 is 25 ug/L. Please correct this discrepancy.

c. The fifth paragraph states that the 2010 maximum perchlorate concentration in the $Tnbs_1/Tnbs_0$ HSU wells was 11 ug/L in a sample from well NC7-25. However, Figure 14 indicates a perchlorate concentration of 25 ug/L for NC7-25 during 2010. Please correct this discrepancy.

Response:

a. The maximum perchlorate concentration of 14 μg/L, detected in the April 2014 duplicate sample from well K7-01 was also added to the text for Section 5.4.2.1.4.

b. The 2010 perchlorate maximum of 27 μg/L in the Qal/WBR HSU in the Pit 7 area (June 2010 at well W-PIT7-2306) has been added to Figure 13 in place of the 25 μg/L perchlorate concentration (January 2010) originally shown for the well.

c. **Figure 14 shows a perchlorate concentration of 10 µg/L (January) for well NC7-25, not 25 µg/L as indicated in the comment. The 2010 perchlorate maximum of 11 µg/L in the $Tnbs_1/Tnbs_0$ HSU in the Pit 7 area (June 2010 at well NC7-25) has been added to Figure 14 in place of the 10 µg/L perchlorate concentration (January 2010) originally shown for the well.**

10. *Section 5.4.2.4, Pit 7 Complex Landfill Detection Monitoring and Results*:

a. The fourth paragraph contains a typographical error for tritium activity. The tritium activity is stated to be 82.000 pCi/L rather than 82,000 pCi/L. Please correct this typographical error.

b. The fifth paragraph states that the highest uranium activities in the Pit 7 Complex detection monitor wells are currently detected in well K1-01 with a 2014 activity of 15 pCi/L. However, K1-01 is not a detection monitoring well for the Pit 7 Complex. K7-01 is the Pit 7 Complex detection monitoring well that had a 2014 activity of 15 pCi/L. Please revise from K1-01 to K7-01.

c. Additionally, the fifth paragraph states that "Uranium activities in this well have decreased from a historic maximum of 27 pCi/L in 1984 and from 10.2 pCi/L in 2010". Please replace the second "from" in the sentence with "to". Also, the reported 2010 activity (10.2 pCi/L) does not correspond to any of the 2010 uranium activities shown on Figures 9, 10, or 19. The Report and or/figures should be revised for consistency.

d. The sixth paragraph states that during the five-year review period, nitrate concentrations in NC7-47 ranged from 64 mg/L to 66 mg/L. However, based on Figure 12, the 2010 nitrate concentration in this well was 68 mg/L. Please revise the text and the figure to be consistent.

Response:

a. **The typographical error has been corrected (82.000 pCi/L has been replaced with 82,000 pCi/L in the referenced text).**

b. **The typographical error has been corrected (K1-01 has been replaced with K7-01 in the referenced text).**

c. **The referenced text in the comment has been replaced as requested. The fifth paragraph of Section 5.4.2.4 has also been revised to state that the maximum 2010 uranium activity in well K7-01 was 19 pCi/L. This uranium activity is depicted on Figure 10.**

d. **The sixth paragraph of Section 5.4.2.4 has been revised to state that during the five-year review period, nitrate concentrations in NC7-47 ranged from 64 mg/L to 68 mg/L.**

Comment Responses for the Draft Five Year Review Report for Operable Unit 5 at Lawrence Livermore National Laboratory (LLNL) Site 300

Tri-Valley Communities Against a Radioactive Environment (CAREs) comments:

1. In general, TVC supports the EPA and the Central Valley Regional Water Quality Control Board (CVRWQCB) comments on the OU5 Five-Year Review.

   a) Specifically, we support the Water Boards General Comment 1 and 2 that there are inconsistencies in the report regarding monitoring results and conclusions, and the Specific Comments that identify the discrepancies.

Response: **In the response to Regional Water Quality Control Board (RWQCB) General Comments #1, DOE/LLNL noted that the specifics of this comment were addressed in detail in the responses to Specific Comments 2, 3, 6, 7, 8, 10, and 11. DOE's response to RWQCB General Comment #2 is that the Draft Final Five-Year Review text referenced in the comment has been revised to consistently refer to well NC7-29 as located south-southeast of Building 850.**

   b) We also support, and wish to highlight, EPA's General Comment #2. This concerns the drainage diversion system. TVC agrees that heavy rainfalls typically associated with "El Nino" events have not yet challenged the Pit 7 complex engineered drainage diversion system. We recommend that the fourth numbered paragraph in the protectiveness statement be removed until this system is challenged during heavy rainfalls similar to the El Nino events. It should be added as issue, and it should be added as well that enhanced monitoring of the system will be undertaken when high-duration rainfall accompanying an El Nino (or similar) event occurs.

Response: **As indicated in Section 5.4.2.5.4 of this Five-Year Review and the Remedial Design for the Pit 7 Complex, the drainage diversion system was designed to divert excess surface water runoff and shallow subsurface recharge from the hillslopes to the west and east of the Pit 7 Complex landfills during high intensity storms and periods of extreme rainfall (i.e., the 1997-1998 El Niño) to minimize ground water rises into the pit waste and underlying contaminated bedrock. Thus, the drainage diversion system performance can best be evaluated during a future El Niño season or other period of extended intense rainfall (e.g., several continuous days with >1 inch of daily rainfall). DOE/LLNL acknowledge that there has not been an El Niño event since the drainage diversion system was installed. However DOE/LLNL has been monitoring and evaluating ground water data (i.e., ground water elevations) in the Pit 7 Complex area since the drainage diversion system was installed. As**

discussed, these data indicate that the drainage diversion system is operating as intended to: (1) reduce ground water elevation responses to rainfall, (2) prevent ground water rises into the pit waste, and (3) decrease concentrations of contaminants of concern (COCs) in ground water. Therefore, DOE believes that the statement in #4 of the Protectiveness Statement (Section 9) is valid. Since the statement that the drainage diversion system performance can best be evaluated during a future El Niño season or other period of extended intense rainfall has been included in the Record of Decision when the drainage diversion system was selected as part of the remedy in the Pit 7 Complex area, identifying this as an issue in the Five-Year Review does not appear to be appropriate or necessary.

Multiple key wells that are included in the monitoring network for the drainage diversion system are outfitted with transducers and water-level data from these wells are recorded every 15 minutes. Therefore, the monitoring network is capable of providing significant detail on ground water level rises during an El Niño event.

c) We also support in particular the EPA General Comment #4. This concerns information regarding the extraction of uranium, perchlorate, and nitrate from the tritium-bearing groundwater and re-injection of this water. It is not clear from the FYR that re-injection is not accelerating downgradient migration of tritium. We concur with EPA that re-injection should be evaluated in this FYR so ensure that there is no accelerated movement of tritium through the environment. If data are not available, we recommend that this be added as an issue, and that this work be accomplished in the next Annual Groundwater Report.

Response: **The following text is almost verbatim (except for words in parenthesis) from the DOE/LLNL response to the U.S. Environmental Protection Agency (EPA) General Comment 4: To clarify that local ground water tritium activities have not been adversely impacted by the discharge of tritium-bearing effluent into the infiltration trench (and that downgradient migration of tritium has not been accelerated), the following text has been added to Section 5.4.2.5.2: "Specifically, tritium activities in water samples collected from wells NC7-16 and NC7-21, located immediately downgradient of the infiltration trench in the Qal/WBR (Quaternary alluvium/weathered bedrock) HSU (hydrostratigraphic unit), have decreased from 2010 maxima of 42,700 and 64,700 picocuries per liter (pCi/L) respectively to the most recent five-year review period maxima of 20,700 and 32,800 pCi/L, respectively. The most recent sample from NC7-16 was collected on July 10, 2013; the well subsequently went dry. The most recent sample from well NC7-21 was collected on October 14, 2014."**

In responding to EPA General Comment 4, DOE/LLNL also noted that the decreasing extent of saturation and volume of water within the Qal/WBR that

are a result of reduced local recharge arising from drought conditions would not in themselves cause a lack of significant local tritium activity increases (or cause decreases). The observed reduction in tritium activities in the area of the infiltration trench is presumed to be the result of radioactive decay and dispersive mixing of tritium from the treatment facility effluent with that already present in the ground water.

d) We also support in particular the EPA General Comment #10. This concerns HMX and RDX found in groundwater at B-850. These contaminants were found recently, as noted in Issue #1 of the FYR. We note that this could affect future protectiveness. While the recommendation is to monitor activities and evaluate attenuation mechanisms, as EPA states, the monitoring wells to be sampled and the frequency of sampling are not discussed. Additionally, we have not seen a discussion of how LLNL intends to evaluate attenuation mechanisms. Further, we recommend that contingencies be discussed early in the process in case attenuation mechanisms prove insufficient as a remedy.

Response: **The following text is the response to EPA General Comment 10: "To verify the continued decrease in Research Department Explosive (RDX) and High Melting Explosive (HMX) concentrations and extent, and to continue to evaluate attenuation mechanisms driving these decreases, samples for high explosive (HE) compound analysis by EPA Method 8330 will be collected semi-annually from monitor wells NC7-10, NC7-11, NC7-14, NC7-15, NC7-19, NC7-27, NC7-28, NC7-44, NC7-54, NC7-55, NC7-60, NC7-61, NC7-70, NC7-71, NC7-73, W-850-05, W-850-2313, W-850-2314, and W-850-2417." This information has been added to Section 8.1 of the Five-Year Review.**

DOE/LLNL will continue to evaluate the attenuation of HMX and RDX in local ground water by evaluating concentration trends in wells downgradient and the lateral extent of these chemicals during the next five-year review period. In addition, as discussed in the recommendations, DOE/LLNL will be collecting subsurface soil samples for HE compound analysis from boreholes in the Building 850 Firing Table to determine if a significant ongoing source of HE compounds is present in the vadose zone under the firing table that could impact ground water above cleanup standards. These data will be discussed with the regulatory agencies to determine a path forward.

2. TVC also notes that the Background section of the FYR on the B-850 firing table (Section 3.1.1.1) states that, prior to 1988, firing table gravel was routinely removed and disposed of in the Pit 7 complex. High explosive compounds, beryllium and lead, as well as large quantities of PCBs, dioxin and furan, contaminated these gravels, along with the Contaminants of Concern (COCs) of tritium, uranium, perchlorate and nitrate. We recommend adding (as a Table) previous sampling results that rule out any of these contaminants as COCs for Pit 7. If not available,

we recommend that a new issue be added that would evaluate the surface soil and groundwater for these additional contaminants.

Response: **Firing table gravels were placed in the Pit 7 Complex Landfills and covered. Therefore, contamination of surface soil surrounding the landfills is not an issue. Ground water monitoring for constituents of concern in detection monitor wells located at the Pit 7 Complex Landfill Complex has been conducted since the landfills were closed in 1993. The objective of the detection monitoring program is to identify any new releases from the waste in the landfills to ground water. Constituents of concern, as defined by Title 23 of the California Code of Regulations Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the landfill. The constituents of concern identified for the Pit 7 Complex landfills that are monitored under the Pit 7 Complex detection monitoring program include volatile organic compounds (VOCs), nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals including beryllium and lead, lithium, and polychlorinated biphenyls (PCBs). Wells K7-01, K7-03, K7-06, K7-09, K7-10, NC7-26, NC7-47 and NC7-48 comprise the current detection monitoring well network for the Pit 7 Complex. These detection monitor wells are screened in the alluvial and bedrock ground water-bearing zones.**

The detection monitoring of the Pit 7 Landfill Complex was initially conducted under the oversight of the RWQCB under a Waste Discharge Requirement Order, and later (and currently) under CERCLA in accordance with the Compliance Monitoring Plan Detection Monitoring Program under the oversight of the U.S. EPA, the California Department of Toxic Substances Control, and the RWQCB.

The detection monitoring data for the Pit 7 Complex landfills indicate that there have been: (1) no releases of metals, HE compounds, or PCBs from any of the Pit 7 Complex landfills, and (2) no new releases of VOCs, nitrate, tritium, uranium, or perchlorate from the Pit 7 Complex landfills. While dioxins and furans are not monitored in ground water at the Pit 7 Complex detection monitoring wells, dioxins and furans are oxidation/combustion products of PCBs. If PCBs were to be detected in Pit 7 Complex ground water, monitoring for dioxins and furans would be discussed with the regulatory agencies.

Prior to 2010, Pit 7 Complex detection monitoring results were reported in the quarterly "Compliance Monitoring Program for the (Resource Conservation and Recovery Act) RCRA-Closed Landfill Pits 1 and 7. In 2009, the detection monitoring of the Pit 7 Complex landfills was incorporated into the CERCLA Site 300 Compliance Monitoring Plan. Since 2010, the results of the ongoing detection monitoring at the Pit 7 Complex have been reported semi-annually in the Site 300 Compliance Monitoring Reports.

3. At Pit 7, one issue is to improve the surface and slope of road to the east of the Pits to minimize erosion reduce flooding, and improve operation and reduce maintenance of the "eastern drainage swale". Although it reportedly has no effect on future protectiveness, as EPA points out, this issue is not discussed in the text of the report. TVC recommends that it should be included.

Response: **As discussed in DOE/LLNL's response to EPA Specific Comment 11, text has been added to Sections 4.4.2.2 and 8.2 of the Five-Year Review detailing the observed erosion and resulting sedimentation at the road and roadside drainage way (vegetated swale) on the east side of the Pit 7 Complex and the potential for flooding that resulted in the recommendations, and the recommendations themselves.**

4. Regarding the first numbered item in the protectiveness statement, please define what is meant by "reasonable timeframe". Is this consistent with the National Contingency Plan and EPA's definition of "reasonable timeframe"?

Response: **The goals of the long-term ground water cleanup program are summarized in the National Contingency Plan (NCP) as follows: "EPA expects to return usable ground waters to the beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site" (40 Code of Federal Regulations 300.430 (a)(1)(iii)(F). In the EPA guidance for monitored natural attenuation, it states that "the NCP preamble suggests that a "reasonable" timeframe for a remedy relying on natural attenuation is generally a "timeframe comparable to that which could be achieved through active restoration." There is no practicable technology capable of removing tritium from ground water. However, ground water modeling results showed that the portion of the tritium plume in excess of the drinking water cleanup standard will not migrate offsite, impact water-supply wells, or threaten human health during the time necessary for all tritium activities to naturally attenuate below the cleanup standard. The most recent data (June 2015) indicate that tritium activities have decreased to below the 20,000 pCi/L ground water cleanup standard in all wells at and downgradient of Building 850. The maximum tritium activity in Building 850 ground water in June 2015 was 18,700 pCi/L in well (NC7-70), located directly downgradient of Building 850. At the Pit 7 Complex, tritium activities in ground water have decreased by over one order-of-magnitude from the historic maxima of 2,660,000 pCi/L in 1998to a 2014 maximum of 182,000 pCi/L, and the extent of tritium above the cleanup standard is now approximately 800 ft downgradient of the landfills, compared to the maximum extent of about 1,000 ft in 1999 following the 1998 El Niño. While tritium is present in ground water above background levels at a greater distance from the Building 850 and Pit 7 Complex source areas, the tritium will decay to background levels without migrating offsite.**

5. Given the current drought conditions in CA, it is imperative that all steps be used to conserve and replenish groundwater resources. Section 3.1.2.3 describes the catchment basin used for infiltrating diverted water. TVC recommends that the catchment basin be evaluated and redesigned if necessary, to provide as much infiltration as possible. Needless to say, the basin should be designed without accelerating the migration of tritium. Any basin design that may accelerate the migration of tritium through the environment should be rejected.

Response: **The term "catchment", as used in Section 3.1.2.3, is defined as drainage area or basin or the area of land bounded by watersheds draining into a basin. This is a large natural feature and as such cannot be "redesigned." However, the clean surface water runoff and shallow subsurface flow from the hillslope west of the Pit 7 Complex is discharged to the catchment (drainage basin) north of Site 300 via an unlined rip rap channel that allows the water to infiltrate and recharge ground water in this area. The purpose of discharging this water to the drainage basin/catchment north of the Pit 7 Complex is to prevent ground water recharge under the Pit 7 Complex landfill that could cause ground water to rise into the pit waste. Because this clean water is discharged into a clean drainage basin/catchment, the discharge will not accelerate the migration of tritium in ground water.**

Appendix B2

Responses to Regulatory Comments on the Draft Final Five-Year Review

Appendix B2

Comment Responses for the Draft Final First Five-Year Review Report for the Building 850/Pit 7 Complex Operable Unit 5 at Lawrence Livermore National Laboratory (LLNL) Site 300

California Department of Toxic Substances Control (DTSC) comment:

The Department of Toxic Substances Control (DTSC) has reviewed the Draft Final Five-Year Review Report for Operable Unit 5 at Lawrence Livermore National Laboratory Site 300, dated October 2015. DTSC comments have been addressed adequately; therefore, DTSC, hereby, approves the Draft Final Five-Year Review Report for Operable Unit 5.

Response: **The U.S. Department of Energy (DOE) appreciates DTSC's comment and approval of the Five-Year Review Report for Building 850/Pit 7 Complex Operable Unit (OU) 5.**

U.S. Environmental Protection Agency (EPA) comments:

GENERAL COMMENT

This Five-Year Review identifies several issues and 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 does not track these types of programmatic recommendations and would therefore advise LLNL that they not be identified as formal issues and recommendations in the Final (Five-Year Review) FYR.

Response: **EPA is correct that several of the recommendations will be implemented as part of administrative or programmatic processes in place to optimize the remedy, and therefore are not protectiveness issues. However, as DOE executes its responsibilities as the lead agency for the LLNL Site 300 cleanup, its Five-Year Review Summary Form provides a useful tool to identify recommended additional scope of work to optimize cleanup in the Operable Unit (OU) for DOE management and to support funding requests. Text is included in the Summary Form for these recommendations that indicates that while no deficiencies in the overall remedy were identified, some follow-up actions remain useful to optimize remediation. This should provide EPA with the necessary justification not to include and track them in the EPA database. For this reason, DOE intends to leave them in the Summary Form.**

SPECIFIC COMMENTS

1. Page ii: "Monitoring will continue throughout the next five-year review period (January 1, 2015 through December 30, 2020." EPA recommends that LLNL note in the footnote the potential (given that EPA has so requested) for the FYR period to be adjusted to accommodate the consolidation of Site 300 FYRs.

Response: **Per discussion with the EPA on March 28, 2016, the consolidation of Site 300 Five-Year Reviews will be discussed at a later date.**

2. Page 2, ¶ 1: Please add text in parenthetical or footnote regarding EPA's request for consolidation of Site 300 FYRs and LLNL's plans for such.

Response: **Please refer to the response to EPA's Specific Comment #1.**

3. Page 2, § 1.1, penultimate sentence: The sentence seems to mischaracterize the "Third Five-Year Review" with regard to "offsite land use controls." While the 3rd FYR, at EPA's instigation, noted EPA's policy preference for layered ICs, the primary point of EPA's comments on the draft 3rd FYR regarding LUCs (including ICs) was that the IC called for in the GSA ROD had not been implemented. Please revise text to more accurately describe the situation, such as: "The Third Five-Year Review for the GSA determined that offsite land use controls for long-term protectiveness due to the

presence of contamination in offsite ground water, part of the selected remedy, had not been implemented as stated in earlier FYRs, and that ICs are necessary to ensure long-term protectiveness." LLNL responded. However, the response itself is inaccurate as there is no settlement agreement in place nor ICs in place.

Response: **Per the discussion in a teleconference call with the EPA on February 24, 2016 and subsequent discussions with the EPA Remedial Project Manager (RPM), the discussion of the Five-Year Review conclusions was removed from Sections 1.1 through 1.7. Further discussion of the General Services Area (GSA) OU Land Use Controls (LUCs) will be included in more detail in the upcoming 4th Five-Year Review for the GSA OU, the draft of which is scheduled to be submitted to the regulatory agencies in June 2016.**

4. Page 24, § 3.5, 2nd full ¶, last sentence: Please provide a citation to the reference agreement between DOE and the regulators. The modified text references that ICs "will prohibit such use [of GW for drinking water] during cleanup." The text "during cleanup" should be revised to "until cleanup standards are achieved."

Response: **The reference to the agreement between DOE and the regulators was deleted from the text in the Draft Final Five-Year Review. Therefore, a citation for this reference was not included. The second to last sentence of this paragraph (third paragraph of Section 3.5) was modified to read: "Ground water in the Building 850/Pit 7 Complex OU is not currently used as drinking water and institutional controls will prohibit such use until ground water cleanup standards are achieved."**

5. Page 28, 1st full ¶: The text should provide a reference for the statement that the Site-Wide ROD documents an agreement regarding the perchlorate treatability study and an FS leading to remedy selection for perchlorate given that a ROD is a remedy selection document and typically not used to document determinations outside of the remedy selection.

Response: **Per the discussion in a teleconference call with the EPA on February 24, 2016 and subsequent discussions with the EPA RPM, the text in the last paragraph of Section 3.6.1 was modified to state: "As indicated in Section 2.9.5 of the Site-Wide Record of Decision (ROD) (DOE, 2008), DOE will implement an *in situ* bioremediation treatability study and discuss possible remedial measures with the regulatory agencies. The treatability study is currently underway. Remedial alternatives for perchlorate in ground water will be presented in a Focused Feasibility Study. Public input will be solicited prior to the selection of a remedy and the selected remedy for perchlorate in ground water will be documented in an amendment to the Site-Wide ROD."**

6. Pages 41-44, § 4.5.1: Most, but not all, of the LUC Objectives, are verbatim the text in Tables 2 and 3 of the Draft FFYR. Please explain discrepancies between the text in §

4.5.1 and Tables 2 and 3 and, absent sound reason, make the text verbatim. Also compare the Draft FFYR text to the text of the Site-Wide ROD, as it should copy that text which is the source document for the text in the Draft FFYR.

Response: **DOE/LLNL compared the LUC Objectives in Section 4.5.1 and Tables 2 and 3 and made modifications as necessary to ensure that the LUC Objectives in the text and tables were consistent. The LUC Objectives text in Section 4.5.1 were changed to be consistent with LUC Objectives presented in Tables 2 and 3 from the Site-Wide ROD.**

The text in Section 4.5.1 in the Draft, Draft Final, and Final FYRs, and Tables 2 and 3 in the Draft and Draft Final FYRs included changes made to reflect a compilation of responses to comments made by EPA and the state regulatory agencies on LUCs in multiple previous Five-Year Reviews. Other changes to Section 4.5.1 and Tables 2 and 3 reflect changes in risk and therefore, necessary LUCs, based on risk reduction or mitigation that has occurred since the ROD was signed. In addition, the text in Section 4.5.1 includes a discussion of the status of the LUCs as part of the Five-Year Review process, whereas the tables are only intended to convey the LUCs, and not their status as of the current Five-Year Review date.

DOE agrees that the FYR tables should reflect the source (ROD) document text, with the only changes to Tables 2 and 3 including text to reflect risk reduction and/or mitigation that has occurred since the ROD was signed. Therefore, the text in Tables 2 and 3 has been changed to copy the LUC table text in the ROD, with risk reduction and/or mitigation discussion added where appropriate. Any clarifying text per regulatory comments, and the status of the LUCs as of the current Five-Year Review date was addressed in the FYR text.

7. Page 44, § 4.5.1.4: The CAMU was created pursuant to a removal action which, based on statements in the Draft FFYR, appears to have been undertaken after selection of the OU-5 remedy in the Site-Wide ROD (see comment --, below). So there is no discussion of the CAMU as a Risk Driver, or a LUC Objective for "maintaining the integrity of the CAMU" or "control[ing] excavation and other ground-breaking activities in the CAMU" in the ROD. Please explain the basis of the LUC Objectives referenced in 4.5.1.4, and address whether the ROD requires modification to support implementation of ICs in relation to the CAMU.

Response: **Because, as stated in the comment, the Building 850 Corrective Action Management Unit (CAMU) was created pursuant to a removal action undertaken after selection of the OU 5 remedy in the Site-Wide ROD, the LUCs for the CAMU were not included in the ROD. The ROD contained a LUC to maintain land use restrictions in the vicinity of Building 850 Firing Table until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}. The soil removal/CAMU construction removal**

action was implemented specifically to mitigate this risk. As such, the LUC in the Five-Year Review to control excavation and other ground-breaking activities to maintain the CAMU's integrity and prevent damage to and/or inadvertent exposure to contaminants in the solidified soil replaces the original LUC. This replacement does not represent a new risk or impact the validity of the remedy. The construction of the CAMU and the replacement LUC to maintain the integrity of the CAMU mitigates the risk of exposure to site workers and ecological receptors.

Per the discussion in a teleconference call with the EPA on February 24, 2016 and subsequent discussions with the EPA RPM, the LUCs for Building 850 will be updated to include the CAMU LUC in the ROD Amendment to be prepared to document the selection of a remedy for perchlorate in ground water at Building 850. In addition, a discussion of the removal action that was conducted to mitigate risk associated with PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table will be included in this ROD Amendment. The text in Section 4.5.1.4 of the final FYR has been revised to include the agreement that the upcoming Building 850 ROD Amendment will include the CAMU LUCs and a discussion of the removal action.

8. Pages 48-49, § 4.5.2.1: The introductory text states that there are "multiple layers of protection (land use controls)" in place to achieve the LUC Objective of preventing the use/consumption of contaminated groundwater in the OU-5 area, but the only LUCs described in relation to the objective are the dig permit and work induction board processes, both of which are governmental controls. No outright prohibition on the use/consumption of the groundwater, for example in a Site 300 planning/resource use document, is referenced. Please explain whether there are other LUCs that have been, or could be, implemented to more directly address the LUC Objective.

Response: **The text in Section 4.5.2.1 (and Section 4.5.1.1) regarding the dig permit process land use control associated with preventing the use/consumption of contaminated ground water in the Pit 7 Complex area (and Building 850 Firing Table) has been modified to better focus on ground water as follows:**

"A LLNL Dig Permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required to drill and install any new onsite wells at Site 300. Prior to a decision to grant any such permit, the LLNL Environment, Safety and Health (ES&H) Team Environmental Analyst (EA) must conduct an evaluation of the proposed well location to determine if the proposed new water-supply well is located in an area of ground water contamination. As part of this evaluation, the EA reviews the LUC maps, such as Figure 6, provided by the LLNL Environmental Restoration Department (ERD) that show areas of contaminated ground water with concentrations of contaminants of concern exceeding drinking water MCL ground water cleanup standards. As water-supply well drilling is prohibited in these areas until

cleanup standards are achieved, the Environmental Analyst works with the LLNL entity proposing the well installation and ERD to relocate the well to ensure ground water contaminants would not be drawn into the well.

a. Suggest revising the description of the dig permit process in the 1st paragraph so that it is clear that the dig permit process is used to achieve the LUC objective. For example, an initial sentence could be added to the description, and the existing second sentence revised as follows: "The construction of water supply wells in OU-5 (Building 850/Pit 7 Complex) is prevented through implementation of the dig permit process. The dig permit process is applicable to well construction activities because well construction involves soil-disturbing activities, and no soil disturbance is allowed at Site 300 without . . . ."

Response: **The text in Section 4.5.2.1 has been revised as requested. The text in Section 4.5.1.1 has also been similarly modified.**

b. The 2nd paragraph of the dig permit process description states that no dig permit will be issued in the event the pre-construction site evaluation required for soil disturbing activities identifies the potential for "unacceptable environmental consequences such as use or exposure to contaminated groundwater," but also discusses exposure to contaminated soil and soil sampling. As the LUC objective at issue is the prevention of contaminated groundwater use/consumption, suggest revising the text to focus on the role of contaminated groundwater in this description of the dig permit process (the discussion of soil contamination is more appropriate in the description in § 4.5.2.3, prevention of site worker exposure to subsurface soil contamination.

Response: **As discussed in the response to EPA Specific Comment #8 above, the text in Section 4.5.2.1 (and Section 4.5.1.1) regarding the dig permit process land use control associated with preventing the use/consumption of contaminated ground water in the Pit 7 Complex area (and Building 850 Firing Table) has been modified to better focus on ground water.**

c. Please explain why the description of the Work Induction Board process in ¶ 4.5.2.1 differs from the description in ¶ 4.5.2.4 and 4.5.2.5.

Response: **The Work Induction Board process is not part of the Land Use Controls to "Maintain Access Restriction at the Pit 7 Complex to Prevent Exposure to Pit Waste (Section 4.5.2.4) or "Maintain Access Restrictions at the Pit 3 Landfill to prevent Onsite Working Inhalation Exposure to Tritium" (Section 4.5.2.5). Therefore, the response was based on explaining why the Work Induction Board discussion was not included. As discussed in Section 4.5.2.4, any access or work on or within the Pit 7 Complex Landfills is prohibited without authorization from the LLNL Site 300 Management. This is a higher level of authorization required than the Work Induction**

Board process that was put in place to prevent any activities from occurring on or within the landfills that could compromise the integrity of the cover/caps. Therefore, a discussion of the Work Induction Board process was not included as a LUC in Section 4.5.2.4.

As discussed in Section 4.5.2.5, the re-evaluation of the risk to onsite workers from inhalation of tritium vapors from the Pit 3 Landfill indicated that the there is no longer an unacceptable risk to onsite workers from tritium evaporation from the landfill, therefore LUCs, including a review by the Work Induction Board, are no longer needed. However, the LUCs discussed in Section 4.5.2.5 still prevent unauthorized access or activities from occurring on or within the landfills.

9. Page 44, § 4.5.1.3, and section 4.5.1.4 on pages 44-46, both concern the creation of a CAMU pursuant to a removal action for PCBs, etc. which, based on statements in the Draft FFYR, appears to have been undertaken after selection of the OU-5 remedy in the Site-Wide ROD. (The timing of the removal action is not entirely clear, however. At page 30, the text states that "[t]he removal action for PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table was selected in an Action Memorandum and implemented in 2008." At page 23, the text states that "[i]n 2009, a non-time critical removal action was conducted . . . associated with PCB-, dioxin-, and furan-contaminated surface soil at the Building 850." At page 44, the text states "[i]n 2010, the risks associated with worker exposure to PCBs, dioxins, and furans in surface soil at the Building 850 Firing Table were successfully mitigated by the removal action . . . ." See also the "Site Chronology" in the Draft FFYR which indicates that an EE/CA for the removal action was completed in 2008; the excavation, consolidation and solidification processes were completed in 2009; and a post-removal confirmation sampling report was submitted and approved in 2010.) There is no discussion in the Draft FFYR explaining why the removal action was not handled as a remedial action under the ROD, and there is no discussion in the ROD of the CAMU as a Risk Driver, or a LUC Objective for "maintaining the integrity of the CAMU" or "control[ing] excavation and other ground-breaking activities in the CAMU." It therefore appears that the IC's put in place for the CAMU have no basis in the remedy selected in the ROD, and that some form of ROD modification is required to discuss the status of the contamination addressed by the removal action and to provide the basis for the selection of ICs as a remedy in relation to the CAMU within OU-5. Please consider and respond to these comments.

Response: **Please refer to the response to EPA's Specific Comment #7 regarding the creation of a CAMU pursuant to a removal action for PCBs, etc. having been undertaken after selection of the OU 5 remedy in the Site-Wide ROD. As indicated in the response to this comment, the text in Section 4.5.1.4 of the final FYR has been revised to include the agreement that the upcoming Building 850 ROD Amendment will include the CAMU LUCs and a discussion of the removal action.**

The text in Section 2 (Site Chronology), Section 3.4 (Initial Response), and Section 4.2.1 (Building 850 Remedy Selection) was modified to consistently state that the Building 850 removal action was initiated in 2009 and completed in January 2010. The text in Section 4.5.1.4 (Control Excavation and Other Ground-breaking Activities to Maintain CAMU Integrity…) indicating that the removal action was completed in 2010 is correct, and therefore was not changed.

10. Page 52, § 4.5.2.5: Please revise the text to reference what the LUCs implemented at the Pit 3 Landfill were.

Response: **As discussed in the response to EPA Specific Comment #8c and Section 4.5.2.5, the re-evaluation of the risk to onsite workers from inhalation of tritium vapors from the Pit 3 Landfill indicated that the there is no longer an unacceptable risk to onsite workers from tritium evaporation from the landfill, therefore LUCs are no longer needed. This would include the need for a review by the Work Induction Board. However, the LUCs discussed in Section 4.5.2.5 still prevent unauthorized access or activities from occurring on or within the landfills.**

11. Page 54, § 5.1: The text regarding notice of publication of the FFYR is incorrect and incomplete. Please revise the sentence beginning "Notice of its initiation and completion.. . ," to read "Notice of its initiation was, and notice of its completion will be, published in two publications . . . ." Also, please insert the appropriate date in lieu of the all-caps term "DATE." Although there may be arguments favoring disclosure of draft FYRs, both EPA and DOE (2002) guidance indicate that that the FYR is not made available to the public until it is final. The RTC thus is incorrect, and EPA should so note.

Response: **It appears that this comment may have been based on a review of the Draft OU 5 Five-Year Review, rather than the Draft Final document. The date of the publication of the notice of initiation of the Five-Year Review was not provided in the Draft version because the notice was published in the newspapers after the Draft Five-Year Review was issued for regulatory review.**

The Draft Final document contained the date on which the public notice of initiation was published in the newspapers (June 19, 2015). The text in Section 5.1 was modified to read: "Notice of the initiation of the Five-Year Review for the Building 850/Pit 7 Complex OU was published in *The Tracy Press* and *San Joaquin Herald* on June 19, 2015. Upon completion of the review, a copy of the final report will be placed in the information repositories, and a notice will appear in the newspapers announcing completion of the Five-Year Review Report. The draft, draft final, and final Five-Year Review are provided to Tri-Valley Communities Against a Radioactive Environment for review at their request, with EPA's previous concurrence."

12. Page 95-96, § 9, items 1 and 3: These statements do not appear to document protectiveness, as they don't address pathways given the existence of contamination; the statement in item 1 that natural attenuation will eventually attain clean-up standards does not document short-term protectiveness; similarly, the statement in item 3 regarding early notification doesn't address exposure.

Response: **Text was added to Item #1 in the Protectiveness Statement in the Five-Year Review Summary Form and in Section 9 (Protectiveness) to indicate that: "Modeling indicates that the tritium plume will not migrate offsite in the period of time it takes to natural attenuate to cleanup standards, and monitoring of the tritium plume is conducted to validate these modeling results (Taffet et al., 1996; Taffet et al., 2004; Taffet et al., 2005). In addition, institutional controls described in Sections 4.5.1.1, 4.5.2.1, and 4.5.1.5 are in-place to prevent exposure to tritium in ground water and surface water at Well 8 Spring until cleanup standards are achieved."**

Text was added to Item #3 in the Protectiveness Statement in the Five-Year Review Summary Form and in Section 9 (Protectiveness) to indicate that: "As indicated in the Site-Wide Contingency Plan (Dibley et al., 2009), if ground water contaminant concentrations (i.e., uranium activities and/or nitrate concentrations in Building 850 ground water) increase in a consistent and significant manner for reasons not attributable to remediation efforts (e.g., cyclic pumping), or natural aquifer or laboratory variables, DOE will notify the regulatory agencies and modifications to the remedial action will be considered as necessary to protect human health."

Regional Water Quality Control Board (RWQCB) comments:

GENERAL COMMENTS

1. Section 4.5.1. Building 850 Land Use Controls and Section 4.5.2. Pit 7 Complex Land Use Controls:

   a. Text that describes the dig permit process, work induction board, and proprietary controls implementation status for the Building 850 area and the Pit 7 Complex is repetitive in multiple subsections of Sections 4.5.1 and 4.5.2. Regional Water Board staff suggest streamlining the discussion of these LUCs by describing them in a single section, which could then be referenced in subsequent subsections where the LUCs are discussed.

Response: **In the interest of finalizing the Five-Year Review for OU 5 on-schedule, DOE/LLNL propose to leave the structure of the text in Section 4.5.1 and 4.5.2 for the Building 850/Pit 7 Complex OU Five-Year Review as presented in the Draft Final document. However, DOE/LLNL will consider opportunities for streamlining the LUC discussion to the extent possible in future Five-Year Reviews.**

   b. Sections 4.5.1 and 4.5.2 state that contamination in the Building 850 Firing Table area and the Pit 7 Complex area is limited to onsite groundwater and modeling indicates that the contaminant plumes will not migrate offsite during the time necessary to achieve cleanup standards. The Report does not however, cite the source of the groundwater modeling data. The Report needs to provide a citation for the groundwater modeling data.

Response: **The citation for the source of the ground water modeling data has been added to Sections 4.5.1.1 (page 43) and 4.5.2.1 (page 51).**

2. Response to Specific Comment No. 6: Regional Water Board Specific Comment No. 6 was only partially addressed. The second paragraph of Section 5.4.2.1.1 still states that during the five-year review period, the maximum tritium activity in 2010 was 255,000 pCi/L in a sample from well NC7-63. However, based on Figure 7, well NC7-63 is shown to have had insufficient water to collect a sample during 2010. Please correct this discrepancy.

Response: **The data presented in Figure 7 is correct. Figure 7 is a primary COC map and was created using second semester 2010 data. During first semester 2010, well NC7-63 contained sufficient water for sample collection and samples for tritium, uranium, nitrate, and perchlorate were collected and analyzed. During second semester 2010, well NC7-63 contained insufficient water for sampling. To address the RWQCB comment, the map in Figure 7 have been labeled as second semester 2010.**

3. Figures 7, 9, 11, and 13: Based on Figure 7, a groundwater sample for tritium analysis was not collected from well NC7-63 during 2010 due to insufficient water in the well. However, based on Figures 9, 11, and 13, groundwater samples for the analysis of uranium, nitrate, and perchlorate, respectively, were collected from NC7-63 during 2010. Please confirm that data presented on these figures is not erroneous, and that groundwater collected from NC7-63 during 2010 was only sufficient to perform analyses for uranium, nitrate, and perchlorate but not tritium.

Response: **The data presented in Figures 7, 9, 11, and 13 are correct. As specified in the Compliance Monitoring Plan, primary contaminants of concern (COCs) are monitored semi-annually, and secondary COCs are monitored annually in Site 300 ground water. Therefore, in a given year, wells are sampled for analysis of secondary COCs in the first semester, and are sampled in both the first and second semester for primary COC analysis.**

The map for the primary COC (i.e., tritium) in Figure 7 presents the most recent data collected which would be the second semester data. During first semester 2010, well NC7-63 contained sufficient water for sample collection and samples for tritium, uranium, nitrate, and perchlorate were collected and analyzed. During second semester 2010, well NC7-63 contained insufficient water for sampling, which is shown on Figure 7 (second semester data). However, the text references the maximum tritium concentration detected in ground water in 2010 which was represents first semester data.

Figures 9, 11, and 13 show maps presenting secondary contaminants of concern (COC) concentrations in ground water that were created using first semester 2010 data.

To address the RWQCB comments, the map in Figure 7 have been labeled as second semester 2010, and the maps in Figures 9, 11, and 13 have been labeled as first semester 2010. In addition, text has been added to Sections 5.4.1.1 (Building 850 Contaminant Concentrations and Distribution) and 5.4.2.1 (Pit 7 Complex Contaminant Concentrations and Distribution) which explains that because the maps are based upon a specific time period, the data discussed in the text may not be shown on the maps.

4. Figure 7 (2010 Isocontour Map): Labels for some wells in the Pit 7 SRC (GWTS) area and in the Pits, 4, 5, and 7 areas, are overlain by well symbols and therefore, are illegible. The Figure 7 (2010 isocontour map) should be revised so that the well labels are legible.

Response: **Figure 7 has been modified to make the well labels more legible.**

5. Response to Specific Comment No. 8: Regional Water Board staff Specific Comment No. 8 was partially addressed. The 2010 uranium activity data shown on Figure 9 and on Figure 19 for well NC7-63 are still different; the uranium activity shown on Figure 9 is 120 pCi/L while that shown on Figure 19 is 103 pCi/L. Please revise the figures for consistency.

Response: **The 2010 uranium activity shown for well NC7-63 in Figure 19 has been changed to 120 pCi/L for consistency with Figure 9.**

Regional Water Board staff concur with the Report's recommendations and the conclusion that remedies at OU 5 remain protective of human health and the environment, provided that the above comments are addressed.

Appendix C

Ground Water Elevation Hydrographs for PIT7-SRC Ground Water Treatment System Extraction Wells, Selected Drainage Diversion System Monitoring Wells, and Monthly Precipitation Bar Charts

Appendix C

List of Figures

C-1. Introduction

This appendix contains ground water elevation hydrographs for all of the Pit 7-Source (PIT7-SRC) extraction wells and the ground water treatment system performance monitor well NC7-51, and drainage diversion system performance monitor wells NC7-17 and NC7-34. A map with the locations of the wells with hydrographs discussed in this appendix is shown in Figure C-1. Two bar charts showing Site 300 monthly precipitation are also included: one for the 2010 to 2014 five-year review period, and the other for the period of 1995 to 2014.

A discussion of the hydrographs for the PIT7-SRC ground water extraction wells and performance monitor wells, and the drainage diversion system performance monitor wells are discussed in Sections C-2 and C-3, respectively.

C-2. Hydrographs for the Pit 7-Source Extraction and Performance Monitor Wells

The ground water elevation hydrographs for the original three PIT7-SRC extraction wells and the three monitor wells that were converted to extraction wells cover the review period from 2010 to 2014 and are composed entirely of Treatment Facility Real-Time (TFRT) transducer data. The TFRT system at the Pit 7 Complex has been in operation since the first semester 2010, and collects ground water elevation data every two minutes from 25 extraction and monitor wells. Prior to establishment of the TFRT system, Pit 7 Complex area ground water elevation data consisted of hand measurement and transducer data (from selected wells) with varying data collection frequencies. The hydrographs for the extraction wells added during wellfield expansion in 2012, cover the time period of 2012 to 2014 and also are composed entirely of TFRT transducer data.

Figure C-2 presents the ground water elevation hydrograph for the PIT7-SRC extraction well NC7-25 during the time period of 2010 to 2014. Extraction well NC7-25 is located downgradient (northeast) of the Pit 3 landfill and is screened in the Tertiary Neroly Lower Blue Sandstone/Silty Sandstone ($Tnbs_1$/$Tnbs_0$) hydrostratigraphic unit (HSU). Well NC7-25 was not used as an extraction well until second semester 2012. Although somewhat noisy (e.g., the vertical bars seen in the 2011 and 2012 data are the result of electrical problems, such as loose or corroded connections, and are not actual ground water elevation fluctuations), the 2010 and 2011 ground water elevation data show the annual recharge response at this location. Beginning in second semester 2012, the ground water elevation response to pumping is visible in the hydrograph.

Figure C-3 presents the ground water elevation hydrograph for PIT7-SRC extraction well NC7-63 for the time period of 2010 to 2014. Well NC7-63 is located immediately downgradient of the Pit 3 landfill and is screened in the Quaternary alluvium/weathered bedrock (Qal/WBR) HSU. This well served as an extremely low yield extraction well from first semester 2010 to second semester 2013, when it was converted back to a monitor well due to insufficient water. The hydrograph indicates active ground water extraction (pumping water level was approximately 1317 to 1317.5 feet (ft) above mean sea level (MSL) during first semester 2010 and first and second semester 2011, but more often than not the ground water elevation was below the pump intake depth (approximately 1317 ft above MSL). During second semester 2013, shortly after being converted back to a monitor well, the ground water elevation dropped below the transducer depth and the bottom of the well screen.

Figure C-4 presents the ground water elevation hydrograph for PIT7-SRC extraction well NC7-64 for the time period of 2010 to 2014. Well NC7-64 is located immediately downgradient of the Pit 3 landfill and is screened in the Qal/WBR HSU. Well NC7-64 has been in operation since first semester 2010 and, with the exception of maintenance shut downs and sampling recovery events, has operated continuously and maintained a pumping water level of approximately 1304.5 ft above MSL.

Figure C-5 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2305 for the time period of 2010 to 2014. Well W-PIT7-2305 is located at the southern end (downgradient) of the Pit 5 landfill and is screened in the Qal/WBR HSU. Well W-PIT7-2305 has been in operation since first semester 2010 and, with the exception of maintenance shut downs and sampling recovery events, has operated continuously and maintained a pumping water level of approximately 1283.6 ft above MSL.

Figure C-6 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2306 for the time period of 2010 to 2014. Well W-PIT7-2306 is located at the north end (downgradient) of the Pit 5 landfill and is screened in the Qal/WBR HSU. Ground water was extracted from well W-PIT7-2306 in 2010, 2011, and 2012, but ground water elevations have been below the pump intake since second semester 2012. During second semester 2013, the ground water elevation dropped below the transducer depth and the bottom of the well screen.

Figure C-7 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2307 for the time period of 2010 to 2014. Well W-PIT7-2307 is located immediately downgradient of the Pit 5 landfill and is screened in both the Qal/WBR and the $Tnbs_1$/$Tnbs_0$ HSU. Between first semester 2010 and first semester 2011, well W-PIT7-2307 was the highest yielding extraction well of the PIT7-SRC extraction wellfield. However, pumping from this well was stopped in the first semester of 2011 as it was yielding primarily clean ground water with contaminant concentrations below cleanup standards. During second semester 2013, the pump intake depth was raised to 1306 ft above MSL to target ground water in the Qal/WBR HSU. A small amount of ground water was extracted before the ground water elevation dropped below the pump intake depth.

Figure C-8 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2703 for the time period of 2012 to 2014. Well W-PIT7-2703 is located near the southeastern corner (downgradient) of the Pit 3 landfill and is screened in the Qal/WBR HSU. Well W-PIT7-2703 has been in operation since second semester 2012 and, with the exception of maintenance shut downs and sampling recovery events, has operated continuously and maintained a pumping water level of approximately 1304.2 ft above MSL.

Figure C-9 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2704 for the time period of 2012 to 2014. Well W-PIT7-2704 is located at the north end (downgradient) of the Pit 5 landfill and is screened in the Qal/WBR HSU. During second semester 2012, a small amount of ground water was extracted from well W-PIT7-2704 before the ground water elevation dropped below the pump intake.

Figure C-10 presents the ground water elevation hydrograph for PIT7-SRC extraction well W-PIT7-2705 for the time period of 2012 to 2014. Well W-PIT7-2705 is located at the southern end (downgradient) of the Pit 5 landfill and is screened in the Qal/WBR HSU. Well W-PIT7-2705 has been in operation since second semester 2012 and, with the exception of maintenance shutdowns and sampling recovery events, has operated continuously and maintained a pumping water level of approximately 1286.5 ft above MSL.

Figure C-11 presents the hydrograph for ground water elevations in the PIT7-SRC ground water extraction and treatment system performance monitor well NC7-51 for the time period of 1995 to 2014. Well NC7-51 is located immediately downgradient of the Pit 5 landfill near extraction well W-PIT7-2703, and is screened in the Qal/WBR HSU. The hydrograph data is a composite of hand-measured ground water elevations, a limited amount of transducer data prior to 2010, and TFRT transducer data from 2010 to 2014. The hydrograph shows an increasing trend in ground water elevation with strong annual responses during the mid-1990s leading to the maximum ground water elevation peak in response to the much greater than average precipitation received during the 1997-1998 El Niño event (Fig. C-12). After 1998, ground water elevation begins a general declining trend. Annual responses are still seen, but are generally of significantly lower amplitude than those observed in the 1990s. During 2012 and 2014, when Site 300 annual precipitation was significantly below average (Figs. C-12 and C-13), ground water elevation responses were minimal.

Figure C-12 presents a bar chart showing monthly precipitation at Site 300 from 1995 to 2014. Average precipitation received during a water year (October 1 thru September 30) at Site 300 is approximately 10.3 inches. During the 1997-1998 El Niño event, Site 300 received 19.74 inches of precipitation. Monthly precipitation generally exceeded one inch and was often significantly more than one inch in a month. This resulted in significant increases in ground water elevation in the Pit 7 Complex area. In contrast, precipitation received during the last three water years has been significantly below average with 7.00 inches, 8.33 inches, and 5.25 inches of precipitation received during water years 2012, 2013, and 2014, respectively. From 2012 to 2014, monthly precipitation rarely exceeded two inches, most months received less than one inch of precipitation, and ground water elevations continued to decline.

Figure C-13 presents a bar chart showing monthly precipitation at Site 300 during the five-year review period (2010 to 2014). During water years 2010 and 2011, Site 300 received 13.29 and 13.53 inches of precipitation, respectively, greater than the average of 10.3 inches. Precipitation received during water years 2012, 2013, and 2014 was 7.00 inches, 8.33 inches, and 5.25 inches, respectively; significantly below the average annual rainfall at Site 300.

Conclusions:

While the PIT7-SRC extraction wellfield has been extracting and removing contaminant mass from ground water at the Pit 7 Complex, the low permeability and limited saturation of the contaminated HSUs in this area limit the mass of contaminants that can be removed. This has been exacerbated by the prolonged drought that has been ongoing during the last three years of the five-year review period. As a result, several extraction wells have gone dry or produce insufficient water for extraction. As such, there are limited opportunities to optimize ground water extraction and contaminant mass removal at this time. DOE/LLNL will continue to monitor and evaluate the performance of the PIT7-SRC extraction wellfield during the next five-year review period (2015-2020) in the cleanup of ground water contaminants.

C-3. Hydrographs for the Pit 7 Complex Drainage Diversion System

The ground water elevation hydrographs for drainage diversion system performance monitor wells NC7-17 and NC7-34 cover the time period of 1995 to 2014 and are composites of hand-measured water level data, individual transducer data, and TFRT transducer data. A brief description/interpretation of the hydrograph in each figure is provided below.

Figure C-14 presents the hydrograph for ground water elevations in drainage diversion system performance monitor well NC7-17 during the time period of 1995 to 2014. Well NC7-17 is located at the south end of the Pit 7 landfill and is screened in the Qal/WBR HSU. The hydrograph data are a composite of hand-measured ground water elevations, a limited amount of transducer data prior to 2010, and TFRT transducer data from 2010 to 2014. The ground water elevations in this well show a strong response to annual precipitation. Hand-measured water level data from 1998 clearly show the maximum ground water elevation in response to the much greater than average precipitation received during the 1997-1998 El Niño event (Fig. C-12). After 1998, ground water elevation shows a general declining trend although still displaying responses to annual precipitation. In 2012 and 2014, when Site 300 annual precipitation was significantly below average, ground water elevation responses were minimal. A comparison of ground water elevation response to precipitation in 2005 (prior to installation of the drainage diversion system) to ground water elevation response to precipitation in 2011 (after installation of the drainage diversion system) indicated a 20% reduction in ground water elevation response to rainfall in well NC7-17 after installation of the drainage diversion system. In 2005, ground water elevation in well NC7-17 increased 5 inches per inch of rain received compared to less than 4 inches per inch of rain received during the same time period during the water year 2011. Total precipitation received during water years 2004-2005 and 2010-2011 was greater than average and almost identical at 13.7 inches and 13.5 inches, respectively.

Figure C-15) presents the hydrograph for ground water elevations in drainage diversion system performance monitor well NC7-34 during the time period of 1995 to 2014. Well NC7-34 is located at the south end of the Pit 3 landfill and is screened in the

Qal/WBR HSU. The hydrograph data are a composite of hand-measured ground water elevations, a limited amount of transducer data prior to 2010, and TFRT transducer data from 2010 to 2014. The maximum ground water elevation peak in response to the 1997-1998 El Niño event is clearly shown in the hydrograph. After 1998, annual ground water elevation responses to precipitation are evident, but there is an overall general decline in ground water elevations. Ground water elevation declined below the transducer and the bottom of the screened interval during first semester 2014.

Conclusions:

Based on the evaluation of ground water elevation and contaminant activity/concentration data collected from Pit 7 Complex area wells against the performance criteria discussed in Section 5.4.2.5.3, the drainage diversion system appears to be operating as intended. While the ground water elevation rises are observed in the hydrograph data after 2010 when the drainage diversion system was installed, it is important to note that this system was not designed to prevent any water level rises. It was designed to prevent ground water from rising into the pits waste during years of extremely high rainfall as occurred during the 1997-1998 El Niño event. Therefore, the drainage diversion system has not yet been tested under the above-average annual rainfall conditions for which it was designed.

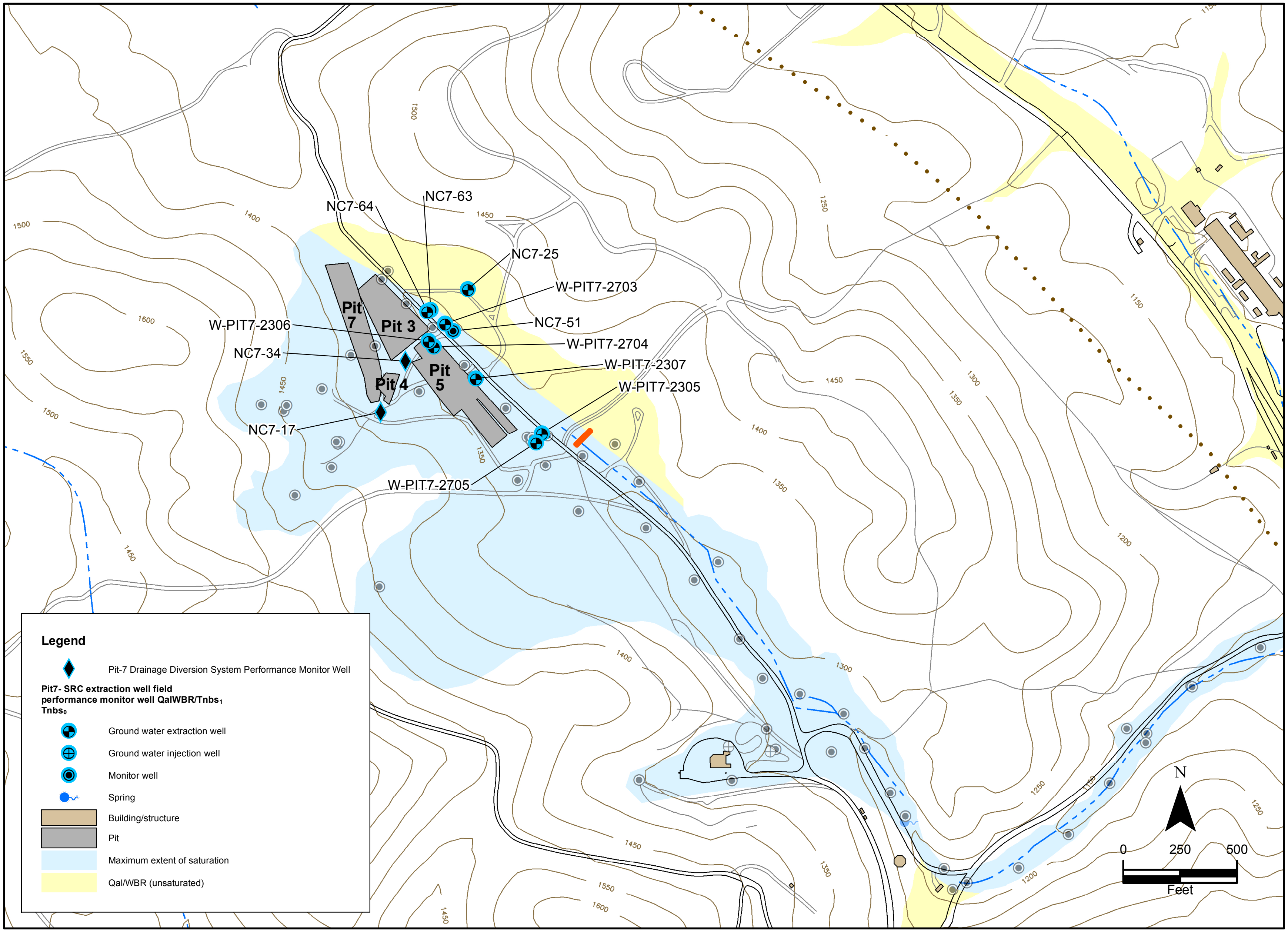


Figure C-1. Site map showing locations of wells with hydrographs included in Appendix C.

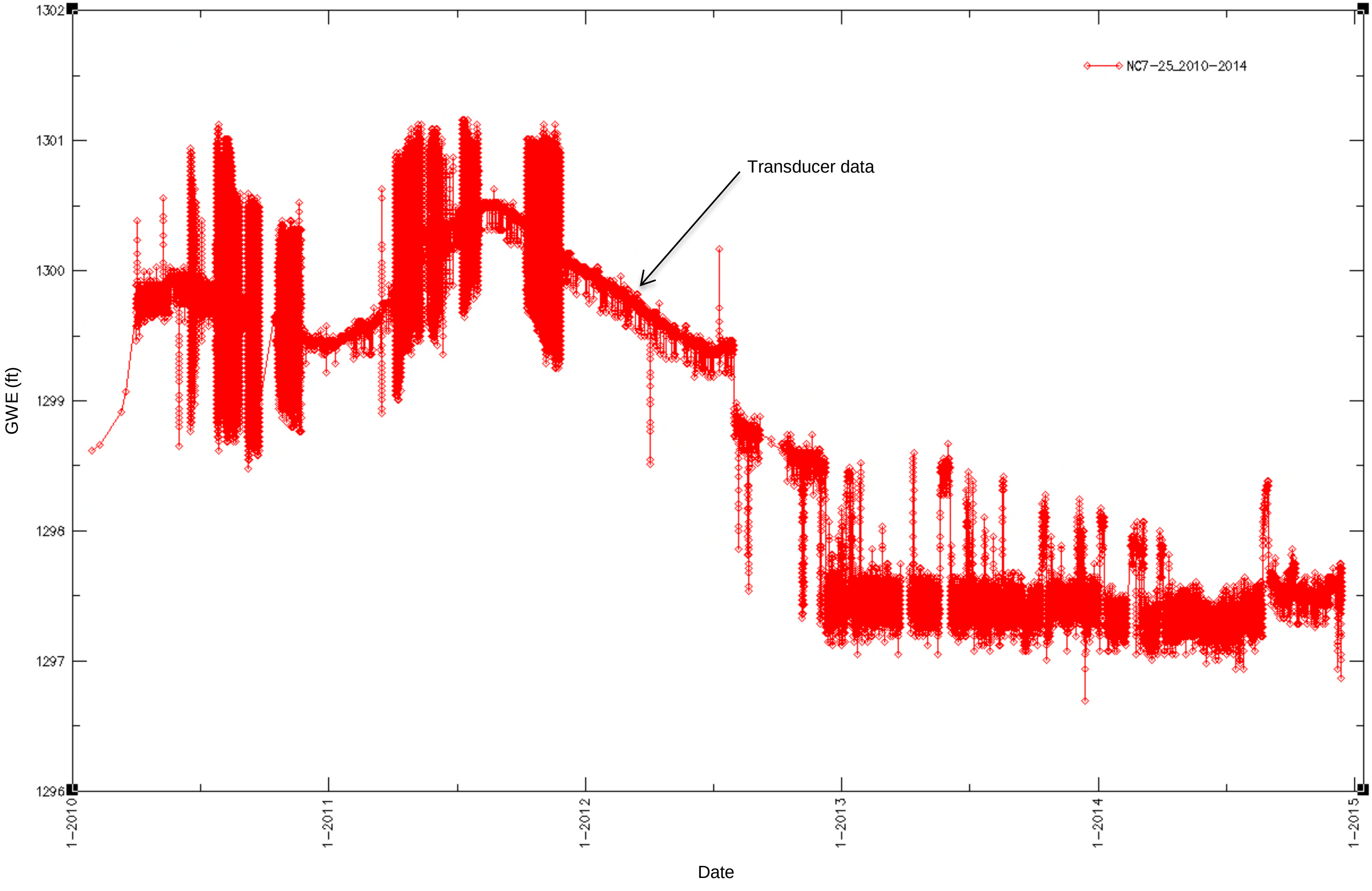


Figure C-2. Ground water hydrograph for extraction well NC7-25 (2010 – 2014).

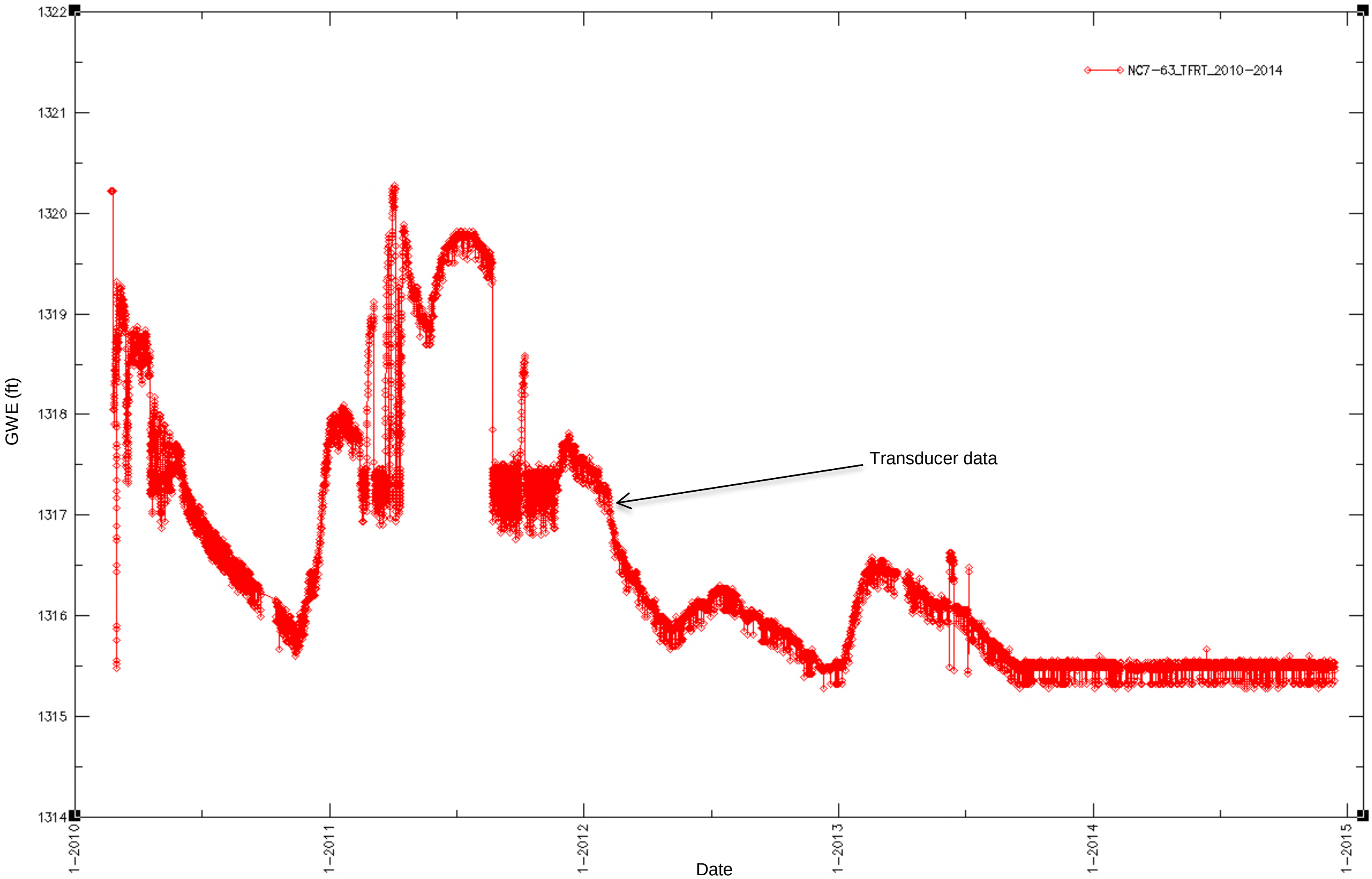


Figure C-3. Ground water hydrograph for extraction well NC7-63 (2010 – 2014).

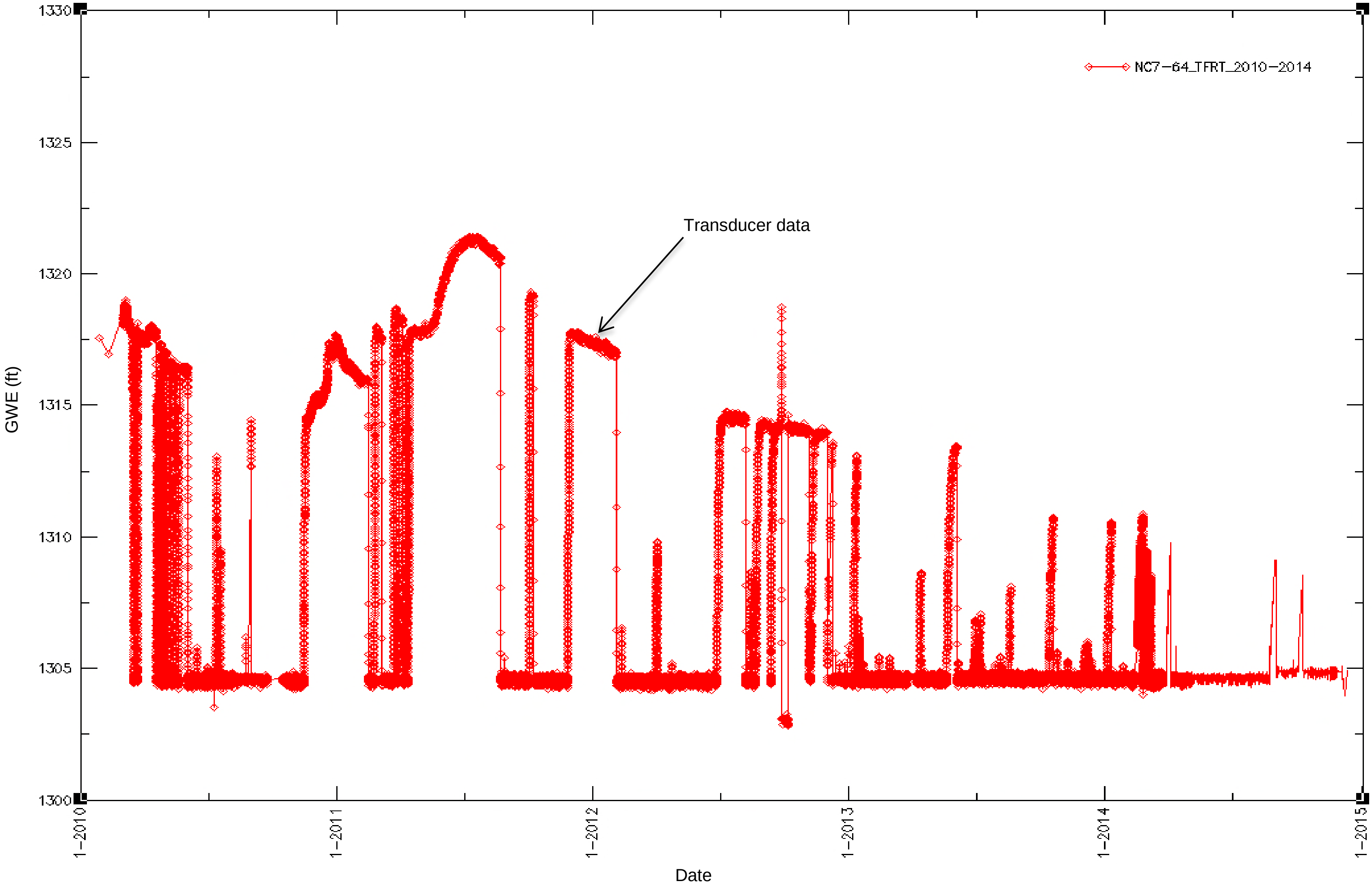


Figure C-4. Ground water hydrograph for extraction well NC7-64 (2010 – 2014).

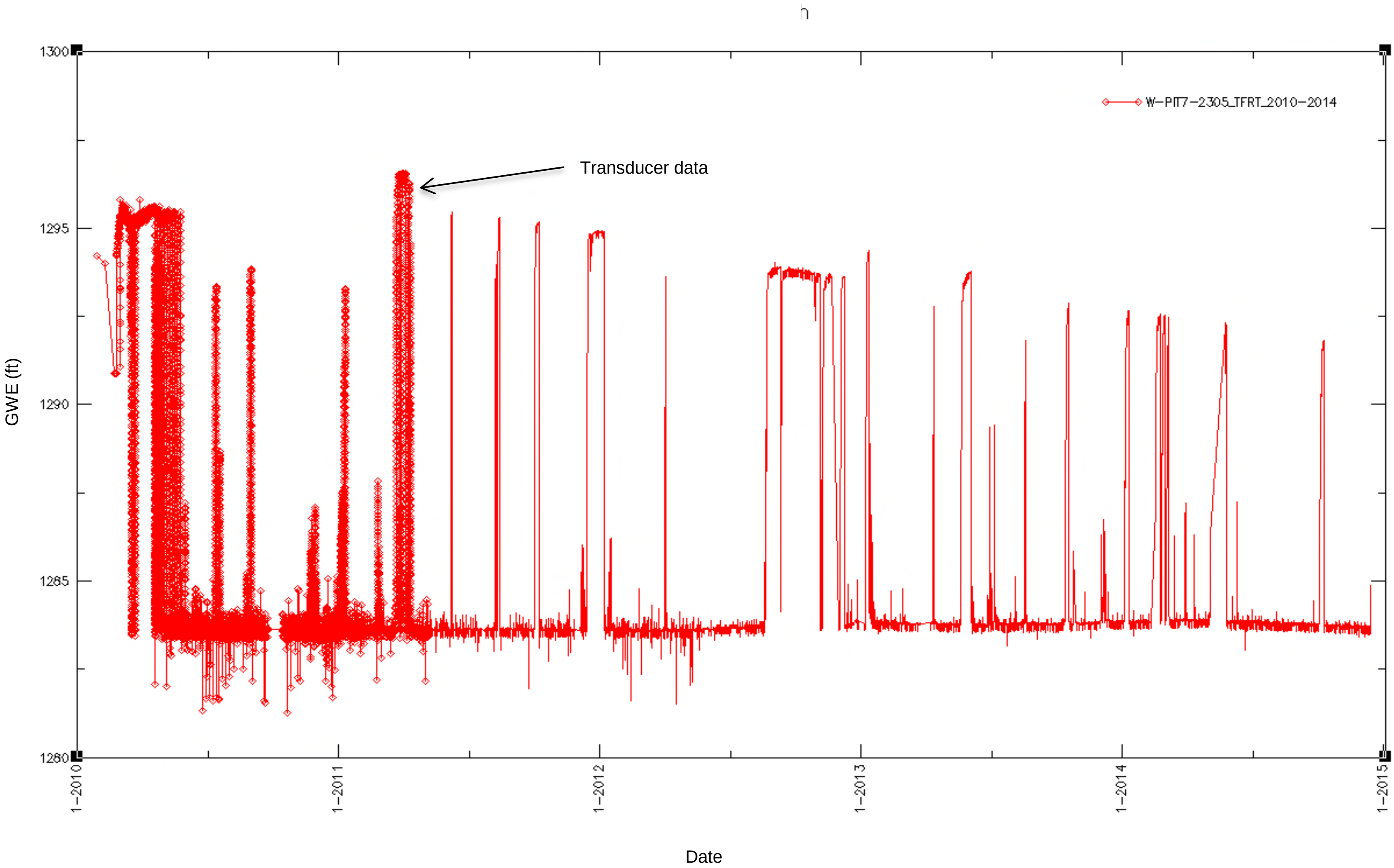


Figure C-5. Ground water hydrograph for extraction well W-PIT7-2305 (2010 – 2014).

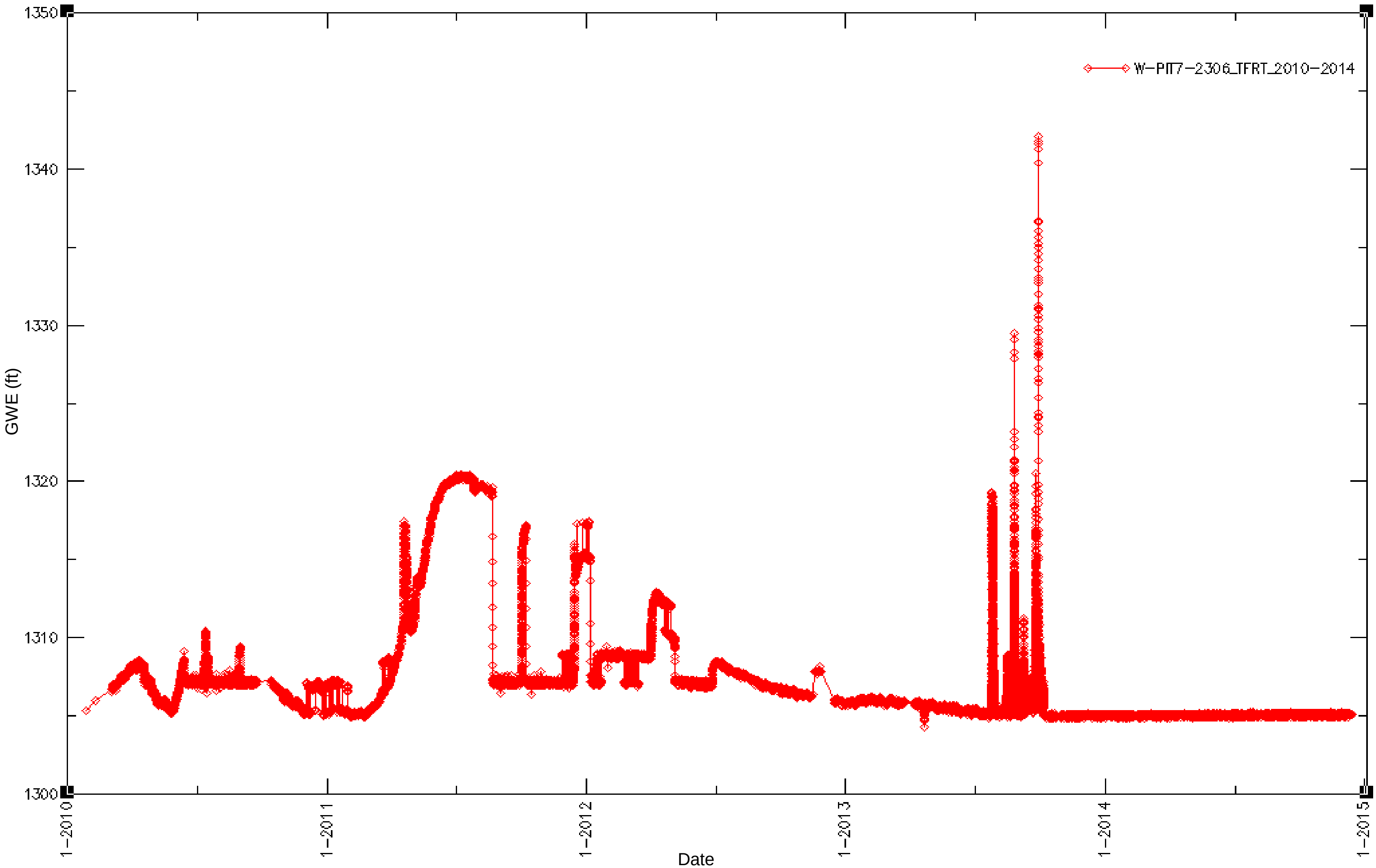


Figure C-6. Ground water hydrograph for extraction well W-PIT7-2306 (2010 – 2014).

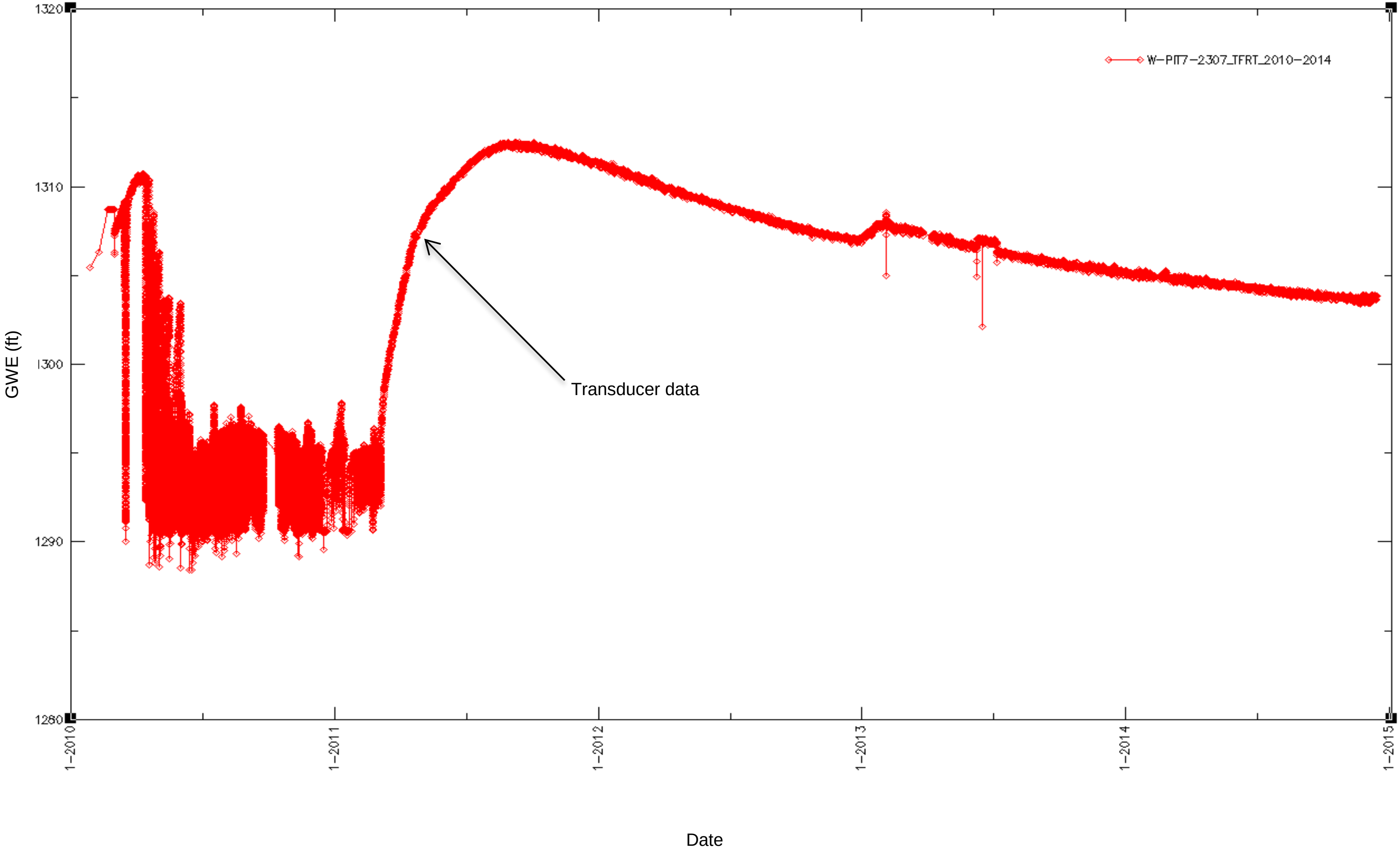


Figure C-7. Ground water hydrograph for extraction well W-PIT7-2307 (2010 – 2014).

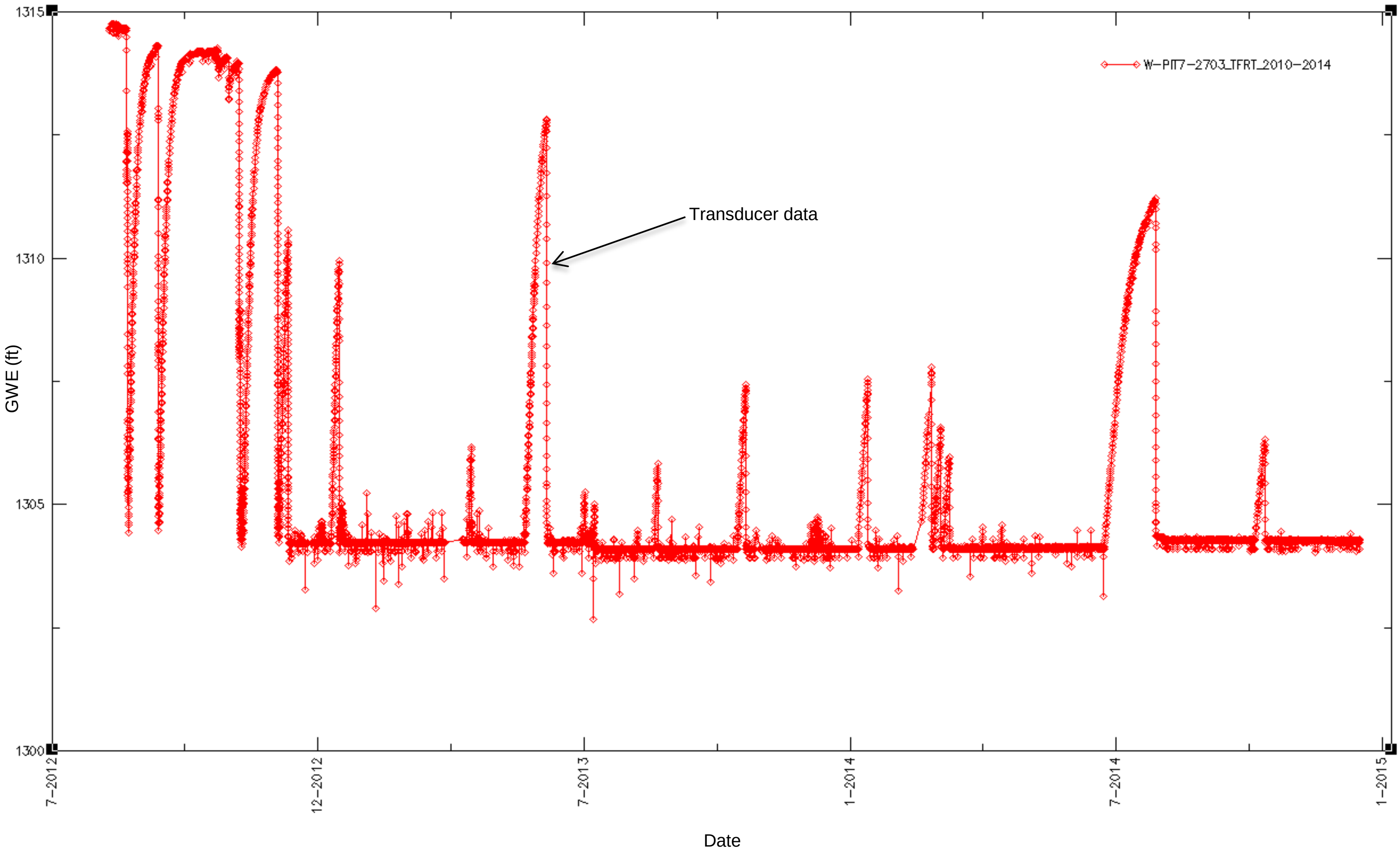


Figure C-8. Ground water hydrograph for extraction well W-PIT7-2703 (2012 – 2014).

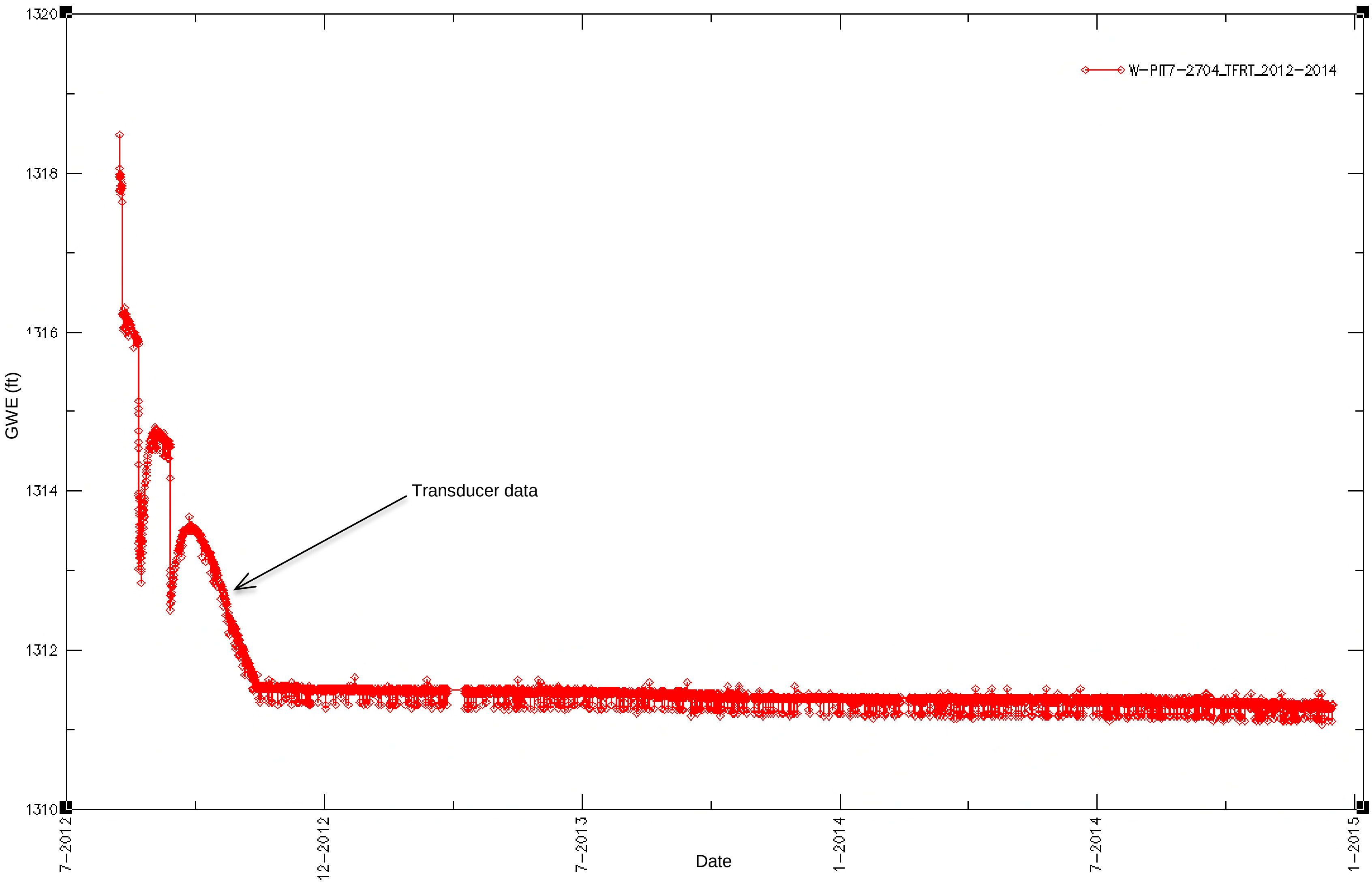


Figure C-9. Ground water hydrograph for extraction well W-PIT7-2704 (2012 – 2014).

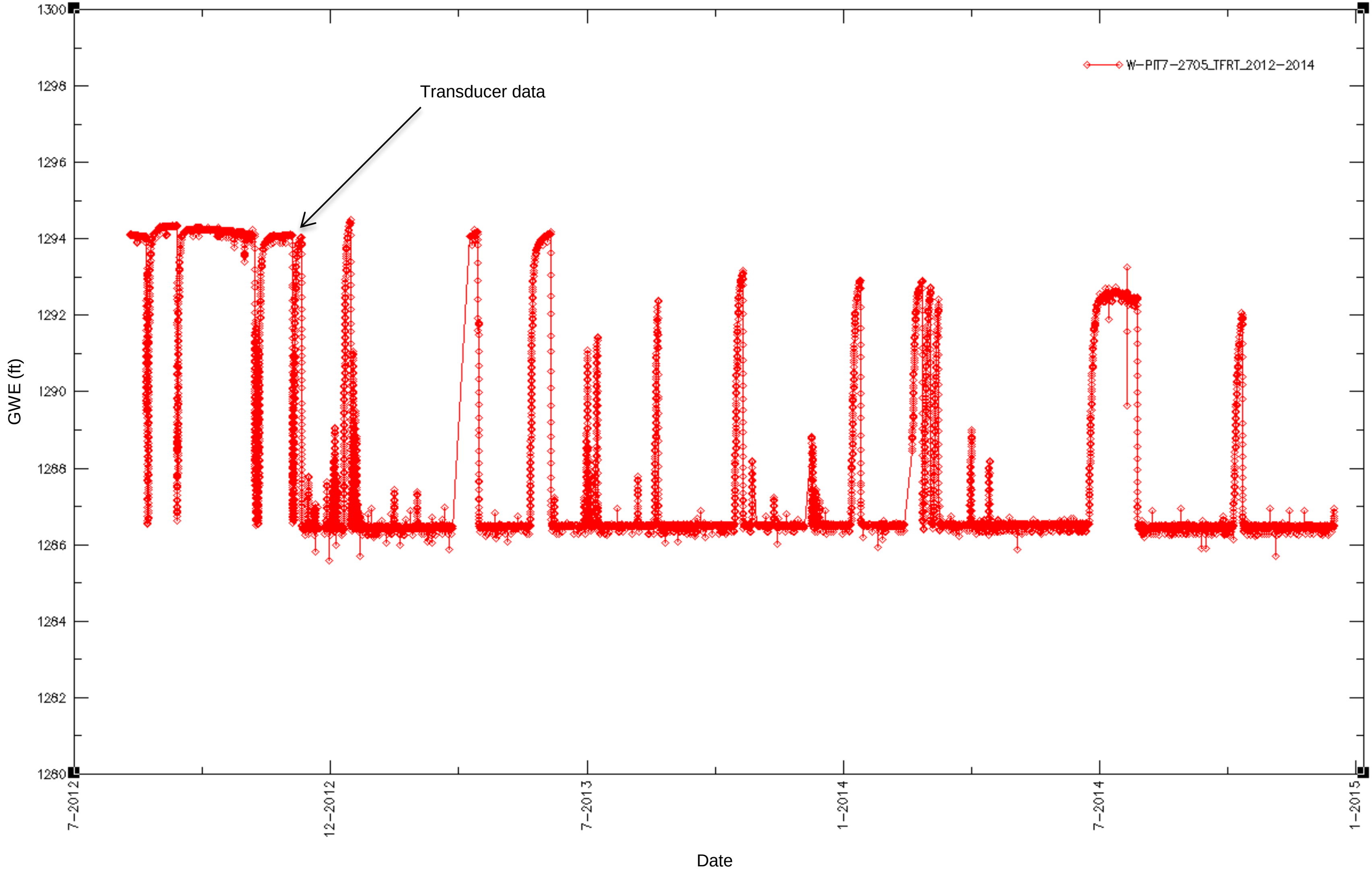


Figure C-10. Ground water hydrograph for extraction well W-PIT7-2705 (2012 – 2014).

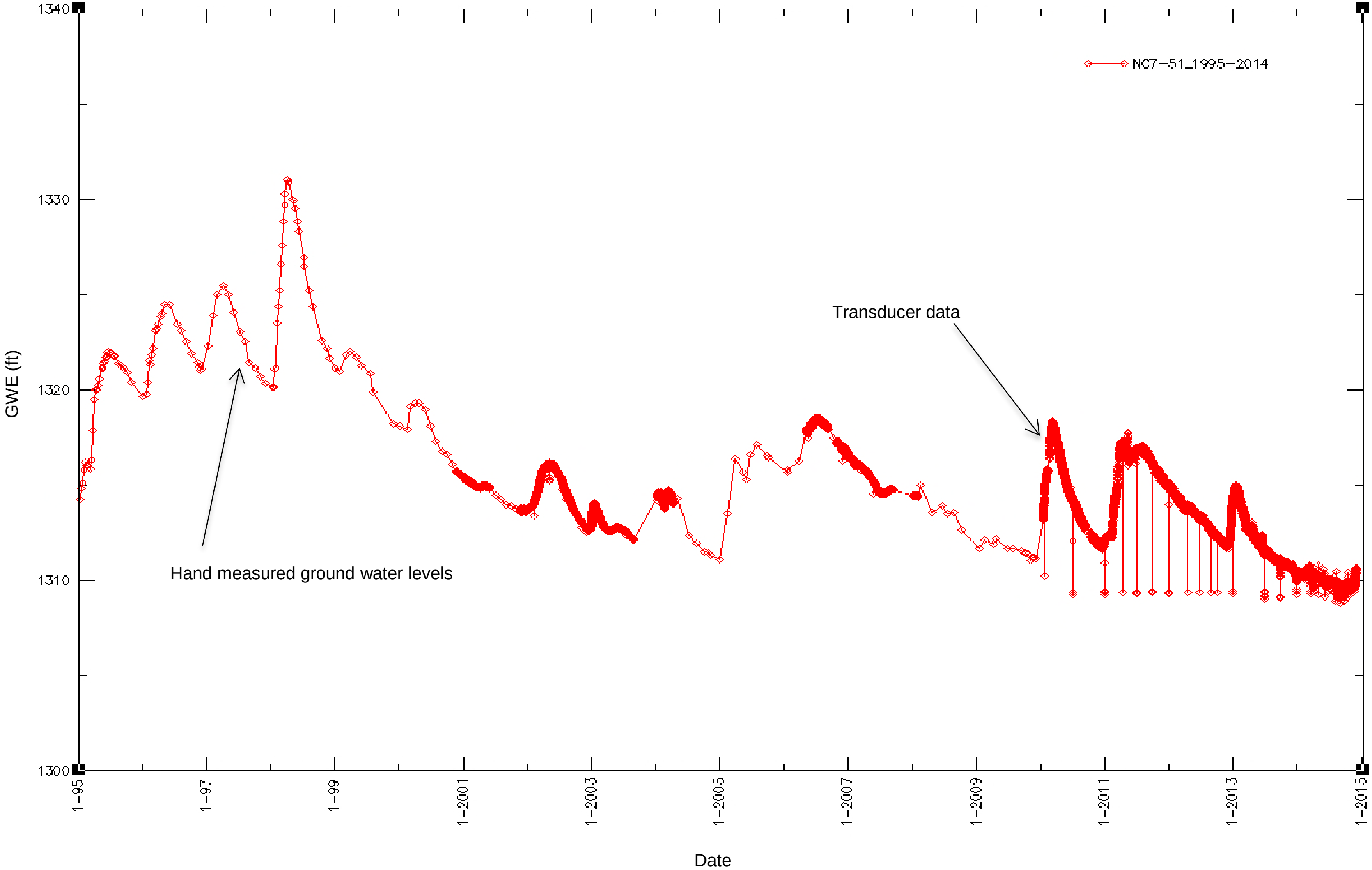


Figure C-11. Ground water hydrograph for monitor well NC7-51 (1995 – 2014).

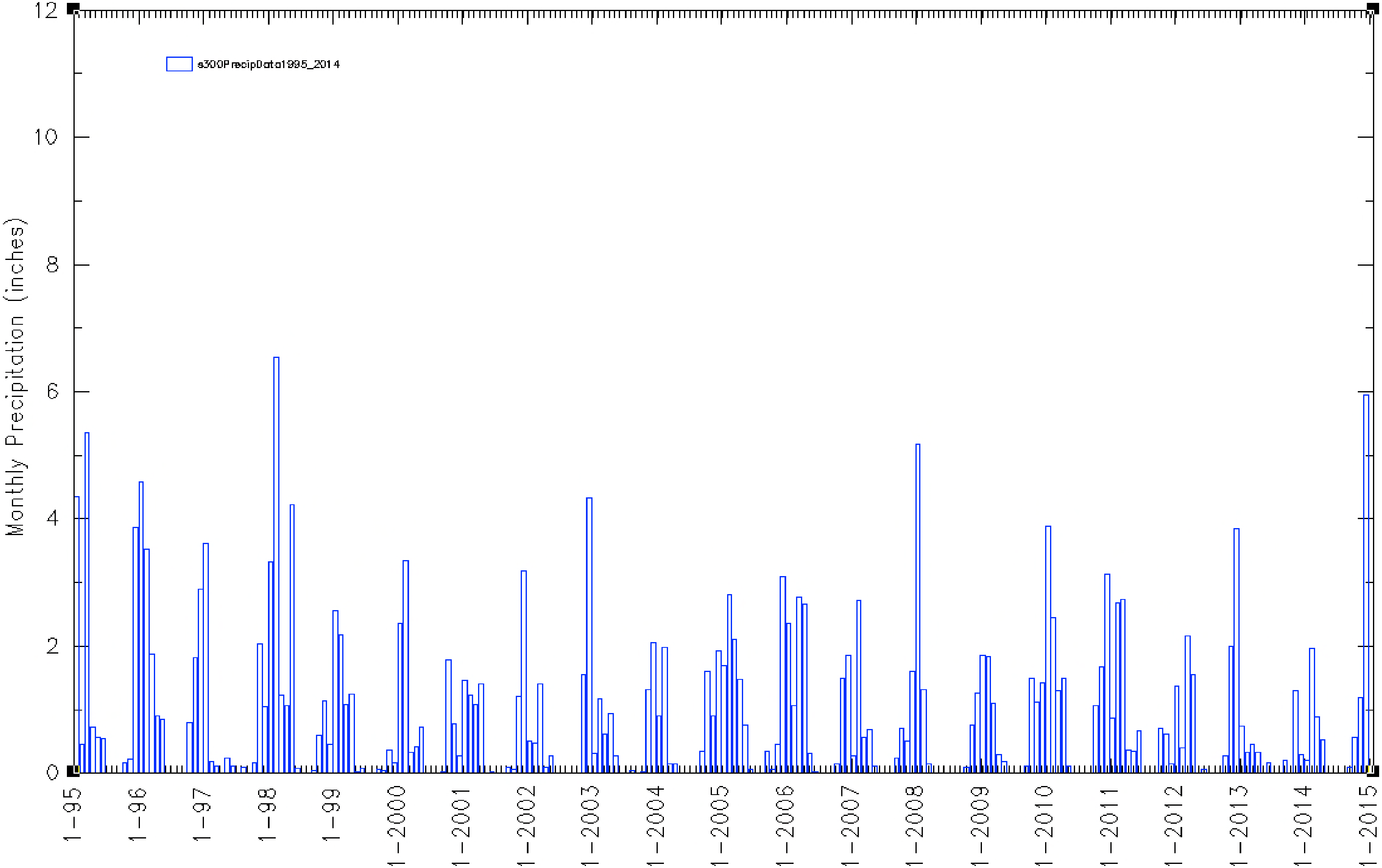


Figure C-12. Monthly precipitation at Site 300 (1995 – 2014).

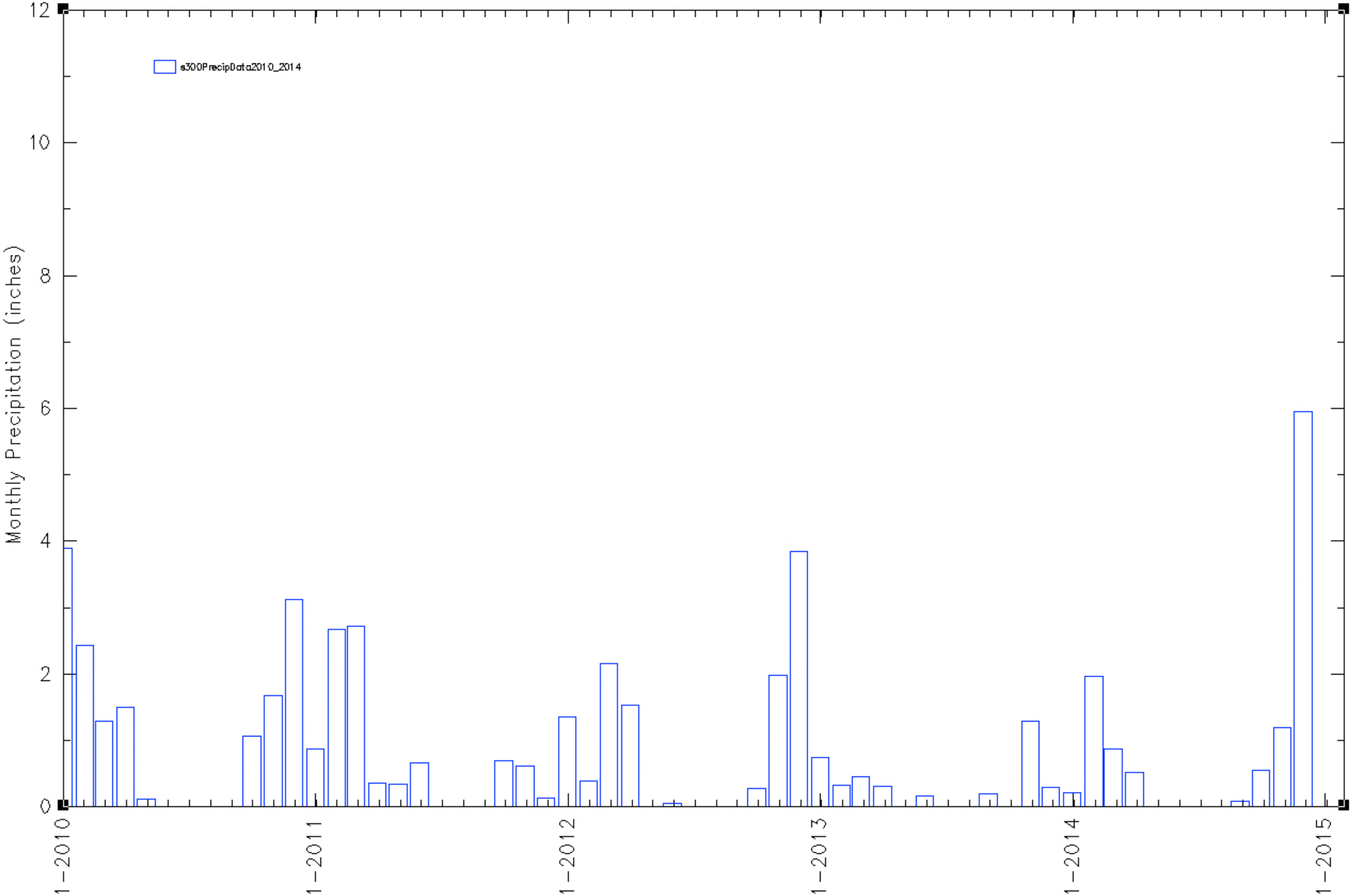


Figure C-13. Monthly precipitation at Site 300 (2010 – 2014).

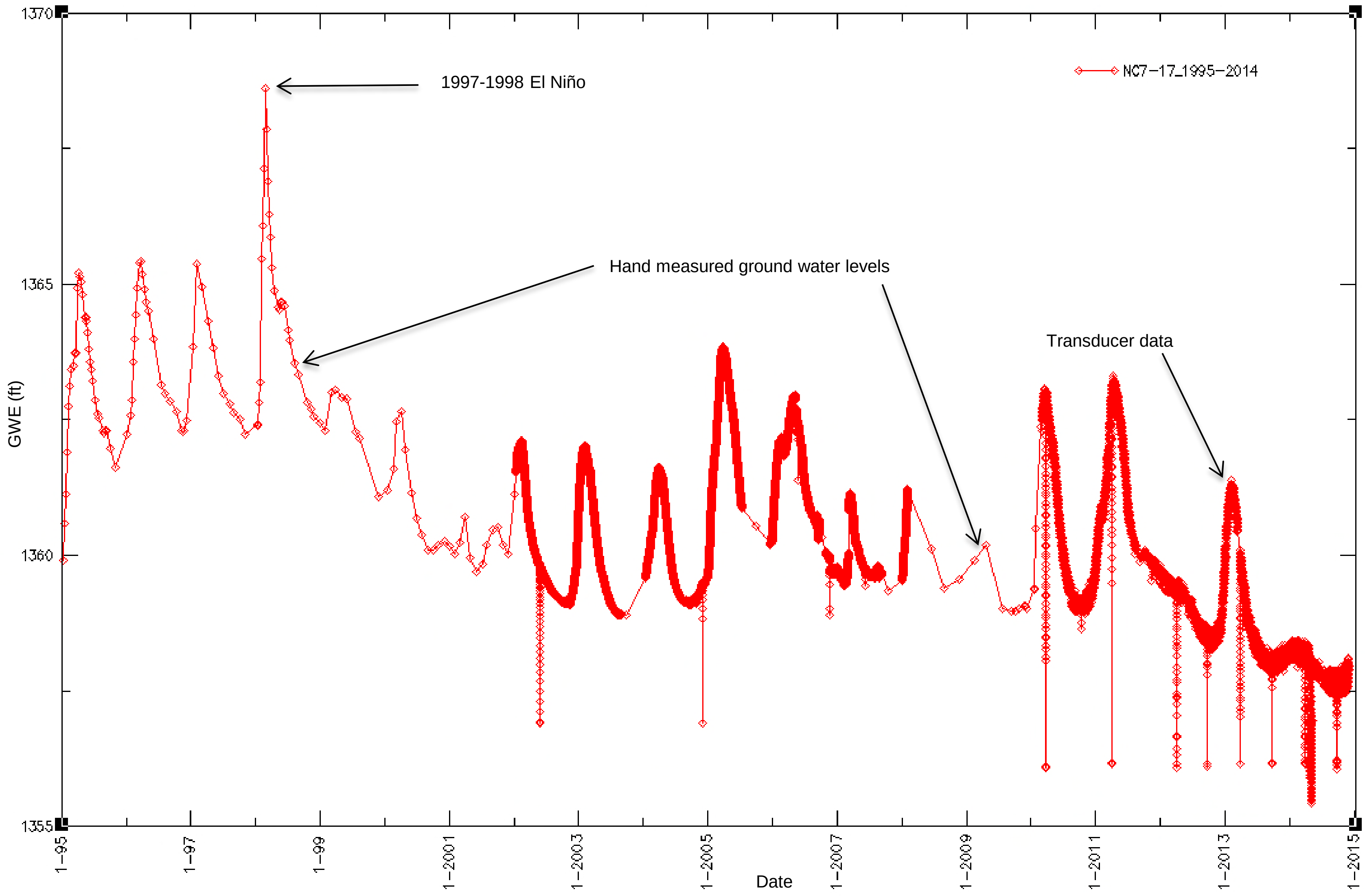


Figure C-14. Ground water hydrograph for the Pit 7 Complex drainage diversion system monitor well NC7-17 (1995 – 2014).

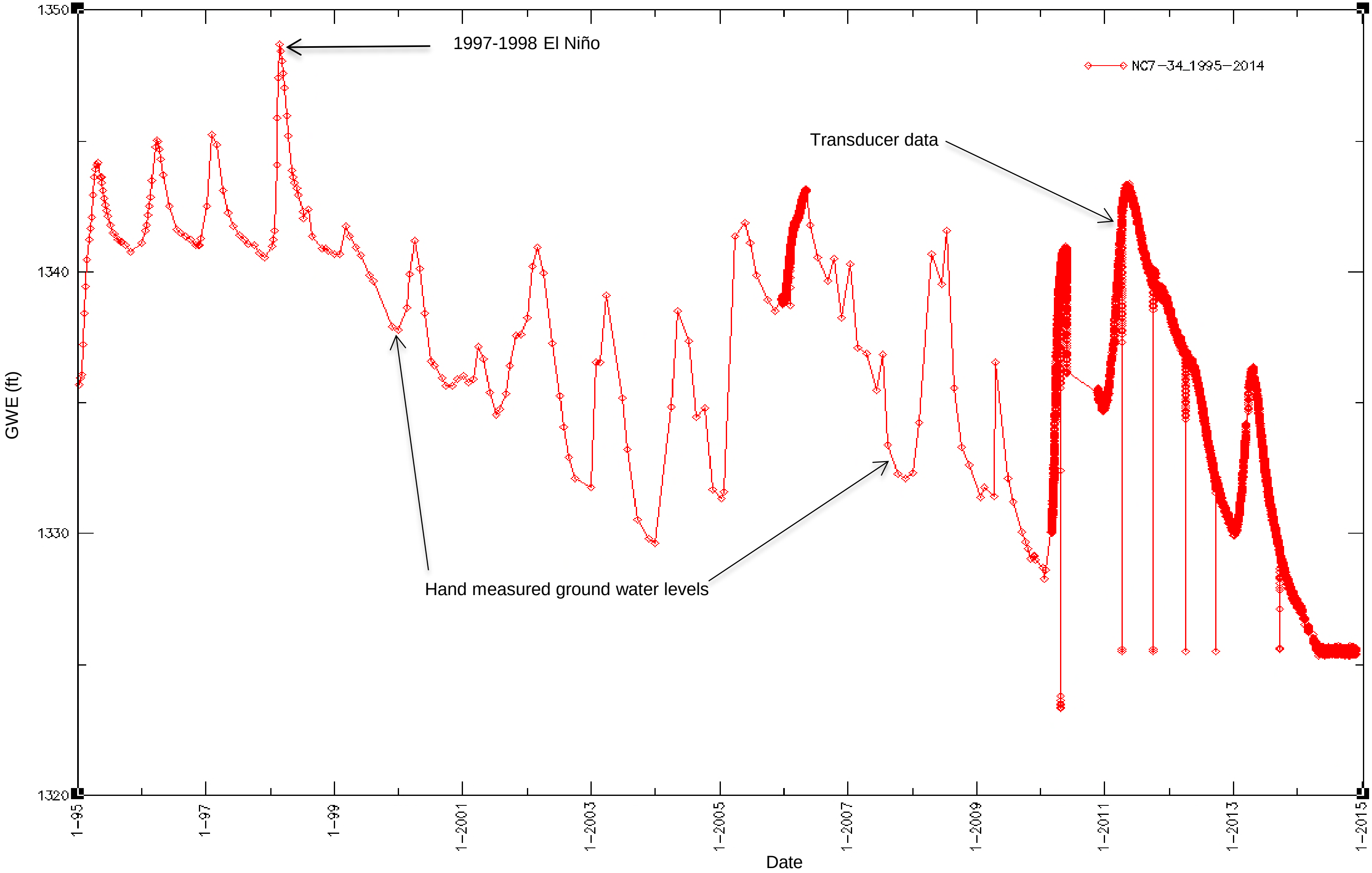


Figure C-15. Ground water hydrograph for the Pit 7 Complex drainage diversion system performance monitor well NC7-34 (1995 – 2014).

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